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ORGANOLEPTIC AND PHYSICOCHEMICAL CHARACTERISTICS OF CONVENTIONAL AND MICROWAVE PROCESSING OF SATAY KOMOH FROM MEAT OF THUNNUS SP. STORED FROZEN AT VARIOUS MEAT DONENESS

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ABSTRACT
Satay as a traditional Indonesian product is still sold directly in fresh processed form and none has been sold in frozen processed form. So far, various types of satay have been found based on raw materials, processing, spices used, and region of origin. One type of traditional satay is *komoh*. Inspired by products that can be sold in frozen processed form such as nuggets sold in frozen semi-cooked processed form, it is necessary to conduct research on satay products. The aim of this study to determine the right conditions for processed satay meat that can be stored frozen. The research method applied was an experimental method carried out in the form of treating raw satay conditions, semi-cooked satay conditions, and cooked satay conditions stored frozen. Satay was made in 2 ways, namely the traditional charcoal grilling process and the microwave grilling process. The results showed that satay *komoh* from *Thunnus* meat made with a microwave was organoleptically preferred over conventional satay *komoh*, both in terms of color, aroma, taste, and texture attributes. Microwave-satay has lower texture, peroxide value, Thio-barbituric Acid, and water content than conventional-satay. Satay *komoh* that stored frozen in half-cooked and cooked conditions is preferred over raw conditions. Satay *komoh* that stored frozen with increasing doneness has an effect on the texture, peroxide, Thio-barbituric Acid, and water content. The best treatment in frozen storage of satay *komoh* was grilling with a microwave in half-cooked conditions.

KEY WORDS
Grilling, peroxide, texture, thio-barbituric acid, water content.

The production of *Thunnus* sp. in 2019 amounted to 323,884 tons and in 2021 increased to 359,143 tons, making this kind of fish a favorite in fisheries exports in Indonesia (Kurnia *et al*., 2019). *Thunnus* sp. as a source of nutrition contains 22.6-26.2g protein/100g meat, a water content of 71.73%, and contains minerals (phosphorus, iron, sodium, calcium), vitamin A (retinol), and vitamin B (thiamine, riboflavin, and niacin) (Utami *et al*., 2021). The high water and protein content makes tuna categorized as a perishable food which is susceptible to post-harvest quality decline, so efforts are needed to maintain the quality of the fish, one of which is through processing tuna into satay products.

Satay according to Hariyanto *et al*. (2021), is a food consisting of pieces of meat (chicken, or beef, or goat) that are cut into cubes with a size ±4-5 cm and skewered on skewers made of wood and usually bamboo, seasoned and generally continued with a grilling process over hot coals. There are various types of traditional satay including *komoh* (Nufus *et al*., 2016) which is one of the dishes from East Java, precisely from the Pasuruan City. The characteristic of satay *komoh* is that the seasoning is quite runny and is given in large quantities. In general, the processing of satay *komoh* is still conventional or traditional, namely using charcoal grilling. The constraints of conventional processing are uneven product doneness and case hardening often occurs (Gulati and Datta, 2015). This problem also occurred in satay *Thunnus* sp. from Small and Medium Enterprises (SMEs) *Poklahsar* Mina Jaya Mandiri, Kondang Merak Beach, South Malang, so that an alternative idea emerged using a microwave oven to overcome this problem. The use of microwaves is based on the characteristics of microwaves that produce heat from within the material and propagate quickly outward so that it can overcome case hardening and the doneness process takes place faster than conventional ones (Sun *et al*., 2016; Rahman *et al*., 2019; Hardoko *et al*., 2023).

Another problem in satay *komoh* products is that their presentation is still limited to direct consumption products ('fresh from the oven'), so they have a limited shelf life and distribution. Therefore, a frozen processing and storage process is needed so that quality can be maintained and the shelf life can be extended. The alternative offered to overcome this problem is to imitate the processing and storage system for nugget products, namely processed in a half-cooked condition (pre-frying system) and frozen storage. The pre-cooking or pre-frying process can stop microbial growth and enzymatic reactions (Mailoa *et al*., 2019) and the freezing process can also inhibit product damage reactions (Tatontos *et al*., 2019).

The aim of this study to make a product of satay *komoh* from *Thunnus* sp. meat that can be stored in frozen conditions and maintain organoleptic and physicochemical characteristics. The specific aim of this study was to obtain the best frozen satay *komoh* from *Thunnus* sp. meat conditions from conventional and microwave processes.

