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QUALITY RETENTION BY HOT FILL METHOD FOR GLASS JAR-PACKAGED SHALLOT-BASED CHILI SAUCE

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ABSTRACT
This study aims to determine quality change of shallot-based chili sauce (*sambal bawang*) in glass jar packaging during storage at room temperature. There were two treatments done to the chili sauce. Both samples were preserved with sodium benzoate with different treatments in filling. Sample A was filled at room temperature 35^{o}C and sample B was hot-filled at 70^{o}C. Both samples were incubated for 56 days at room temperature (± 28^{o}C). During the storage period, Free Fatty Acid (FFA) content and Total Plate Count (TPC) were analyzed on day 0, day 14, and day 56. For Sample A and B, the FFA test showed a significant increase in FFA levels during storage on day 14. However, sample B showed a decrease in FFA content on day 56 while sample A was even higher. TPC test showed there was an increase of microorganism activity on day 14 for sample A and the sample was fully contaminated on day 56. For sample B, there were fluctuations during storage, but it maintained an allowable amount microorganism by day 56 ($5.5 \times 10^{1} \pm 6.3$ cfu/g). These results indicate that the hot-filling process (70^{o}C) for shallot-based chili sauce in glass-jar packaging can maintain the quality of shallot-based chili sauce during storage at room temperature.

KEY WORDS
Storage, microbial growth, free fatty acid, preservation, thermal process.

As a multicultural country, Indonesia has a strong culinary tradition. The tradition comes from an initial multi-generational development and the results of cultural absorption since ancient times (Surya & Tedjakusuma, 2022). One of the culinary riches of Indonesia is chili sauce, commonly referred as *sambal,* which has existed since the ancient Javanese period. this was shown by the mention of chili as a type of food in the Ramayana text from the 10th century (Sulistijowati et al., 2020). *Sambal* is a native Indonesian condiment, generally made from chili peppers with spices such as shallots, garlic, and other ingredients (e.g. lime, shrimp paste, tomatoes, and fish). The varieties of chili (*Capsicum annuum*) which are generally widely used in *sambal* in Indonesia are red chili pepper (or cayenne pepper) and bird's eye chili pepper (Surya & Tedjakusuma, 2022). Indonesia has many types of *sambal* because each region has their own special *sambal*. For example, several variations of *sambal* are *sambal mangga kweni (*kuwini mango chili sauce*)* ((Fitriani et al., 2021), *sambal tuk tuk* from the Tapanuli tribe in Sumatera (Sonangda et al., 2019), *sambal terasi* (fermented shrimp paste chili sauce) (Ahmad et al., 2020; Damanik Ambarita et al., 2019), *sambal ikan asap* (smoked fish chili sauce) (Suseno et al., 2021), and many others.

Recently, technological developments have changed food consumption habits. Traditionally prepared food is being replaced by ready-to-eat food products. There has been an urge to modernize *sambal* which is usually a conventionally cooked food product. Modernization can be marked by applying packaging technology (Fibri & Frøst, 2019) to increase shelf life. Some packaging materials commonly used on *sambal* products there are glass, Polyethylene Terephthalate (PET), aluminum sachets, or plastic packaging (Fibri & Frøst, 2019; Fitriani et al., 2021; Koswara et al., 2017; Nurminabari et al., 2022; Sonangda et al., 2019; Surya & Tedjakusuma, 2022). *Sambal* packaging must be combined with some sort of preservation process to extend its shelf life. Preservation can be done through physical means, such as by applying thermal processes, or chemically, by adding preservatives. One of the most widely used preservatives in *sambal* products is sodium

