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Characteristics of F_0 Values and Organoleptic Canned Roa Chili Sauce with Different Sterilization Periods

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ABSTRACT

North Maluku is rich in marine biodiversity, including small pelagic fish such as julung-julung fish (Hemirhamphus sp.), which are often processed into sambal roa, a traditional chili sauce made from smoked fish and spices. This product is well known as a traditional food and regional souvenir, but traditional processing methods result in a short shelf life and vulnerability to microbial contamination. This study aims to determine the effect of sterilization duration on F_0 value, and organoleptic quality of canned sambal roa. The research was conducted using a completely randomized design (CRD) with four sterilization times at 121°C: 15, 20, 25, and 30 minutes. The results showed that F_0 values increased with longer sterilization times, reaching the highest value of 6.02 minutes in treatment P4 (30 minutes). Organoleptic tests revealed the highest scores in treatment P4 for color (7.88), taste (8.46), aroma (7.67), and texture (8.13), all of which were in the "highly liked" category. hus, sterilization for 30 minutes in the canning process significantly improves the safety, shelf life, and sensory quality of sambal roa, making it a promising traditional commercial product from North Maluku.

Keywords: Canning, Julung fish, Sambel roa, F_0value, Sterilization

ABSTRAK

Maluku Utara memiliki kekayaan sumber daya hayati laut, termasuk ikan pelagis kecil seperti ikan julung-julung (*Hemirhamphus sp*.) yang sering diolah menjadi sambal roa, yaitu produk sambal khas daerah berbahan dasar ikan asap dan rempah-rempah. Sambal ini dikenal luas sebagai pangan tradisional maupun oleh-oleh khas daerah, namun pengolahannya secara tradisional menyebabkan umur simpan yang pendek dan rentan tercemar mikroba. Penelitian ini bertujuan untuk mengetahui pengaruh lama sterilisasi terhadap nilai F_0, dan mutu organoleptik sambal roa dalam kemasan kaleng. Penelitian menggunakan rancangan acak lengkap (RAL) dengan empat perlakuan waktu sterilisasi pada suhu 121°C, yaitu selama 15, 20, 25, dan 30 menit. Hasil penelitian menunjukkan bahwa nilai F_0 meningkat seiring lamanya waktu sterilisasi, dengan nilai tertinggi sebesar 6,02 menit pada perlakuan P4 (30 menit). Uji organoleptik menunjukkan skor tertinggi pada perlakuan P4 untuk warna (7,88), rasa (8,46), aroma (7,67), dan tekstur (8,13) yang termasuk dalam kategori sangat disukai. Dengan demikian, proses sterilisasi selama 30 menit dalam pengalengan sambal roa secara signifikan meningkatkan keamanan, daya simpan, dan mutu sensori produk, sehingga berpotensi untuk dikembangkan sebagai produk komersial khas Maluku Utara.

Kata kunci: Pengalengan, Ikan julung, Sambel roa, Nilai F_0, Sterilisasi

INTRODUCTION

North Maluku Province is known as one of the archipelago regions in Eastern Indonesia that has a wealth of marine biological resources, including small pelagic fish such as julung-julung fish (*Hemirhamphus sp*.). This fish is widely distributed in the waters of Ternate, Tidore, and Maba, and has high economic value and genetic peculiarities that are potential for local germplasm (Achmad *et al*., 2019). One form of utilization of julung-julung fish by the local community is in the form of sambal roa, which is a traditional processed product that combines smoked roa fish with a mixture of spices. This product is not only a typical culinary that is loved by the local community, but also develops as a typical souvenir of North Maluku that has a high selling value in the domestic market. However, sambal roa is generally still produced using traditional methods without modern preservation, so it has a limited shelf life and is susceptible to the growth of microorganisms. This is an obstacle in the distribution of products outside the region and in efforts to develop industrial scale. Therefore, innovations in processing technology are needed to improve the quality and extend the shelf life of roa chili sauce, one of which is through the canning method combined with the thermal sterilization process.