MATERIALS AND METHODS OF RESEARCH

The method that will be used in this research is the frozen storage experiment of satay *komoh* with the satay grilling method factor (A) and the tuna satay condition factor (B). The grilling method factor for tuna satay consists of conventional method (A1) and microwave method (A2), while the condition factor for frozen satay consists of raw satay (B0), half-cooked satay (B1), cooked satay (B2). Based on the treatment applied, this research was designed with a 2x3 RAL factorial design which was repeated 4 times.

Table 1 – Formulation of Spices for Making Satay *Komoh* for 500 g of Fish Meat

Ingredient of Spices	Quantity
Garlic	60 g
Onion	100 g
Chili	150 g
Ginger	50 g
Coriander	15 g
Cumin Powder	2.5 g
Salt	5 g
Sugar	3 g
Brown Sugar	7 g
Tamarind	30 g
Flavoring	10 g
Lemongrass	3 stalks
Lime Leaves	6 leaves
Bay Leaves	4 leaves
Galangal	15 g
Coconut Milk	400 mL

The process of finishing satay *komoh* from meat of *Thunnus* begins with weeding, filleting, skinning, and removing the red/dark meat to produce white meat tuna fillets. Next, the fillet is cut into 3x3 cm squares and coated with satay spices. The satay *komoh* seasoning as stated in Table 1 is ground in a blender by adding 75 mL of cooking oil and sauteed until the color turns yellowish and smells good. Pieces of tuna meat are smeared with cold spices and skewered on bamboo with a quantity of 3 pieces of tuna meat per skewer. Furthermore, raw satay *komoh* was grouped according to treatment, namely rare, medium, and well-done (different level of meat doneness) using the conventional grilling and the microwave grilling method. In accordance with the treatment, groups of raw, semi-cooked tuna satay and cooked satay were put in plastic and stored frozen in a -32˚C freezer for 48 hours.

The test parameters that will be carried out in this research include organoleptic tests which include hedonic, scoring, and physicochemical parameters, namely color, tenderness, tiobarbituric acid (TBA) number, peroxide number, water content, proximate content, and histamine on selected treatments. Before measuring parameters, samples of frozen satay *komoh* from meat of *Thunnus* sp. were first heated in a microwave until cooked.

RESULTS AND DISCUSSION

Yield according to Senduk *et al*. (2020), is the ratio of the dry weight of the product produced to the weight of the raw materials. The yield calculation aims to determine the economic value and effectiveness of using materials for the product. This is done with the satay *komoh* product because in the processing process, not all parts of the *Thunnus* body are processed, but only the white flesh is used and parts such as the head, bones, fins, red meat and skin are removed. The %yield of satay *komoh* from meat of *Thunnus* sp. can be seen in Figure 1.

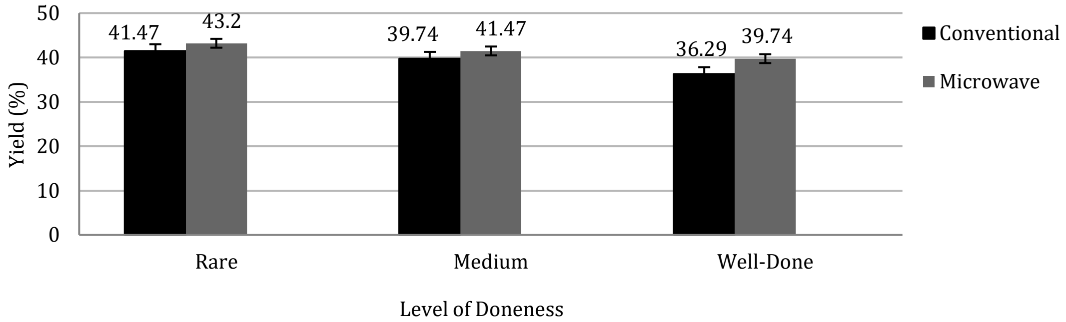

Figure 1 – %Yield of Satay *Komoh*

Figure 1 shows that the yield of satay *komoh* from *Thunnus* stored frozen raw is higher than that stored in half-cooked and cooked conditions, and the yield of satay tuna processed with microwave is higher than that processed conventionally. The %yield in conventional and microwave roasting decreased at the three stages of doneness. This can be caused by the process of applying heat to the product, where the longer the product is exposed to heat, the higher the evaporation of water in the product and the lower the weight of the product. This is in line with research by Litaay *et al*. (2022), where smoked tilapia with a smoking time of 24 hours had a higher water content value compared to 48 hours smoked. The water content in the material will affect the product yield.