benzoate. Several studies have found the use of sodium benzoate on various chili sauce products being sold in local markets of several regions in Indonesia, such as Bengkulu (Ramadhani & Pratiwi, 2019), Pekanbaru (Nasution et al., 2012), Medan (Sari et al., 2022), and in West Denpasar (Pramitha et al., 2020). Sodium benzoate ($C_7H_5O_2Na$) functions as a preservative by inhibiting the growth of microorganisms. However, its use is limited by regulations such as from Indonesia's National Agency of Drug and Food Control (known as BPOM), U.S.' Food and Drugs Administration (FDA), and Codex Alimentarius (CA) in Europe. Consuming food with high amount of preservatives in the long term can potentially cause diseases, such as neurological diseases, a high risk of cancer cell growth, and may also cause allergic reactions (Rosalinda et al., 2021). Based on BPOM and CA Regulation for chili sauces, the maximum quantity of sodium benzoate allowed in a chili sauce product is 1 g/kg of product weight (BPOM, 2013; Codex, 2020). This is in line with the applicable concentration limit at the FDA of 0.1% of the product weight (FDA, 2023).

One of the physical preservation techniques is thermal application. Hot filling is a thermal process that is widely used in the food industry. It has been demonstrated that the hot-filling procedure is a good pasteurization technique that can inactivate and even kill yeasts, lactic acid bacteria, spoilage bacteria, and different types of molds (Park et al., 2020). Hot filling temperatures are usually between 70 – 95^{o}C (Park et al., 2020). hot-filling method has the advantage of low costs, adjustable (based on the number of products), and accessible for use in a remote area (Silva et al., 2003). Hot-filling technology can be carried out using a simple method. For example, the hot-filling treatment can be preserved the cupuacu (*Theobroma grandiflorum*) pulp from Amazonian fruit which has been packaged in glass jars and was produced in a remote area (Silva et al., 2003). Therefore, this treatment can be suitable for small and medium-sized businesses producing liquid and semi-liquid food products. Several studies regarding the preservation of *sambal* have been carried out such as preserving chili shrimp paste product using heat treatment (21,6 minutes, 80^{o}C) and packed in a plastic sachet to effectively control the growth of microflora (Sobhi et al., 2012) and a heat treatment by hot filling (65^{o}C) procedure in HDPE (high-density polyethylene) bottle which was able to maintain the quality of a tomato sauce for 3 months (Raits et al., 2021).

Figure 1 – Shallot-based chili sauce in a glass jar

From several studies that have been done previously on efforts to extend the shelf life of chili sauce, there has not been any research specifically on the effect of hot filling treatment application on *sambal bawang* or shallot-based chili sauce products packaged in a glass jar. This observation is needed to see the effectiveness of hot-filling technique in maintaining the quality of shallot-based chili sauce during storage during storage at room temperature to emulate common storage condition in Indonesia. The quality parameters measured are water activity (A_w), pH value, total plate count (TPC), and free fatty acid content (FFA). An illustration of of shallot-based chili sauce is shown in Figure 1. This study aimed to see the prospect of using the hot filling techniques by evaluating the degradation of shallot-based chili sauce quality during storage.

METHODS OF RESEARCH

Shallot-based chili sauce Product Samples Preparation. The production of shallot-based chili sauce began with measuring ingredients needed for each treatment, as shown in Table 1. The red bird’s eye chili pepper, shallots, garlic, and vegetable oil were then evenly

chopped using a chopper (Phillips HR 2939). Afterward, these ingredients were cooked at 100ºC for 5 minutes (Koswara et al., 2017). Salt, seasoning, sugar, and sodium benzoate were added to the mixture, and it was continuously cooked (80ºC – 90ºC; 45 minutes). After the heating process was complete, then the mix was cooled off until the temperature reached 70ºC (Anwar, 2014). Meanwhile, glass jars were sterilized by putting them in boiling water for 20 minutes and drying before use. At 70 ºC, half of the sample, referred to as sample B, was put into a sterilized glass jar packaging, and was closed tightly. After the bulk sample reached 35ºC, the same filling process was also done. This sample is referred to as Sample A. Both samples were then flipped over (with the cap at the bottom) for several minutes (Hariyadi, 2020) to even out the temperature within the jar and was returned to a normal position afterwards. Both jars were then stored at room temperature ± 28ºC for 8 weeks (56 days).