Canning is a method of food preservation by heating high temperatures in an airtight container to kill microorganisms and extend the shelf life of products. In this process, commercial sterilization aims to inactivate harmful bacteria such as *Clostridium botulinum* without damaging the sensory quality of the product. One of the important parameters used to evaluate the effectiveness of this process is the F_0 value, which is the equivalent time at 121.1°C which indicates the adequacy of sterilization. The F_0 value is influenced by temperature, time, and product characteristics, so it needs to be controlled appropriately so that the product is safe to consume but still has good quality (Santoso *et al*., 2022).

The novelty of this research is combining the determination of F_0 (thermal lethality) value with organoleptic tests on canned roa chili sauce products with a combination of ingredients that are rarely evaluated simultaneously in the context of canning. Research on canning methods has been widely conducted on various ready-to-eat products such as uduk rice, fried rice, and serundeng rice, focusing on sensory characteristics, F_0 values, and shelf life predictions (Kusumaningrum *et al*., 2021). However, scientific studies on the canning of fish sauce products, especially sambal roa typical of North Maluku, are still very limited. In fact, the application of the heat sterilization process in this product is important to ensure microbiological safety, storage stability, and sensory quality. Therefore, this study aims to evaluate the effect of variation in sterilization time on F_0 value, microbiological quality, and organoleptic characteristics of sambal roa in canned packaging.

METHODOLOGY

Time and Place

This research was carried out from April to May 2025. The production of sambal roa was carried out at the Production House Unit of the Business Incubation Center, (BLU) Khairun University, sensory testing was carried out at the Agricultural Product Technology Laboratory, Faculty of Agriculture, Khairun University, F_0 testing at the Laboratory of the Inspection Institute of the Agro Industry Standardization and Service Center (LI BBSPJIA) Bogor, at the Integrated Basic UPT Laboratory, Khairun University.

Tools and Materials

The tools used for this study include scales, blenders, basins, spoons, knives, pans, spatulas, stoves, cans, pressing machines, analytical scales, (seamer machines), autoclaves, stopwatches,

thermometers, stoves, gases, gloves, masks, tissues, rags. The tools used for the analysis of F0 thermocouple, loger data, leptop, Tools for testing analysis are measuring cups, erlenmeyers, petri dishes, test tubes, envelope paper tube racks, spatulas, mortals, droppipettes, analytical scales, hotplates, almanium foil, label paper, colony counter autoclaves, tissues, and incubators. The main ingredient for making sambal roa is smoked juung-julung fish (roa fish) obtained from the Gamalama market in Ternate city. The supporting ingredients used are spices such as curly chili, cayenne pepper, onion, garlic, tamarind, salt, sugar, broth powder, cooking oil. The materials used for F_0 testing are wood-dried cooked fish products in microbial analysis cans, namely aquaade, NaCL and alcohol.

Research Design

This study uses a laboratory experiment method with a Complete Random Design (RAL). The factor tested in this study was the sterilization temperature in the canning process, which consisted of four treatments of four replicates: a) P1: 121°C, 15 minutes, b) P2: 121°C, 20 minutes, c) P3: 121°C, 25 minutes and d) P4: 121°C, 30 minutes.

Making Sambal Roa

Smoked julung-julung fish (*Hemiramphus sp*.) or smoked roa fish obtained from the Gamalama market in Ternate City are then separated from the bones and skin. After that, the fish is mashed using a blender. Blend additional spices using a cooper blender such as onion, garlic, curly chili, cayenne pepper. Then, the oil is heated in a pan until it reaches the appropriate temperature, after that sauté the mashed spices until they give off a distinctive aroma, add the mashed roa fish, stir slowly until evenly mixed, then add salt, sugar, broth powder, and tamarind water, cook for 30 minutes and after that set aside the roa chili sauce product to be canned.

