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Application of Citric Acid and Packaging Type Selection in Preserving Stability of Homemade Tomato Sauce

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ABSTRACT

Tomatoes are horticultural product widely grown in Indonesia and consumed by societies. They contain minerals, vitamins, and bioactive compounds beneficial for health. Unfortunately, tomatoes quickly decline in quality, causing their post-harvest shelf life to be short. One attempt to prevent the wastage of tomatoes is to process them into sauce products. To extend the stability of tomato sauce, food-grade preservatives such as citric acid need to be added. Furthermore, different packaging also affects the stability of tomato sauce. This study used citric acid with varying concentrations of 0.05%, 0.10% and 0.15%. The packaging used included Clear Glass Bottles, Dark Glass Bottles, Clear Plastic Bottles, and Dark Plastic Bottles. The tomato sauce was evaluated by room storage for 30 days to investigate the stability of water content, acidity level, and total microbes. Adding 0.15% citric acid may be considered in preserving tomato sauce with a difference in increasing water content of 1.7%, a difference in decreasing pH of 0.1, and a difference in increasing total microbes of 1.4 cfu/g. Using a dark glass bottle may better protect tomato sauce from quality degradation.

Keywords: *Tomato Sauce; Citric Acid; Glass Bottle; Plastic Bottle; Stability*

INTRODUCTION

Indonesia is an agrarian country with abundant natural plant resources (Wirawan & Budianto, 2023). Apart from having agricultural commodities with their macronutrient content, horticulture has become a pride sector for Indonesian society (Suryati et al., 2022). Several fruits and vegetables, including tomatoes, donate minerals and vitamins for health (Rusu et al., 2023). Tomato plants are often cultivated in mountainous areas with tropical climates, such as Batu and Malang, East Java (Hadi, 2023). Numerous people commonly like tomatoes as a pleasing foodstuff because of their freshness, taste, and nourishing (Hadi, 2023). Tomatoes are berry plants belonging to the *Solanaceae* family or eggplant tribe. Some of the nutrients in tomatoes are polysaccharides, pectins, vitamin C, lycopene, flavonoid, β-Carotene, potassium, phosphorus, folate, and vitamin E (Siddiq & Uebersax, 2018). The presence of lycopene and flavonoid causes tomatoes to be associated with their properties as a good source of antioxidants (Hernández-Carranza et al., 2023).

Unfortunately, tomatoes are one of the less resistant horticulture crops (Palai, Al Islamiyah, Nurhafnita, & Engelen, 2022). The high water content (94.5 g/100 g) causes tomatoes to tend to rot easily after harvest and the shelf life of tomatoes is short, thus affecting the efficacy of consuming fresh tomatoes (Siddiq & Uebersax, 2018). In addition, tomatoes that have been harvested continue to undergo respiration, transpiration, and ethylene production processes, resulting in a decrease in quality (Smith & Emmanuel, 2018). In order to prevent product waste, several studies have attempted to process tomatoes into versatile products in making their shelf life longer (Saloko, Handito, Rahayu, Rahman, & Dwiani, 2019) (Widyasari, Sulastri, Zainuri, Zaini, & Nofrida, 2019).

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The sauce is a method of processing tomatoes made from tomato concentrate, containing 20% tomato solids and additional flavors and seasonings (Siddiq & Uebersax, 2018). To further increase the stability product, the sauce product needs to be added with other food additives such as preservatives (Jannah et al., 2023). One safe food additive that is suitable for use is citric acid. Citric acid is reported to be able to increase the stability of polyphenols in several processed food products (Trissanthi & Susanto, 2016). Adding acid ingredients can acidify the product, thereby preventing the growth of contaminants (Magalhães, Vilas-Boas, Teixeira, & Pintado, 2023). Therefore, this research was carried out regarding the use of preservatives on the stability of tomato sauce products.

Besides preservatives, packaging type selection is also needed to maintain the quality of tomato sauce (Imelda & Simina, 2023). A proper and clean packaging system can limit direct contact of food ingredients with environmental factors and reduce the potential for degradation of processed products (Suryati et al., 2022). Sauce products require packaging that can protect them from changes in water content, pH, and microbe amount during storage (Suryati et al., 2022). The types of packaging for sauce products that are often used are glass bottles and plastic bottles (Imelda & Simina, 2023). Besides the usage of citric acid, in this research, how plastic and glass bottles affect the stability of tomato sauce during storage is also being studied. This research can provide recommendations for selecting packaging and using citric acid to maintain the quality of homemade tomato sauce made by the general public.