Table 1 – Composition and treatment of shallot-based chili sauce sample product

Compositions	Information	Sample Code	
		A	B
Ingredients*			
Red bird's eye chili pepper	300 g	v	v
Shallot	300 g	v	v
Garlic	50 g	v	v
Vegetable oil	300 ml	v	v
Salt	15 g	v	v
Sugar	5 g	v	v
Seasoning	5 g	v	v
Sodium benzoate**	0.665 g	v	v
Treatments			
Hot fill***	70ºC	-	v
Filling condition	35ºC	v	-

Note: A = packaged shallot-based chili sauce with sodium benzoate addition and room temperature filling treatment at 35ºC; B = packaged shallot-based chili sauce with sodium benzoate addition and hot filling treatment at 70ºC.(Hermawan, 2021); **(Codex, 2020; FDA, 2023); ***(Anwar, 2014).*

Study Framework. The research used a completely randomized single-factor experiment design with the hot filling (70ºC) treatment as the singular factor (Anwar, 2014). Product samples were taken after the product filling process. Next is the process of packaging and storage. On the first day of storage, both packaged shallot-based chili sauce was analyzed for their pH value and water activity (Aw). During storage, free fatty acid content (FFA) and the total plate count (TPC) of the shallot-based chili sauce inside a jar package were analyzed on days 0, 14, and 56.

Analysis Methods. Sample analysis was conducted in an MBRIO Food Laboratory. The analysis method used is shown in Table 2.

Table 2 – Analysis method that used for shallot-based chili sauce for all treatments

Parameter	Method
Water Activity (Aw)	IKP/K-40 (AW meter)
pH	SNI 01-2891-1992, Point 16 (Poteniometric)
Free Fatty Acid (FFA)	SNI 01-3555-1998, Point 8 (Titrimetric)
Total Plate Count (TPC)	ISO 4833-1:2013 (Pour Plate)

Water activity was measured with a water activity meter (IKP/K - 40).

pH measurement was carried out using a pH meter consisting of a hydrogen glass electrode as a polymer standard and a column reference electrode. These two electrodes produce a voltage change of 59.1 mv/pH unit at 25ºC. The prepared sample was dipped in a pH meter electrode that was cleaned with distilled water. Then the sample pH value appeared on the pH meter (Indonesian National Standard, 1992).

Free Fatty Acid (FFA): 2 – 5 grams of sample and 50 ml of 95% neutral ethanol were put into a 250 ml Erlenmeyer. Then the sample was stirred until mixed, and 3-5 drops of PP

indicator (phenolphthalein) were added. The sample solution was then titrated with 1 N NaOH standard solution until the color changed to pink (the color lasted 15 seconds). Afterward, the FFA content was calculated with the following formula:

$$Free\ Fatty\ Acid = \frac{M.V.T}{10.m}$$

Where: M is the fatty acid's molecular weight; V is the amount of NaOH required for the titration (in milliliters); T is NaOH's normalcy, and m is the sample weight (g) (National Standardization Agency of Indonesia, 1998; Paquot, 1979).

The total plate count analysis was carried out by counting the number of growing bacterial colonies from the sample. Firstly, 1 ml of the sample was diluted to 10 ml, then 1 ml was diluted again to 10 ml using distilled water. Afterwards it was poured into a sterile petri dish and then followed by 12 – 15 ml of plate count liquid agar at 44ºC – 47ºC. The inoculum with the media was mixed by rotating the petri dish until they completely blended. The mix was let to rest and solidify. After the agar and inoculum were solid, the petri dishes were stored with their bottom on the top and placed in an incubator at 30 ± 1ºC for 72 ± 3 hours. After that, the colony count was carried out on the plate with a colony counter (ISO, 2013).

The data was statistically analyzed using T-test analysis and one-way ANOVA, with a significance level of ≤5%.