Conventional grilling has a smaller yield value because the heat produced in conventional grilling occurs directly by convection heat transfer, where the hot air produced by the charcoal rises vertically on the surface of the satay *komoh Thunnus* which can cause evaporation of the product (Martuti *et al*., 2014). The heat process in microwave baking is where microwave energy is absorbed by the food product and converted into heat energy to heat the food product volumetrically (Permatasari *et al*., 2015). This causes the yield value for *microwave* roasting to be greater than conventional roasting. Another factor that influences the yield is the material's ability to hold water, where heating can result in protein denaturation which has the effect of reducing (water holding capacity) (Tatontos *et al*., 2019).

Hedonic organoleptic analysis was carried out to determine the panelists' level of preference for a product based on the attributes of color, aroma, texture, taste and overall acceptability, while scoring organoleptic analysis was carried out to determine the intensity of the attributes of a product based on the attributes of color, aroma, texture and taste. Hedonic organoleptic characteristics and scoring of satay *komoh* from meat of *Thunnus* sp. which has been stored frozen at various levels or conditions of maturity, thawed, and cooked according to the microwave can be seen in Table 2 and Table 3 respectively.

Table 2 shows that frozen satay processed by microwave is more preferred than conventionally grilled with charcoal, based on the hedonic attributes of color, aroma, texture, taste, and overall acceptability. The preferred satay is satay that is processed in the microwave until half cooked. The level of liking for an attribute can be seen in relation to the attribute intensity score (Table 3), where the most liked satay *komoh* is yellow in color (score 4.34), slightly grilled aromatic (score 3.36), slightly soft in texture (score 3.61), and tastes of spices (score 4.86).

Table 2 – Hedonic Organoleptic of Satay *Komoh* Stored Frozen Under-Different Conditions

Process	Level of Doneness	Hedonic Parameters				
		Color	Flavor	Texture	Taste	Overall
Conventional	Rare	3.99^{c}	3.98^{b}	3.90^{b}	4.93^{b}	4.74^{ab}
	Medium	4.18^{c}	3.87^{b}	4.01^{b}	5.13^{ab}	4.71^{ab}
	Well Done	4.03^{c}	3.99^{b}	4.06^{b}	5.01^{ab}	4.73^{ab}
Microwave	Rare	4.83^{b}	4.96^{a}	5.04^{a}	5.18^{ab}	4.85^{ab}
	Medium	5.16^{ab}	5.15^{a}	5.10^{a}	5.23^{a}	5.01^{a}
	Well Done	5.23^{a}	5.20^{a}	5.26^{a}	5.01^{ab}	5.05^{a}

Note: Different letter notations in the same column indicate significant differences (P-Value < 0.05).
1= strongly dislike; 2 = dislike; 3 = somewhat dislike; 4 = neutral; 5 = somewhat like; 6 = like; 7 = strongly like.

Table 3 – Organoleptic Scoring of Satay *Komoh* Stored Frozen Under-Different Conditions

Process	Level of Doneness	Scoring Parameters			
		Color	Flavor	Texture	Taste
Conventional	Rare	3.29^{b}	3.44^{abc}	3.44^{abc}	4.46^{b}
	Medium	3.30^{b}	3.36^{bc}	3.36^{bc}	4.52^{ab}
	Well Done	3.10^{b}	3.32^{c}	3.32^{c}	4.38^{b}
Microwave	Rare	4.27^{a}	3.57^{ab}	3.57^{ab}	4.67^{ab}
	Medium	4.34^{a}	3.61^{a}	3.61^{a}	4.86^{a}
	Well Done	4.15^{a}	3.61^{a}	3.61^{a}	4.45^{b}

Note: Different letter notations in the same column indicate significant differences (P-Value < 0.05).
Color score: 1= brown; 2= brownish yellow; (3) reddish yellow; (4) yellow; (5) yellowish brown; (6) brownish yellow.
Aroma score: 1 = no roasted aroma; 2 = slightly roasted aroma; 3 = slightly roasted aroma; 4 = quite roasted aroma; 5 = roasted aroma; 6 = very roasted aroma.
Texture score: 1 = hard; 2 = quite hard; 3 = slightly hard; 4 = slightly soft; 5 = quite soft; 6 = soft.
Taste score: 1 = no spices at all; 2 = no spices at all; 3 = slightly spices at all; 4 = quite spices at all; 5 = spices at all; 6 = very spices at all.