METHODS

Material and Tools

The ingredients used to make homemade tomato sauce are fresh tomatoes, citric acid monohydrate (Weifang Ensign Industry Co.,Ltd.), kitchen salt (NaCl), sugar (sucrose, PG. Kebon Agung Malang), carboxymethyl cellulose (CMC, Chongqing Lihong Fine Chemicals Co.,Ltd), garlic, and aquadest. Blender, knife, whisk, stainless steel pan, stainless steel basin and strainer were used in this research.

Tomato Sauce Production

The process of making tomato sauce uses literature which is then modified (Alam, Ahmed, Akter, Islam, & Eun, 2009) (Irianto, Susianti, Darmawan, & Syamdidi, 2017). One kilogram of tomatoes was washed and separated from the complex parts. The clean tomatoes was cooked for 5-10 minutes and continue by pureeing the boiled tomatoes with a blender, then filter. Heat the strained tomatoes until boiling using low heat until slightly thick while stirring. After that, adding a half teaspoon of salt, 6 teaspoon of sugar, a half teaspoon carboxymethyl cellulose and citric acid was carried out while stirring. The finished tomato sauce mixture was then packaged into sterile bottles.

Research Design

There are two variables used in this research: 1) the citric acid concentration factor; and 2) the tomato sauce packaging. Citric Acid concentrations consist of 0%, 0.05, 0.1%, and 0.15% concentration. Packaging types consist of dark glass bottles (DG), clear glass bottles (CG), dark plastic bottles (DP), and clear plastic bottles (CP). These following 16 variables were described in Table 1.

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Table 1. Variations in packaging type and citric acid concentration in processed tomato sauce

Codes	Treatment	
	Packaging Type	Citric Acid Concentration
CG 0%	Clear Glass Bottles	0.00%
CG 0.05%		0.05%
CG 0.1%		0.10%
CG 0.15%		0.15%
DG 0%	Dark Glass Bottles	0.00%
DG 0.05%		0.05%
DG 0.1%		0.10%
DG 0.15%		0.15%
CP 0%	Clear Plastic Bottles	0.00%
CP 0.05%		0.05%
CP 0.1%		0.10%
CP 0.15%		0.15%
DP 0%	Dark Plastic Bottles	0.00%
DP 0.05%		0.05%
DP 0.1%		0.10%
DP 0.15%		0.15%

Test Parameters

The analysis carried out in this research included analysis of product quality during 30 days of storage (28-30°C; with lighting from LED lamp) and measured every 5 days. The analytical methods tested include:

1. Water content
   Tomato sauce (with a known mass) was placed in a petri dish (with a known mass). Then, the petri dish was dried in an oven set at 105 °C. for 12 hours. After heating, the petri dish containing the material is removed from the oven and immediately placed in the desiccator. After 30 minutes, the petri dishes containing the dried tomato sauce were weighed. After weighing, the oven drying process and desiccator storage were repeated until a constant weight was obtained from the petri dish containing the material. The percentage of water content was obtained by dividing the mass of dried tomato sauce by the mass of tomato sauce before treatment (Wandira et al., 2023).

2. Acidity level (pH)
   The pH value was measured using a pH meter calibrated with a pH 3.0 buffer and a pH 7.0 buffer. All samples were diluted first by adding 50 ml of distilled water to 5 grams of product, then homogenized, and pH measurements could be carried out (Inneke & Kristopo, 2023).

3. Total number of microorganisms (Total Plate Count)
   This total microbial test was carried out to determine the growth of bacteria and yeast during storage. Microbes were analyzed using the petri dish dilution method. By diluting the sample and then pouring it into the Potato Dextrose Agar (PDA) medium, the sample was incubated for 1x24 hours at 40 °C. The number of colonies was counted using a Colony Counter (Handayani, Halimatushadyah, & Krismayadi, 2023).