RESULTS AND DISCUSSION

The level of water activity in food ingredients is indicated by water activity (A_w), which can shorten shelf life and degrade the product and food quality (Fitriani et al., 2021). Table 2 displays the investigation findings into the water activity in shallot-based chili sauce packaged in glass jars. These findings show that shallot-based chili sauce without hot–filling treatment (A) and shallot-based chili sauce with hot-filling treatment (B) do not have a significant difference. This result indicates that the hot filling process did not affect the water activity value of the resulting shallot-based chili sauce product. Furthermore, the data in Table 2 shows the high water activity value in both shallot-based chili sauce samples. These factors play a crucial role in restricting the growth of pathogenic bacteria. Because pathogenic bacteria cannot grow under the water activity value of 0.85 – 0.86 (M.Shafiur Rahman, 2007), on the other hand, yeast and mold are more resilient. They can grow in environments with water activity levels as low as 0.80. As a result, water activity on the two shallot-based chili sauce samples can be safely free of pathogenic bacteria, though yeast and mold attacks are still possible. However, other factors such as pH, salt content, storage temperature, and heat treatment all impact bacteria growth on food products (M.Shafiur Rahman, 2007).

The pH level of food products is a crucial factor that may impact their quality in terms of color, flavor, and texture (Fitriani et al., 2021). The pH value analysis results for the shallot-based chili sauce product in glass jar packaging are shown in Table 2. The data shows that Sample B has a lower pH level than Sample A, a significant difference from the statistical study. It means that the hot filling treatment can significantly impact pH values dropping. This result is in line with previous studies on mango *kweni* chili sauce products (Fitriani et al., 2021) and *tuk tuk* chili sauce (Nairfana et al., 2022), which found a decrease in pH value after heating. The pH decrease occurs because the high temperature in the heating process releases organic acid compounds from the chili ingredients, causing the pH level to fall (Fitriani et al., 2021; Nairfana et al., 2022). However, the quality standard for chili sauce has a maximum pH value of 4 when referring to the pH value of chili sauce in compliance with SNI 01 - 2976 – 2006 (SNI, 2006). Based on this, samples A and B did not meet these quality parameters. Food products with a water activity (A_w) value higher than 0.85, and a pH value greater than 4.5 must be sterilized to extend their shelf lives (Muhandri, 2021). The heating process can be carried out for 3 minutes at 121ºC, while the hot filling process can be used on chili products with a pH value of less than 4.5 (Muhandri, 2021).

Table 3 – Results of the Hot Filling Treatment on Shallot-based chili sauce Jar Packaging with Water Activity (Aw) and Acidity (pH) Analysis

Sample	Parameters	
	Aw	pH
A	0.8500 ± 0.0028[a]	6.9650 ± 0.0353[a]
B	0.8540 ± 0.0014[a]	6.5900 ± 0.0000[b]

***One column with different letter notations reveals a significant difference ($p<0.05$). A = packaged shallot-based chili sauce with sodium benzoate addition and room temperature filling treatment at 35^{o}C; b) B = packaged shallot-based chili sauce with sodium benzoate addition and hot filling treatment at 70^{o}C.*

The Free Fatty Acid (FFA) level demonstrates the quality parameters that result from processing and storage (Edyson et al., 2022). The increase in FFA content in food products indicates a decrease in food product quality. Sample A shows an increase in FFA content of shallot-based chili sauce during storage. Statistical calculations show that the increase in FFA occurred significantly. Sample B also shows a significant increase in FFA content on day 14, even though it shows a decrease on day 56. The increase of FFA content during storage is in line with another research on *Gami Bontang* chili sauce which was stored in polyethylene terephthalate (PET) jar packaging for six days under various temperature conditions (Nurminabari et al., 2022).