The treatments for different levels of doneness were significantly different (P-value < 0.05) in the hedonic color of satay *komoh*, where cooked satay was able to maintain its color well during frozen storage, while raw and half-cooked satay experienced a process of losing color intensity which was thought to be due to a reaction, oxidation of natural pigment (myoglobin) is faster (Wodi *et al*., 2014). This is in line with the report by Gluchowski *et al*. (2019) on salmon (*Salmo salar*), where cooked salmon has a higher lightness (L) value compared to raw and undercooked salmon. The differences in satay grilling methods also produce significantly different levels of preference, where conventionally made satay is browner than microwaved satay. Heat transfer in microwave roasting occurs from the inside of the product quickly and simultaneously, resulting in an even and consistent color, while remaining yellow with the spices (Saputri and Purwayantie, 2024). The heat transfer process in conventional baking is from the outside to the inside of the product and runs more slowly. Apart from that, charcoal used in conventional grilling also produces carbon in the form of soot which can stick to the baked product and will affect the color of the surface (Yudhistira *et al*., 2017; Agusaputra *et al*., 2023). Conventional grilling using charcoal contains polycyclic aromatic hydrocarbon (PAH) compounds which can stick to the surface of satay *komoh* and give it a darker color (Salindeho and Pandey, 2019).

The aroma of satay *komoh* when grilling is more preferable with microwave than conventionally grilled satay (Table 2). This may be related to the smoky aroma that is present in conventional grilled satay so that it has less grilled aroma, whereas in microwaved satay what appears is a higher grilled aroma (Table 3). The strong aroma of smoke is caused by a chemical reaction between the carbon in the charcoal and oxygen which then gives rise to volatile chemical compounds, such as phenol and formaldehyde which can produce a strong smoky aroma (Sulistyaningkarti and Utami, 2017). Volatile compounds increased in conventional charcoal grilling of salmon and sardines (Alves *et al*., 2022). The aroma that appears in microwave grilling is the result of lipid oxidation which produces roasting compounds, such as ketones which give the characteristic aroma of grilled meat and is formed along with the oxidation of lipids and proteins due to the heat used (Li *et al*., 2019) and preferred by panelists. These results are also supported by Luo *et al*. (2022), where products processed using microwaves retain their aroma better than other heating treatments.

The texture of microwaved satay *komoh* is preferable to conventional tuna *komoh* satay. Based on the texture intensity score, it appears that microwaved satay is softer than conventional satay. Thus, softer satay was preferred by the panelists. This is in line with research by Hardoko *et al*. (2023), where grilling tuna satay using the microwave grilling method is more tender than using the conventional grilling method (charcoal). The tenderness of microwave tuna satay may be related to the propagation of microwave heat which occurs simultaneously and moves out of the material, so that steam will come out of the material and form more pores which will have an effect on the tenderness of the satay. On the other hand, the heat propagation of conventional roasting occurs by conduction and convection which moves from outside to inside the product material and does not occur simultaneously, so that the pores formed are small and result in hardening only on the outside of the material (case hardening). This is also supported by research by Bulanda and Janozka (2022), where it is stated that the surface of a product that is cooked first will harden and cause the product texture to be harder. Gawat *et al.* (2024) also stated that when roasting using a microwave, microwaves can quickly penetrate food so that proteins, especially collagen, can stretch and soften quickly. This is also supported by research by Ramesh and Al-Khusaibi (2020), where it is stated that microwaves can provide a softer texture compared to conventional grilling using charcoal.