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RESULT AND DISCUSSIONS

Profile of Tomato Sauce Stability Based on Water Content

Figure 1 implies how different concentrations of citric acid directly affect the percentage of moisture content of homemade tomato sauce, even before being stored for 30 days. Tomato sauce without adding citric acid has an initial water content of 85.3%. Tomato sauce with the addition of 0.05%, 0.1%, and 0.15% citric acid had a tomato sauce water content of 80.9%, 77.8%, and 74.6%, respectively. The presence of citric acid helps the role of carboxymethyl cellulose as binder .

Applying citric acid to homemade tomato sauce also suppressed the potential for additional water content during storage. Tomato sauce without citric acid experienced an increase in the percentage of water content of around 3 to 4 percent after being stored for 30 days. Meanwhile, the rate of increasing water content of tomato sauce containing citric acid is only 1 to 2 percent after 30 days of storage. The use of 0.15% citric acid has been proven to maintain product stability based on its water content during storage, superiorly, compared to the use of 0.05 and 0.10% citric acid. Citric acid obviously acts as a preservative, according to the reference. Citric acid works by binding to the hydroxyl group of water from tomato sauce (Asasia & Yuwono, 2018).

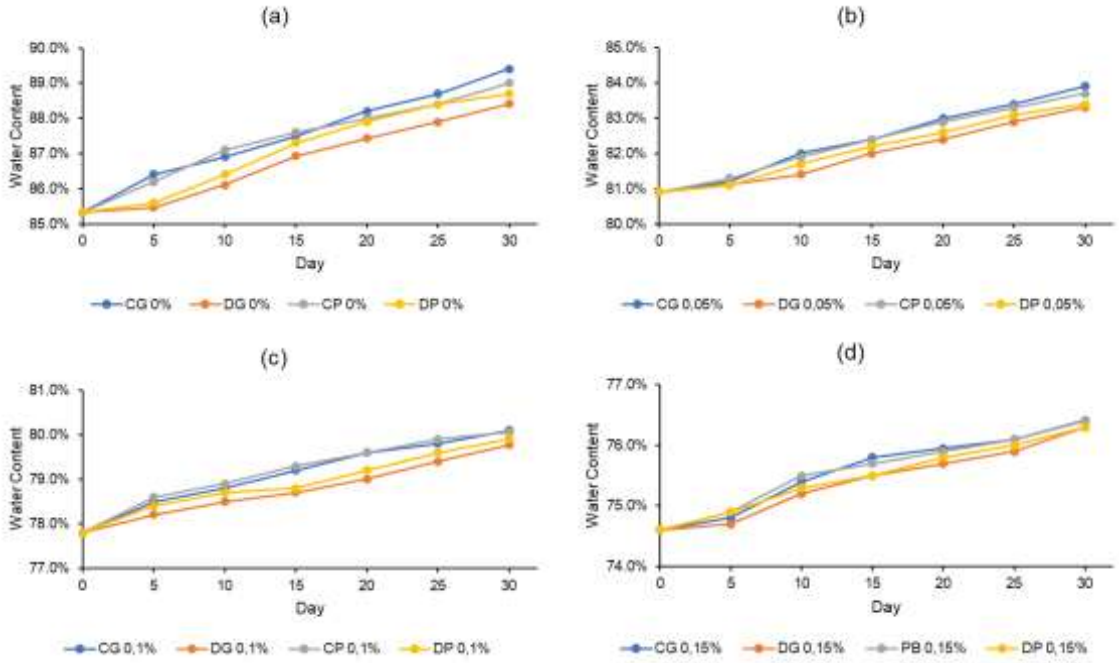

Figure 1. The effect of citric acid concentration: (a) 0%; (b) 0.05%; (c) 0.10%; (d) 0.15% and the effect of different types of packaging on the water content of homemade tomato sauce stored for 30 days

Different types of packaging provide different percentage values for the water content of tomato sauce after 30 days of storage. The effect of packaging application on water content can be seen specifically in Figure 1 (a). On day 30, tomato sauce packaged in dark glass bottles and dark plastic bottles contained a water content of 8.4% and 8.7%, respectively. Meanwhile, tomato sauce packaged in clear glass bottles and clear plastic bottles contains water content of 9.0% and 9.4%, respectively. Darker packaging is considered to provide product protection, where the tomato sauce is not exposed to direct light (Mulyani, Admadi, Budhiarta, & Diah Puspawati, 2015). .