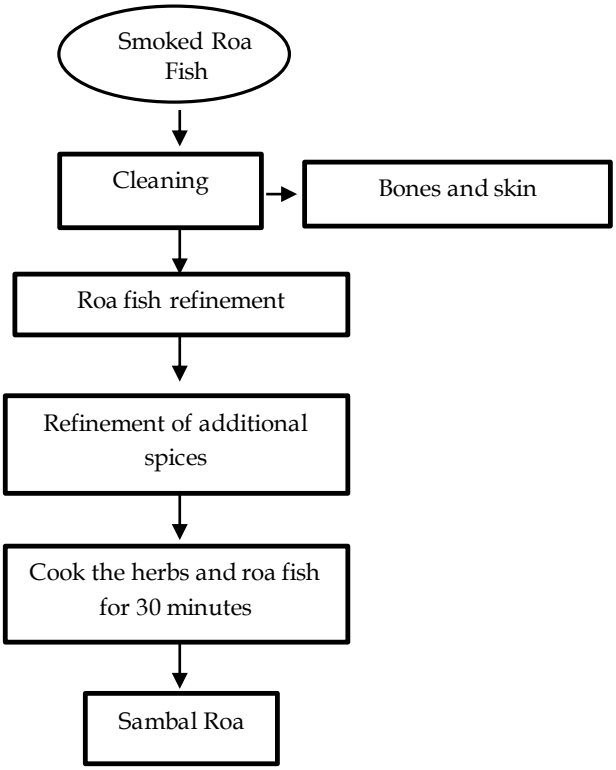

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Figure 1. Flowchart of the process of making sambal roa
(Modified from Triardianto *et al*., 2024)

Sambal Roa Canning

The canning process begins with the provision of cans as packaging containers. The cans are first sterilized using boiling water to remove any dust and contaminants that may be attached to the surface. After that, the cooked roa sauce is put into the can (filling) according to the size and capacity of the can. The net weight of chili sauce packaged in each can is adjusted to the set standard, which is 200 grams. The next stage is preheating (exhausting) which is carried out by heating a can of chili sauce at a temperature of about 70°C for approximately 15 minutes. This exhausting aims to remove air from inside the can to create a partial vacuum condition when closed. After the process, the can is tightly closed using a seamer machine to make it airtight. Furthermore, sterilization was carried out at a temperature of 121°C using an autoclave, with a variation in sterilization time of 15, 20, 25, and 30 minutes, depending on the treatment. After sterilization, the cans are cooled by soaking them in water at about 30°C for ±30 minutes. Products that have cooled are then quarantined for 14 days to ensure there are no leaks or damage to the packaging. Once declared safe, the product is labeled and ready for further distribution or testing.

Parameters Tested and Data Analysis

The parameters observed in this study include F_0 values (Heat distribution and heat adequacy), and sensory properties including taste, aroma, color, texture. Data analysis was carried out using multiple fingerprint analysis (ANOVA), if there was a difference, it was followed by a Real Difference Test (BNT) at α 0.05 (Magani, *et al.*, 2020).

RESULTS AND DISCUSSION

Heat Distribution and Heat Adequacy Test (F_0)

The heat distribution at five points in the retort shows even results, indicating the system is working optimally. Heat penetration at the coldest point of the product results in an F_0 value of 6.02 minutes at 121°C for 25 minutes. This value is sufficient to kill target microorganisms and meet food safety standards (Kusnandar *et al.*, 2023). The analysis of the F_0 value test of canned roa chili sauce with sterilization time can be seen in Figure 2.