The taste of satay *komoh* processed microwave is generally slightly more favorable than conventional satay, and the most preferred satay is satay that is stored half-cooked. This is in line with research conducted by Paramartha *et al*. (2015), regarding the hedonic taste of satay *lilit* and also Miratis *et al*. (2013). The more mature the product is, the ability of the fish raw material to absorb seasonings increases, resulting in a distinctive taste of the product that is more pronounced compared to the raw and semi-cooked conditions. Fish has a more open and permeable tissue structure, so that the process of absorbing spices occurs more effectively into the tuna flesh. Conventional grilling with charcoal has a very strong aroma and can mask the distinctive taste of spices so that it can provide a different perception of taste and acceptability (Handayani *et al*., 2024). Microwave roasting does not contain aromatic compounds from roasting, so the resulting taste comes from the spice composition and the amino acid glutamate content contained in tuna meat (Guo *et al*., 2017; Ramesh and Al-Khusabi, 2020).

The grilling method has a different influence on the overall acceptability of satay *komoh*, where microwave grilling is preferred over conventional grilling and the most preferred satay is the one stored frozen in a half-cooked condition. This can be caused by the satay *komoh* using the microwave grilling method having an even yellow color, a grilled aroma that is not too strong, soft and even texture on the surface of the satay, and an even flavor of satay *komoh* seasoning from the inside and outside of the satay *komoh*. It can be said that the overall formulation of satay *komoh* using the microwave grilling method was most liked by the panelists. This can conclude that the working principles of microwave and conventional grilling methods greatly influence the panelists' acceptance of satay *komoh*. This is supported by research by Fradiana *et al.* (2022), where the use of the microwave roasting method produces color, texture, aroma and taste that are preferred by panelists.

Color testing in this research was carried out using a colorimeter reader which aims to measure the surface color of an object, in this case the satay *komoh* product. A colorimeter reader measures the color of an object with three components, namely a lighting source, a light filter, and a photoelectric detector which produces values in the form of lightness (L), redness (a*), and yellowness (b*). According to Kahar (2019), the colorimeter reader is used to determine concentration by analyzing the intensity of light transmitted by the solution and has the ability to measure sample absorbance in the range of 0.05 to 1.0. The working process of this tool is based on the Beer-Lambert Law, where the reduced light intensity indicates that the light is being absorbed by the absorbing molecules. The °Hue value can be seen in the Table 4.

Table 4 – °Hue and Lightness of Satay *Komoh*

Roasting Method	Level of Doneness	°Hue	Information Color	Lightness
Conventional	Rare	64.38±2.16	Reddish-Yellow	40.55±1.95[b]
	Medium	55.05±3.67	Reddish-Yellow	39.24±2.11[bc]
	Well Done	68.67±3.15	Reddish-Yellow	35.05±2.51[c]
Microwave	Rare	72.81±4.99	Reddish-Yellow	49.82±2.31[a]
	Medium	73.79±4.07	Reddish-Yellow	53.94±2.10[a]
	Well Done	75.43±6.17	Reddish-Yellow	52.37±2.51[a]

Note: Different letter notations in the same column indicate significant differences (P-Value < 0.05).

Table 4 shows that ˚Hue of 54-90 is included in the reddish-yellow color spectrum (Nguyen *et al*., 2021), so that satay *komoh* which has ˚Hue of 55.05-75.43 also has a reddish-yellow color. Organoleptically, the color of conventionally grilled satay *komoh* is different from that of microwave grilled tuna (Table 3). This colorimetric difference is caused by the color brightness value, where microwave-baked satay *komoh* has a higher L value or a brighter reddish - yellow color (Table 4). The difference in the brightness of the reddish yellow color is caused by the difference in heat propagation power between conventional roasting and microwave roasting. Conventional heat propagates from the outside into the material and travels slowly, giving a darker color and vice versa for microwave heat (Hardoko *et al*., 2023; Saputri and Purwayantie, 2024).

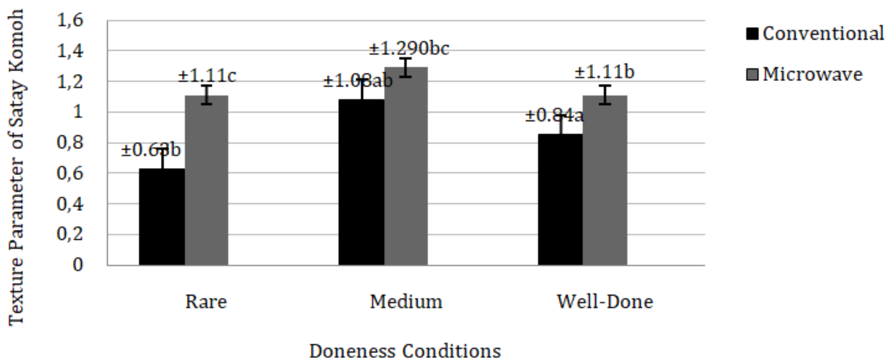

Figure 2 – Texture Parameter of Satay *Komoh*

Physical testing of the texture of satay *komoh* was carried out using a Durometer Shore C which is generally used to measure the hardness of soft materials (Gilbert and Giacomin, 2018). The hardness texture of satay *komoh* grilled conventionally and microwaved that stored frozen can be seen in Figure 2.