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The difference between glass and plastic materials influences the stability of tomato sauce products. Based on Figure 1, it can be observed from the rate of increase in water content of tomato sauce in clear glass bottles, which is faster than tomato sauce in clear plastic bottles. This pattern may correspond to the thermal conductivity of the packaging material. The convection heat transfer of glass is 0.17 W, while plastic is 0.016 W (Riupassa & Allo, 2019). It means that glass has the ability to conduct heat at a higher rate than plastic. Dark glass bottles also appear to have absorption and emissivity values equal to one (Astiti, Eryani, Yudiastari, & Semaryani, 2023). Therefore, using clear glass bottles lowers the pH of tomato sauce more quickly than clear plastic bottles due to the insulating properties of plastic.

Profile of Tomato Sauce Stability Based on pH

Citric acid is a food ingredient that is often found in citrus fruits, grapefruit and pineapple, and has been used to improve the taste of juice or ice cream products (Behera, Mishra, & Mohapatra, 2021). Consuming a reasonable pH of citric acid is still good for the stomach. The presence of citric acid will certainly lower the pH of food, which means it is possible to reduce the number of microbes (Cahyadi, 2023).

Differences in citric acid concentration influence the acidity level of homemade tomato sauce before being held for a month. Tomato sauce without added citric acid has an initial pH of 5.1. Tomato sauce with 0.05%, 0.1%, and 0.15% citric acid has a pH of 4.8, 4.6, and 4.3, respectively. The higher the concentration of citric acid, the more acidic the tomato sauce. Citric acid is an acidulant compound that can decompose in solvent media and release hydrogen ions, causing the acidity of the product to increase and causing the pH value to become lower. The citric acid specified as a preservative in food products has a maximum pH of 4.3, thus adding more citric acid is not recommended. (Azabi, Ega, & Polnaya, 2023).

Figure 2 implies the influence of citric acid addition on the pH stability of tomato sauce products. During 30 days of storage, tomato sauce without citric acid experienced a more significant pH reduction than tomato sauce with citric acid. If the pH decreasing rate from tomato sauce without citric acid can reach 0.7 pH/30 days, the pH decreasing rate of tomato sauce with citric acid is only 0.1-0.3 pH/30 days. The lowest pH-reducing rate of tomato sauce is processed tomato sauce products containing 0.15% citric acid (from pH=4.3 to pH=4.2).

The usage of citric acid in tomato sauce has been proven to maintain product stability. Even though tomato sauce with citric acid has a higher acidity level than without citric acid, tomato sauce with citric acid provides satisfactory quality during storage. Citric acid is able to ensure food safety and avoid undesirable microbial, physical–chemical, or enzymatic reactions (García-García & Searle, 2015).

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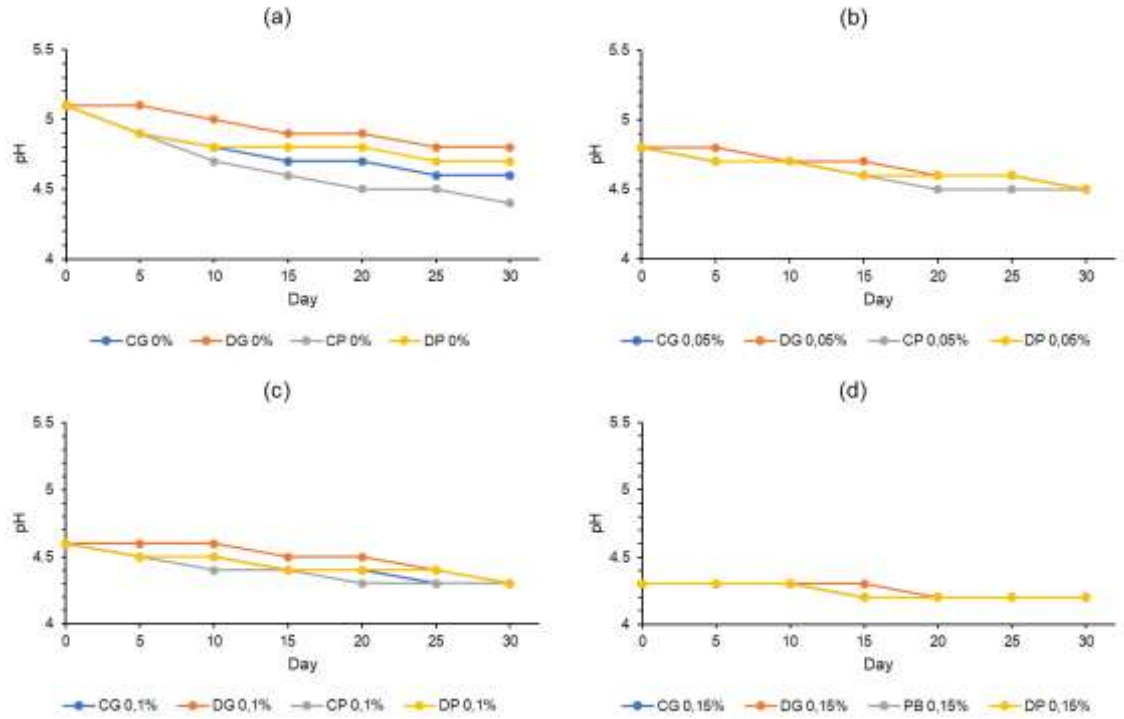