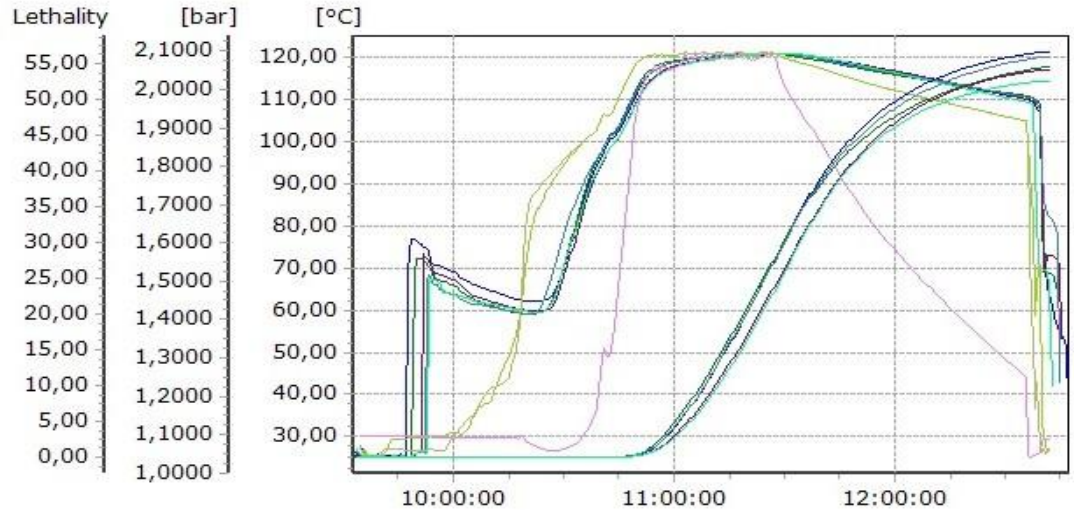

Figure 2. Heat distribution curve and heat adequacy value F_0 sambal roa cans

Based on the results of the F_0 value test on canned wood dry cooked fish products (Figure 1), the heat distribution at five different points in the retort showed a relatively uniform curve. This indicates that the retort system is able to distribute heat consistently, without significant differences between points. The heat penetration test is carried out by monitoring temperature changes in the coldest part of the product. The temperature data is then converted into a lethal rate (LR) value and plotted into a heat penetration curve. The results of the observations showed that the curves of all points had almost the same profile, indicating that the heat had been evenly distributed to the deepest part. Temperature measurements are focused on the middle of the material, which is generally considered a cold spot.

The sterilization process is carried out at a temperature of 121 °C for 25 minutes and produces an F value$_0$ by 6.02 minutes. This value is considered sufficient to inactivate pathogenic microorganisms. In comparison, in other studies of canned rice products, F_0 values varied between 4 to more than 30 minutes depending on the type of ingredient, suggesting that the composition of the food also affects the duration of heating required (Kusumaningrum *et al.*, 2021). F_0 values of less than 3 minutes are not recommended as they do not guarantee microbiological safety, while values above 3 minutes are considered to have met heat adequacy standards for low-acid products.

Organoleptic

The organoleptic study of canned roa chili sauce with different sterilization periods reviewed from several aspects such as color, taste, aroma, and texture

Color

Color is one of the important aspects in the organoleptic assessment of sambal roa, which can affect consumer perception of product quality and taste. Sambal roa usually has a bright red to orange color, which is produced from ingredients such as red chili and smoked roa fish. Attractive colors not only provide visual appeal, but can also be an indicator of the freshness and quality of the raw materials used (Sari *et al.*, 2021). The results of the average analysis of color organoleptic tests in the testing of canned roa chili sauce with sterilization time can be seen in Figure 3.

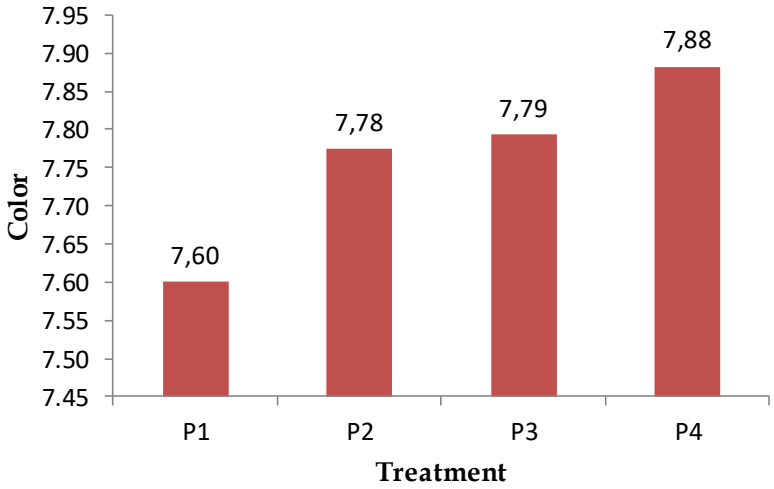

Figure 3. The average graph of organleptic color test of canned sambal roa color with sterilization duration

Based on Figure 3, the average results of organoleptic assessments of the color of canned sambal roa showed scores ranging from 7.60 to 7.88, which fell into the category of "like" to "very like". The lowest value was obtained in the P1 treatment with a sterilization time of 15 minutes, which was 7.60. Meanwhile, the highest value was achieved by the P4 treatment with a sterilization time of 30 minutes, which was 7.88. All treatments meet sensory quality standards based on SNI 2712:2013, which states that the minimum value for the hedonic test is 7 on a scale of 1–9.