Figure 2 shows that the texture of conventionally grilled satay *komoh* is harder than microwaved satay *komoh*. This is in line with the texture organoleptic intensity score (Table 3). Based on the condition of the satay before being stored frozen, it can be seen that raw and semi-cooked satay is tenderer than cooked satay. It was previously explained in the organoleptic scoring section that the difference in texture of satay grilled conventionally and in the microwave is related to the different direction and power of heat transfer between the two grilling methods. Heat transfer by microwaves occurs simultaneously and moves out of the material to form more pores which will have an effect on the tenderness of the satay. The heat propagation of conventional roasting occurs by conduction and convection which moves from outside to inside the product material and does not occur simultaneously, so that the pores formed are small and result in hardening only on the outside of the material (case hardening) (Ramesh and Al-Khusaibi, 2020; Hardoko *et al*., 2023). The difference in doneness conditions for satay *komoh* before it is stored frozen, where raw and half-cooked satay are more tender is related to water content. Raw and undercooked satay has higher humidity which will produce more steam and pores when heated by the microwave, making it softer. High water content can accelerate heat transfer and the propagation of microwaves so that it can have an effect on protein denaturation which also tenderizes the tuna satay meat. Based on Figure 2, the textures obtained in the conditions of raw, semi-cooked and cooked maturity in microwave roasting were 4.63±1.11 N, 5.50±1.29 N, and 6.38±1.11 N.

Water content is a measurement of the total water contained in a food. It also affects the physical and chemical characteristics of a food, which influence the freshness and storage stability of the food for a long period of time. The water content of satay *komoh* at various meat doneness conditions by conventional grilling and microwave before being stored frozen is presented in Figure 3.

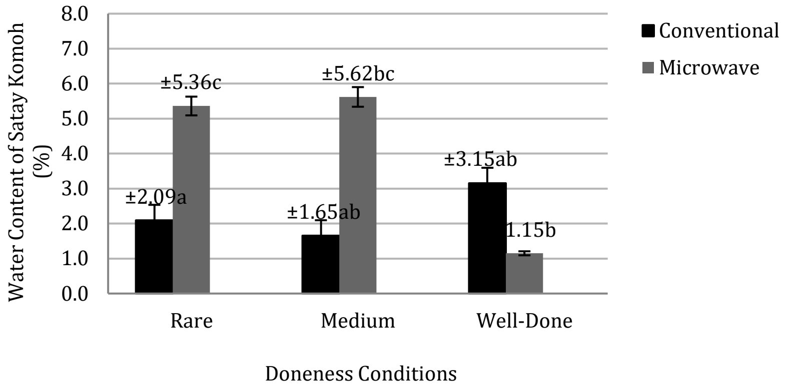

Figure 3 – Water Content of Satay *Komoh*

Figure 3 shows that in general the water content of satay *komoh* grilled conventionally is higher than that baked in a microwave oven. The higher water content in the conventional grilling method is also related to the movement of heat propagation that occurs, namely from the outside to the inside of the product and does not occur simultaneously, causing the pores that form on the surface of the satay *komoh* to be smaller and hardening to form only on the surface (case hardening) and causes the water in the product to be retained and unable to penetrate out of the product (Hardoko *et al*., 2023). This is in line with research by Kaban *et al*. (2019), regarding the water content of smoked tilapia which has a high of water content, 55%. The case hardening event that occurs on the surface of the meat during the smoking process means that water cannot penetrate the outer part which has previously hardened (Santoso *et al*., 2020). The water content value will decrease along with the length of time heat is applied to the product (Costa and Manihuruk, 2021).

The peroxide value is a sign of damage to oil or fat due to the oxidation process which in the next stage can cause a rancid odor to appear in the product. Peroxide is an intermediate product formed during the initial stages of lipid oxidation (Djamaludin et al., 2023). The highest peroxide value that can still be tolerated is between 10-20 meq/1000 g. The peroxide values of satay komoh stored frozen in various conditions of doneness are presented in Figure 4.