Figure 2. The effect of citric acid concentration: (a) 0%; (b) 0.05%; (c) 0.10%; (d) 0.15% and the effect of different types of packaging on the acidity level of homemade tomato sauce stored for 30 days

Differences in packaging type affect the pH stability of processed tomato sauce during 30 days of storage. Referring to Figure 2 (a), tomato sauce packaged in four different packages has a different acidity level. The pH value of tomato sauce on day 30 in the types of packaging: clear glass bottles, dark glass bottles, clear plastic bottles, and dark plastic bottles was 4.6, 4.8, 4.4, and 4.7, respectively. Dark bottles are considered capable of maintaining product pH stability for 30 days of storage, compared to clear bottles.

Both glass and plastic provide the same product stability pattern. Referring to Figure 2 (all the graph), the difference in packaging type does not affect the pH stability of the product due to the same pH value. In this case, the color of the packaging is more influential than the type of packaging material

Profile of Tomato Sauce Stability Based on Results of Total Plate Count

The total microbial test was carried out to determine the growth of bacteria and yeast during storage. On day 0, it was counted that the total number of microbes in homemade tomato sauce without citric acid was 3.7×10^3 colonies/g. Tomato sauce with the addition of 0.05%, 0.1%, and 0.15% citric acid had total microbes of 3.2×10^3, 2.6×10^3, and 3.7×10^3 colonies/g, respectively. Based on the regulations of the Indonesian Drug and Food Control Agency (Per BPOM 13-2019), the maximum limit for microbial contamination in tomato sauce is no more than 10^4 colonies/g (ISO 4833-1 method) (BPOM, 2019)(Ali, Sulistijowati, & Sutianto Pratama Suherman, 2022). In this research, the total number of microbes counted is still under 10^4 colonies/g, fulfilling food standard requirements.

Based on Figure 3, adding citric acid in tomato sauce influences the total number of microbes of homemade tomato directly. On day 0, the total number of microbes in tomato sauce with citric acid was less than in tomato sauce without citric acid. Moreover, after all the

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products were stored for 30 days, tomato sauce with citric acid did not improve much compared to tomato sauce without citric acid. On day 30, tomato sauce with the addition of 0.05%, 0.1%, and 0.15% citric acid had total microbes, ranged of (6.3 – 6.5) × 10^3; (4.7 – 4.9) × 10^3; (3.8 – 4.1) × 10^3 colonies/g, respectively. Meanwhile tomato sauce without citric acid had total microbes of (8.8 – 9.2) × 10^3 colonies/g. The decreased pH of tomato sauce without citric acid during 30 days of storage indicates much undesirable pathogenic microbial activity.

Total microbial data further confirmed the role of citric acid as a preservative, especially regarding the pH stability data in the previous sub-discussion. Citric acid works as an antimicrobial agent by lowering the acidity level (Eliuz, 2020). It inhibits bacteria through chelating metal ions, thus diminishing the chance of bacterial growth in the food (Burel, Kala, & Purevdorj-Gage, 2021).