The results of the fingerprint analysis showed that the variation in the length of sterilization had a significant influence on color perception by the panelists. Increased sterilization duration tends to result in a darker or brownish color of the product. This is related to the browning reaction due to heating, which affects the visual appearance of sambal roa. Browner colors are considered more attractive by most panelists, as they are associated with the ripeness and concentration of spices.

This phenomenon is in accordance with the statement of Putri (2017), that heating for a long time at high temperatures can cause a darker color change due to chemical reactions during processing. In addition, according to Sholihah (2011), color changes can also occur due to the denaturation of myoglobin compounds into hemicromogenic globins, which causes the color of food to become browner. This change then has an impact on the difference in the level of panelists' preference for product colors. The results of the Smallest Real Difference (BNT) follow-up test on the color parameter can be seen in Table 1. The average number of color tests followed by the same notation was not significantly different in the smallest real difference test (BNT) α 0.05 = 0.09.

Table 1. Follow-up test of the smallest real difference (BNT) of sambal roa with a long sterilization time

Treatment	Average
P1	7.60a
P2	7.78b
P3	7.79b
P4	7.88b

Table 1 shows that the P4 treatment has significantly different color values compared to the P1, P2, and P3 treatments. These results confirm that the longer sterilization duration of canned roa chili sauce has a significant impact on product color change. The longer the heating time, the color intensity of the product tends to increase to be darker. This color change is closely related to the Maillard reaction, which is a non-enzymatic reaction between amino compounds and reducing sugars that occurs during the heating process. This reaction produces brown compounds that affect the visual appearance of food (Faizah and Ilyas, 2022). Thus, the color differences observed between treatments are not only affected by the length of sterilization, but also by the chemical reactions that take place during heat processing.

Taste

Taste is one of the important factors in the acceptance of food products by consumers. The results of the organoleptic test showed that the longer the sterilization process, the taste assessment score tended to increase. This is because heat helps to unite the components of spices, oils, and fish meat so that the taste becomes more even and steady (Nasution *et al.*, 2022). In addition, the sterilization process also inhibits the growth of decaying microbes that can cause unwanted taste changes during storage (Maulidia *et al.*, 2021). The results of the average test of the hedonic value of the taste of dried canned fish with the length of sterilization time can be seen in Figure 4.

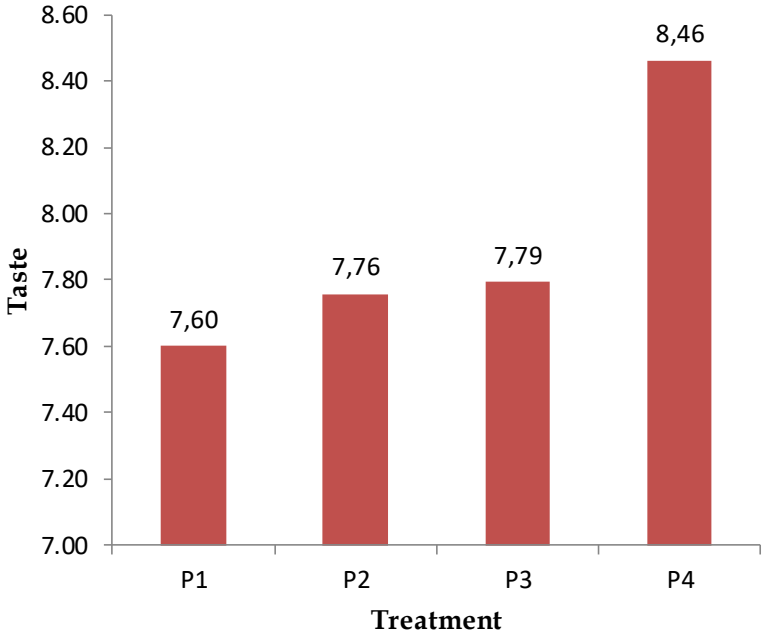

Figure 4. Graph of the average taste test of canned sambal roa with the length of sterilization duration