Figure 4 shows that the different roasting methods have a significant effect (P-Value < 0.05) on the peroxide value of satay *komoh*, where conventionally grilled satay *komoh* has a higher peroxide value than microwave grilled satay. This difference is caused by differences in heat propagation power and heating time. A longer heating process will provide an opportunity for the lipids contained in the product to be oxidized and can increase the peroxide value. The heating process for microwave roasting has a shorter time compared to conventional roasting, so it has a lower peroxide value. Oxygen from the air in the conventional roasting process can also accelerate lipid oxidation, resulting in higher peroxide values. In addition, microwave roasting according to Hardoko *et al.* (2023), occurs from the inside to the outside of the product material evenly, thus maintaining lipid integrity and reducing oxidation and influencing the formation of peroxides. High temperatures in conventional grilling using charcoal can stimulate more intense fat oxidation (Regulska-Ilow and Ilow, 2022). This is also in line with research by Secci and Parisi (2016), where it was concluded that grilling using microwaves has a lower peroxide value compared to conventional grilling using charcoal. Even though the oxidation process occurs in satay *komoh* due to differences in grilling methods, the resulting peroxide value is still far below what can be tolerated.

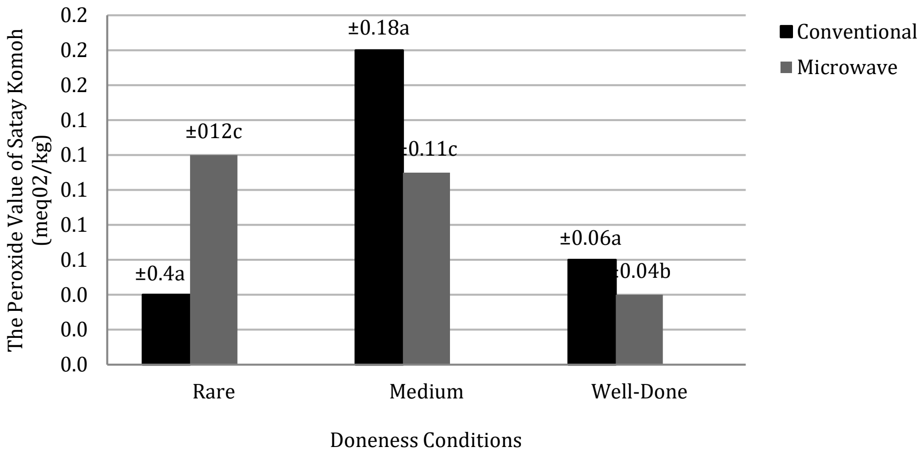

Figure 4 – The Peroxide Value of Satay *Komoh*

The treatment of different conditions of doneness level also had a significant effect (P Value < 0.05) on the peroxide value of satay *komoh*, where tuna satay grilled in a microwave in raw and semi-cooked conditions had the lowest peroxide value. This is caused by greater heat exposure in the mature doneness condition compared to the raw and semi-doneness conditions. The use of high temperatures during the roasting process can accelerate oxidation which involves the reaction of fat molecules with oxygen (Nurhasnawati, 2015). Oxygen will react with the unsaturated double bonds in unsaturated fatty acids and form free radicals and peroxides. This is in line with research by Fuadi *et al*. (2015), where it was found that the peroxide value in smoking fish for a smoking period of 2 hours was lower than for a smoking period of 4 hours. Even though an oxidation process occurs in satay *komoh* which is stored at different conditions of maturity, the resulting peroxide value is still far below what can be tolerated.