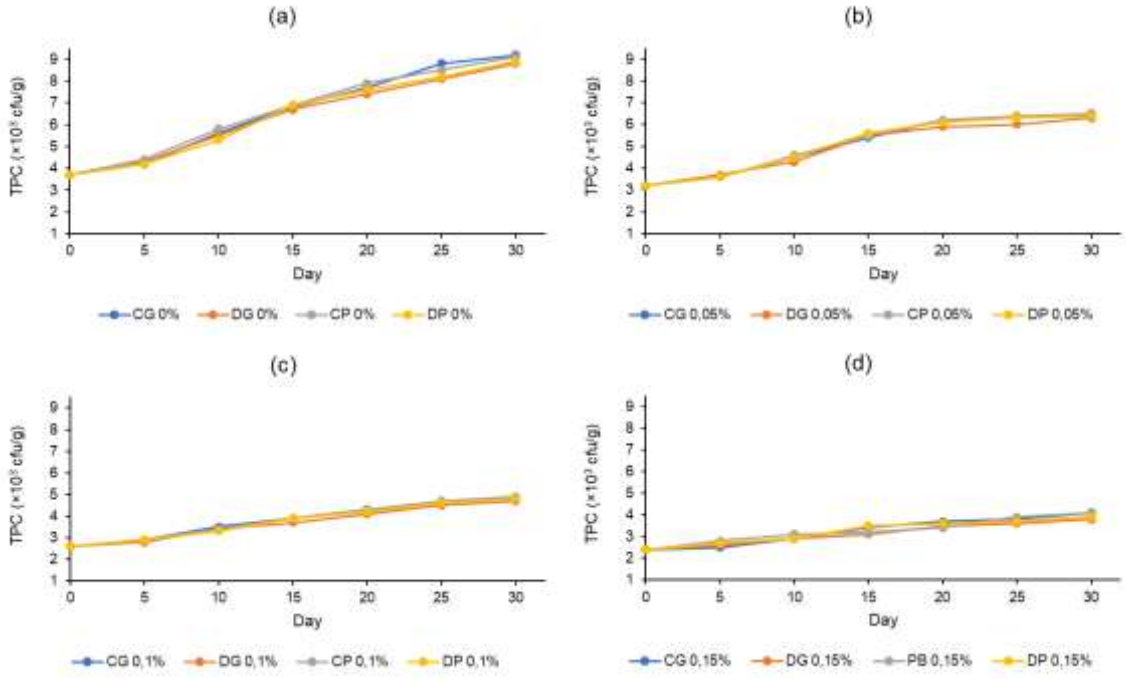

Figure 3. The effect of citric acid concentration: (a) 0%; (b) 0.05%; (c) 0.10%; (d) 0.15% and the effect of different types of packaging on the total number of microorganisms of homemade tomato sauce stored for 30 days

However, differences in total microbes in each variable are also caused by differences in the packaging materials used. The pattern of increasing total microbes in tomato sauce in Figure 3 follows the pattern of increasing water content (Figure 1) and decreasing acidity levels (Figure 2). Tomato sauce in dark bottles has lower of microbe amount than in the clear bottles. Storing products in more transparent packaging provides an opportunity for exposure to light to reduce product quality (Narulitta, Sutopo, & Khumaira, 2023).

The total microbial stability data for tomato sauce showed the same pattern as the stability data for water content and acidity level. The order of packaging types from best to worst can be determined: Dark Glass Bottles – Dark Plastic Bottles – Clear Plastic Bottles-Clear Glass Bottles. Tomato sauce in Clear Glass Bottles tends to have lower stability than other types of packaging, considering the direct interaction of the product with exposure to light and heat which causes the water content to increase, pathogenic microbes to grow, and

the pH to decrease (Atencio, Verkempinck, Reineke, Hendrickx, & Van Loey, 2022). Moreover, the tomatoes used are natural with bioactive compounds that is susceptible to environmental factors.

CONCLUSION

This study investigated the stability of homemade tomato sauce with and without citric acid stored in four-type packaging bottles. For this, this study proved that applying citric acid and packaging selection in tomato sauce affects the stability and quality of tomato sauce in 30 days of storage at room temperature with lighting. Citric acid is valuable in maintaining the stability of tomato sauce's water content, pH, and total microbial content. Adding 0.15% citric acid is recommended to preserve tomato sauce from deterioration. Afterward, darker packaging better protects tomato sauce from quality degradation than the clear one. Clear glass bottles should not be used for tomato sauce products stored at room temperature. The data on water content, pH and total microbes reported in this research can be a reference for sustainable research development related to the use of food and packaging materials to improve the quality of tomato products.

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