The results of hedonic testing on the taste of canned sambal roa showed an average score ranging from 7.60 to 8.46, which falls into the category of "very like". The lowest score was found in the P1 treatment with a sterilization time of 15 minutes, which was 7.60, while the highest score was obtained in the P4 treatment with sterilization for 30 minutes of 8.46. All average values are still above the minimum threshold set in SNI 2712:2013, which is a score of 7 on a scale of 1–9, which indicates that all treatments still meet taste quality standards.

Multiple fingerprint analysis showed that the variation in sterilization time had a significant effect on the perception of taste by the panelists. The difference is suspected to be related to the condition of the product when organoleptic tests were carried out, where canned roa chili sauce has gone through a seven-day shelf life at room temperature. During storage, there may be changes in chemical composition as well as enzymatic activity that affect the taste of the product.

The changes in taste that occur are generally caused by biochemical reactions in food, especially in protein and fat components. These substances can break down into compounds that cause an unpleasant smell and taste, especially in products that have a fairly high moisture content. This process is in line with findings (Sarifudin *et al.*, 2022) that the degradation of proteins and fats in fish can produce volatile compounds that mark the beginning of sensory damage. The results of the Smallest Real Difference (BNT) follow-up test on the taste parameters can be seen in Table 2.

Table 2 shows that the P4 treatment has a significantly different average taste value compared to the P1, P2, and P3 treatments. These results indicate that the duration of sterilization has a real effect on the level of taste acceptance in canned roa chili products. The increased sterilization time is thought to contribute to the stability of flavor components and reduce the likelihood of unpleasant taste due to chemical changes during storage. The average number of taste tests followed by the same notation did not differ significantly in the smallest real difference test (BNT) α 0.05 = 0.21.

Table 2. Follow-up test of the smallest real difference (BNT) of canned sambal roa flavor with sterilization time duration

Treatment	Average
P1	7.60a
P2	7.76b
P3	7.79ab
P4	8.46c

Aroma

Aroma is one of the important parameters in the assessment of the sensory quality of food products because it can affect the taste and level of consumer acceptance. The results of organoleptic tests on canned roa chili sauce show that the more optimal the sterilization time, the more likely the product aroma is to be preferred. This happens because sufficient heating during the sterilization process can trigger the release of volatile compounds from the roa fish and spices, which then form the product's distinctive aroma. According to Ikrawan *et al*. (2021), the heating process is able to increase aroma-contributing compounds if done at the right temperature and time, as well as prevent rancid odors due to fat oxidation. Another study by Faizal and Herawati (2023) also states that the aroma of fishery products in retort pouch packaging will be more stable and preferred by consumers if they go through a sterilization process at least at 121 °C for 25–30 minutes. The average results of organoleptic assessments of the aroma of canned roa chili sauce with variations in sterilization time can be seen in Figure 5.

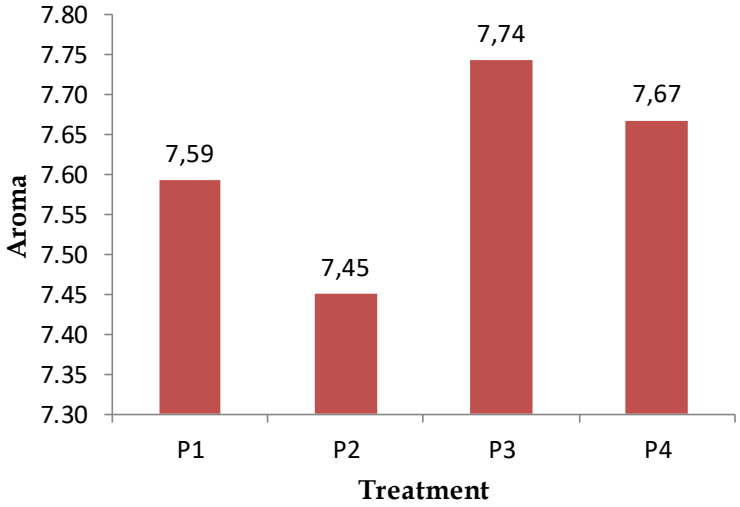

Figure 5. The average graph of analysis of canned roa chili sauce aroma with the length of sterilization time