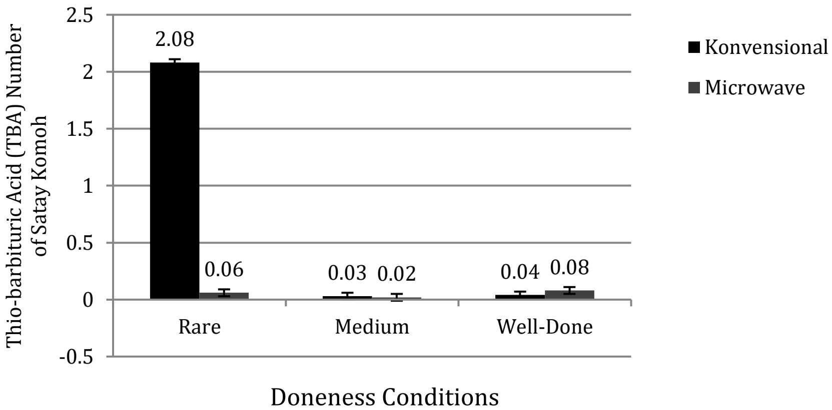

Figure 5 – Thio-barbituric Acid (TBA) Number of Satay *Komoh*

Thio-barbituric Acid (TBA) number is a parameter used to measure the level of fat oxidation in food products, especially in detecting the presence of compounds resulting from fat oxidation, namely malonaldehyde (Ukekpe *et al.,* 2014; Polutu *et al*., 2015). More peroxide is produced from the primary oxidation process, but more TBA is produced in tertiary oxidation. Tuna fish is rich in polyunsaturated fatty acids such as EPA and DHA (Hardoko, 2023) which are very susceptible to oxidation, so they can cause undesirable changes in products including satay *komoh* (Husain *et al*., 2016) in the form of peroxidant and TBA. The results of measuring TBA levels in various conditions for satay *komoh* that has been stored frozen can be seen in Figure 5.

Figure 5 shows that the different roasting methods had a significant effect (P Value < 0.05) on the TBA content of satay *komoh*. The TBA of conventional roasting is higher compared to microwave roasting. This is caused by the conventional roasting method, which takes longer to process than the microwave roasting method. A longer heating process will provide an opportunity for the lipids contained in the product to oxidize and can increase the TBA value. Exposure to hot temperatures during the heating process can cause denaturation of proteins and decomposition of free fatty acids, resulting in the product being more easily oxidized (Pandiangan *et al*., 2019), where the damage to the fat that occurs causes a rancid odor and taste due to the oxidation reaction. TBA is degraded into other compounds. The conventional roasting process also involves oxygen from the air which can accelerate lipid oxidation, resulting in a higher TBA value. This is in line with research by Mahmudan and Nisa (2014), where it was found that the TBA value increased during repeated frying of palm oil which was caused by lipid oxidation during the frying process.

Table 4 – Nutritional Content of the Best Satay Komoh Treatment

Parameters	Results	Standard: SNI 2725:2013
Color Hedonic	5	-
Flavor Hedonic	5	-
Texture Hedonic	5	-
Taste Hedonic	5	-
Overall Acceptance Hedonic	5	-
Color Scoring	4	-
Flavor Scoring	3	-
Texture Scoring	5	-
Taste Scoring	4	-
Carbohydrate (%)	23.77	-
Water (%)	40.34	Max. 60
Protein (%)	29.11	-
Fat (%)	1.83	Max. 20
Ash (%)	1.44	-
Tenderness	5.5	-
Peroxide Number (meq O_2/kg)	1.31	-
Thio-barbituric Acid (TBA) (mg MDA/kg)	0.68	-
Lightness (L)	53.94	-
°Hue	73.78	-
Histamine (mg/kg)	46.23	Max. 100

Based on the Naive Bayes method, it was found that the best treatment for all parameters was the grilling of satay *komoh* using a microwave and frozen storage when the satay was half cooked. The characteristics of the best satay *komoh* from meat of *Thunnus* sp. are presented in Table 4.

CONCLUSION

The treatment of different levels of meat doneness and different roasting methods have a significant influence on hedonic organoleptic and scoring of color, aroma, texture, taste and overall acceptability, lightness, texture, water content, peroxide value and TBA value for satay *komoh* from meat of *Thunnus* sp. The best storage condition for frozen satay *komoh* from meat of *Thunnus* sp. is roasting in the microwave until half-cooked (medium). The best treated satay *komoh* had overall hedonic organoleptic characteristics of 5 (somewhat favorable), color intensity score of 4 (yellow), aroma intensity score of 4 (grilled aroma), texture intensity score of 4 (slightly soft), taste intensity score of 5 (tastes of spice).

Physicochemically, reddish-yellow color (°Hue 73.79), texture 5.5 N, water content 40.34%, protein 29.11%, fat 1.83%, histamine 46.23 mg/Kg, peroxide value 0.6692 meq O_2/kg, and Thio-barbituric Acid value 1.4785 mg MDA/Kg.

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