Table 4 – Analysis result of FFA content on glass jar packaged shallot-based chili sauce under storage under room temperature

Sample	Free Fatty Acid (g/100g)		
	Day 0	Day 14	Day 56
A	0.1000 ± 0.0000 [a]	0.2100 ± 0.0000 [b]	0.2754 ± 0.0021 [c]
B	0.1100 ± 0.0000 [a]	0.2800 ± 0.0000 [c]	0.1875 ± 0.0005 [b]

Note: different letter notation in a row shows a significant difference ($p<0.05$). A = packaged shallot-based chili sauce with sodium benzoate addition and room temperature filling treatment at 35^{o}C; B = packaged shallot-based chili sauce with sodium benzoate addition and hot filling treatment at 70^{o}C.

The lipid contained in chili sauce is hydrolyzed by water molecules and produces FFA. Higher fatty acid degradation will increase FFA content. The high FFA can decrease nutritional content by destroying fat-soluble vitamins and essential fatty acids and decreasing sensory quality due to an unpleasant pungent aroma (Nurminabari et al., 2022). The FFA carbonyl group will build up on the product's surface during storage, which could speed up the rate at which oxygen from the headspace diffuses into the product. This condition will accelerate the oxidation of the oil (Wardhani et al., 2020) and decrease the quality of chili sauce.

One aspect of the quality and safety of food products is the microbiological activity level. In this study, the microbial analysis was done using the TPC method during the storage period at room temperature. The result is shown in Table 4. The A sample shows an increase in plate count total after 14 days of storage. However, within day 56, the TPC analysis was not done due to sample contamination by mold and yeast inside the jar packaging. For the B sample, the analysis shows an increase in TPC after 14 days of storage. However, the TPC value is still relatively low level. The contamination in sample A indicated that adding sodium benzoate as a preservative can only maintain quality for a short time. The sodium benzoate in shallot-based chili sauce is an antimicrobial agent and growth inhibitor of mold and yeast. However, in sample A, this preservative use is less effective. It must combine with proper heating treatment to support the product's shelf life (Rosalinda et al., 2021). Furthermore, other factors influencing microbe growth in food products are water activity (A_w), pH value, nutritional content, and antimicrobial component (Rosalinda et al., 2021). Sodium benzoate can reduce the growth of yeasts and microbes at pH 2.5 – 4 (Faroch, U., K. R. Dhanti, 2021).

The sample B that was given the same amount of preservative but used the hot filling method at 70^{o}C as treatment was able to maintain its quality within a much more extended period. However, the result of TPC in this research is varied. This result is concurrent with

the study about tomato sauce (Raits et al., 2021), which examines the TPC during storage. The result of tomato sauce TPC shows a varied and unstable result. This happened because the sample was from a different packing jar glass.

Table 5 – Result of *Total Plate Count* (TPC) analysis on shallot-based chili sauce in jar packaging during storage at room temperature

Sample	*Total Plate Count* (cfu/g)		
	Day 0	Day 14	Day 56
A	$<2.50 \times 10^1 \pm 21.21$ [a]	$6.5 \times 10^6 \pm 0.00$ [b]	contaminated
B	$<1.0 \times 10^1 \pm 0.00$ [a]	$3.9 \times 10^4 \pm 0.00$ [b]	$5.5 \times 10^1 \pm 6.36$ [a]

Note: Different letter notation in a row shows a significant difference (p<0.05). A = packaged shallot-based chili sauce with sodium benzoate addition and room temperature filling treatment at 35°C; B = packaged shallot-based chili sauce with sodium benzoate addition and hot filling treatment at 70°C.

The sampling process takes one sample each during incubation. Therefore, this can cause different contamination levels on each sample, which are evaluated independently. Consequently, it can be assumed that there was no significant microbial growth on day 56 of sample B. The result of TPC sample B complies with Indonesian National Standard SNI 01 - 2976 – 2006 about chili sauce since it is much lower than the applied maximum threshold of 1×10^4 cfu/g (SNI, 2006).

CONCLUSION

The production of shallot-based chili sauce with the hot filling process in a glass jar and the addition of sodium benzoate can maintain the quality of the product. It is indicated by the absence of changes in the value of water activity (Aw) and free fatty acids. A decreased pH value and a low Total Plate Count value for chili products also support it.

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