Based on Figure 5, the results of the organoleptic assessment of the aroma of canned roa chili sauce showed an average value ranging from 7.45 to 7.74, which is included in the category of "like" to "very like". The lowest value was obtained in the P2 treatment (20 minutes sterilization time) of 7.45, while the highest value was found in the P3 treatment (25 minutes) of 7.74. All treatments were above the minimum value of the aroma quality standard based on SNI 2712:2013, which is 7 on a scale of 1–9, which means that the product is still sensorially acceptable to the panelists.

Aroma is one of the important aspects of food quality assessment, as it greatly affects consumer preferences and acceptance rates. According to Soekarto (1985), aroma plays a big role in determining the attractiveness and deliciousness of a food product, so it greatly affects the overall perception of product quality. Fingerprint analysis showed that the variation in sterilization time had a significant influence on the quality of the aroma of canned sambal roa This is in line with research by Laitupa (2021), who reported that the distinctive aroma of canned fish products is influenced by the use of regional spices and spices and the effectiveness of the sterilization process. The optimal heating process is able to maintain the characteristic aroma of the material without being disturbed by the activity of microorganisms. The results of the Smallest Real Difference (BNT) follow-up test for aroma parameters can be seen in Table 3. The average number of aroma tests followed by the same notation is no different real on the smallest real difference test (BNT) α 0.05=0.6.

Table 3. Follow-up test of the smallest real difference (BNT) of canned sambal roa aroma with sterilization time duration

Treatment	Average
P1	7.59b
P2	7.45a
P3	7.74c
P4	7.67bc

Table 3 shows that the P3 treatment provides significantly different aroma values compared to the P1, P2, and P4 treatments. These findings indicate that the variation in sterilization time has a significant influence on the quality of the aroma of canned roa chili sauce. The difference in aroma values between treatments showed that the duration of heating during the sterilization process played a role in shaping or maintaining the product's distinctive aroma, which also influenced the level of acceptance by the panelists.

Texture

Texture is one of the important characteristics in food products that greatly affects consumer acceptance. This characteristic is related to the sensation felt in the mouth when chewing, tasting, or swallowing solid food. Organoleptically assessment of texture usually includes the perception of the elasticity, softness, and compactness of the material. Hedonic tests on texture are carried out based on the panelists' preference level, where testing may involve sensing through touch, including using fingers as an aid in assessing the physical character of the sample (Husen *et al.*, 2023). The average value of the analysis of the texture test of canned sambal roa with variations in the length of sterilization time is presented in Figure 6.

Based on Figure 6, the average value of the hedonic test on the texture of the canned roa chili sauce showed a range of 7.71 to 8.13, which falls into the category of "very like". The lowest value was recorded in the P1 treatment with a sterilization time of 15 minutes, while the highest value was found in the P4 treatment with a sterilization time of 30 minutes. All treatments met the minimum sensory quality standards based on SNI 2712:2013, which is a value of ≥7 on a scale of 1–9. Because this product is in the form of a fine chili sauce from the smoothing of roa fish, the texture parameters assessed include overall softness, consistency, and comfort in the mouth. The longer the sterilization process, the texture of the chili sauce tends to become softer and more homogeneous, making it more preferred by the panelists. This is due to the heat effect during sterilization that can soften coarse particles, soften spices, and help bring oils, fish fibers, and spices together more evenly.

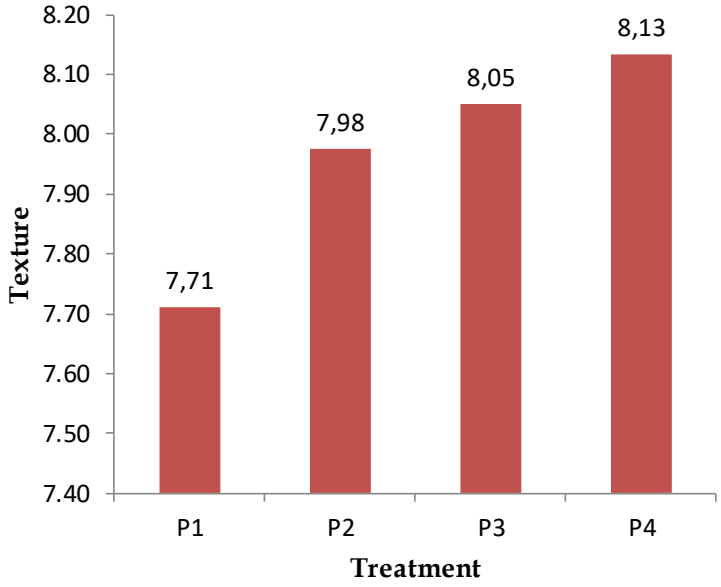

Figure 6. Graph of the average hedonic test of the texture of sambal roa with the length of sterilization time.

The results of the fingerprint analysis showed that the variation in sterilization time had a real influence on the texture of the canned roa chili sauce. Panelists tend to give higher scores to products that have a smooth texture, do not clump, and are easy to swallow. According to Putrinita *et al*. (2022), heating with high intensity and sufficient duration can cause changes in the structure of the material that make the texture softer. The results of the Smallest Real Difference (BNT) follow-up test on texture parameters are presented in Table 4. The average number of the texture test is followed by the same notation is not significantly different in the smallest real difference test (BNT) α 0.05=0.9.

Table 4. Follow-up test of the smallest real difference (BNT) of canned sambal roa texture with sterilization time

Treatment	Average
P1	7.71a
P2	7.98b
P3	8.05b
P4	8.13b

Table 4 shows that the P4 treatment provides significantly different texture average values compared to the P1, P2, and P3 treatments. These results show that the length of sterilization time has a real effect on the texture characteristics of the canned roa chili sauce. On treatments with longer sterilization times, panelists tended to score higher because the product had a smoother consistency, did not clump, and was easy to swallow.

The heating process during sterilization not only inactivates microorganisms, but also affects the interaction between oil, mashed fish meat, and seasonings, resulting in a softer and more stable final texture. This is in line with the statement *of Husen et al*. (2023), that heating that lasts a long time, both at the steaming, exhausting, and sterilization stages, can increase the free moisture content in the material due to water absorption. As a result, the texture of the product becomes softer or thinner—in the context of fine chili sauce, meaning softer and more homogeneous.

CONCLUSION

Based on the results of this study, it can be concluded as follows The characteristics of F_0 values, microbiology, and organoleptics of canned sambal roa were influenced by variations in sterilization duration (P1 = 15 minutes, P2 = 20 minutes, P3 = 25 minutes, and P4 = 30 minutes). The F_0 value was analyzed through heat distribution and heat adequacy data, and the P4 treatment showed the best results with a value of 6.02 minutes, which was considered to meet food safety standards. Organoleptic assessments were carried out on four main attributes, namely color, taste, aroma, and texture. The color of the product obtained a score of 7.60–7.88, taste 7.60–8.46, aroma 7.59–7.67, and texture 7.71–8.13. These results indicate that the product is generally liked to the point of being highly liked by the panelists. The best treatment in this study was obtained in P4, namely canned roa chili sauce that was sterilized for 30 minutes. In this treatment, the F_0 value characteristics reached the minimum standards required for food safety, the lowest microbiological contamination, and the highest organoleptic score on all parameters: color, aroma, taste, and texture. These results show that the sterilization process for 30 minutes is able to produce canned roa chili sauce that is safe, durable, and liked by the panelists, so it is feasible to be developed as a quality ready-to-eat food product.

ACKNOWLEDGEMENTS

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