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# Partial properties of ready-to-use shrimp paste affected by heating time

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ABSTRACT

Ready-to-use shrimp paste is a traditional shrimp paste produced by a small producer scale in East Lombok through the non-fermentation process and continued by un-control heating time. The qualities were ununiform. Aim of this study was to determine the physical, sensory and microbial quality of ready-to-use shrimp paste affected by heating time. The method conducted was a completely randomized design. The heating time was arranged for 0 to 70 min, with a 10 min interval. The data was analyzed using Co-Stat Software at 95% significant level, then further tested for significance difference data with Tukey's HSD. Microbial data was analyzed using descriptive method. The result showed that the properties of ready-to-use shrimp paste were influenced by heating time of controlled oven. The heating time affected moisture content, °Hue, sensory of aroma, taste and texture. However, it did not affect the appearance and L value (brightness). Heating time for 50 min at 100°C using the controlled oven is recommended as the best treatment to produce ready-to-use shrimp paste with 32.61% of moisture content, 3.9 x $10^3$ CFU/g of total microbe, less than $10^2$ CFU/g of total fungi and undetected coliform. The shrimp paste had yellow-red color, clean appearance which was specific shrimp paste, very specific odor and taste. It also has a compact texture. Heating time for 50 min at 100°C can extend the shelf life of ready-to-use shrimp paste up to minimum 60 days at room temperature.

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## 1. Introduction

Shrimp paste is known as *Nappi* (Bangladesh), *Kapi* (Thailand and Cambodia), *Belacan* (Malaysia and Brunei) and *Mamruoc* or *Mamtom* (Vietnam) (Kim et al., 2014). It is also known as *terasi* in Indonesia (BSN, 2016). According to (BSN, 2016), shrimp paste is a processed fishery product with raw materials of "*rebon*" or fresh shrimp or a dry mixture or mixed with or without the addition of other ingredients with salting, hoarding, grinding and fermentation. Kim et al. (2014) show that shrimp paste contains several important nutritional components: moisture content (21-48%), protein (22-57%), fat (0.6-4.9%) and ash (14-46%). In addition to these proximate levels, Pongsetkul et al. (2014) stated that shrimp carotenoid levels ranged from 0.54 to 1.97 mg / g of sample; 10-29 volatile compounds from traditional fermented shrimp from regions of northern coast of Central Java, Indonesia (Murwani et al., 2016), and 25 volatile compounds like aldehydes, ketones, alcohols, esters, pyrazines, acids, and sulphides are identified during fermentation of Jinzhou shrimp paste (Lv et al., 2020). Rosida and Enny (2007) stated that shrimp paste which has a moisture content of 26-42% is categorized as good shrimp paste because if the moisture content is very low, the surface will be covered by crystals and the texture of the paste will not be elastic. If the shrimp paste moisture level is too high, the shrimp paste will become too soft.

Shrimp paste is consumed as additional ingredients (flavorings) in the menu of Southeast Asian dishes, including Thailand (Faithong et al., 2010). In Indonesia, shrimp paste is used in *sambal terasi* (a type of chilli sauce) (Ambarita et al., 2019). Generally, shrimp paste is produced through fermentation for two days to at least two months (Chuon et al., 2014). In traditional shrimp paste after being fermented, shrimp paste is sold in the form of large blocks. Also, shrimp paste is then packed with banana leaves, plastic or paper and a container in the form of woven pandan leaves as a raw product. There are also types of cooked shrimp paste that have been heated or baked in the oven after drying, called ready-to-use (RTU) shrimp paste. Dehydrated shrimp paste using an oven is used when there is not enough sunlight. Drying process by sunlight needs more time because of weather fluctuation (Sari et al., 2018). In households or on small industrial, shrimp paste is dried/heated by roasting on a large hot pan.

The heating process is aimed to enhance the quality and self-life of shrimp paste. The manufacture of RTU shrimp paste using an un-controlled commercial oven "Reksa" has been carried out by small producer in the village of Jerowaru, East Lombok. The absence of the temperature control unit in the oven resulted in the unknown temperature being used and was suspected to be one of the weaknesses that caused the low quality of the product (tends to experience case hardening). Similar conditions also occur with the use of uncontrolled "Hock" ovens, which is commonly used by small scale industries. The temperature that should remain at 135°C following the requirements of jerky oven temperature (Nielsen, 2010) tends to experience a temperature increase of ±150°C. On the other hand, the controlled oven has been widely applied to products with meat-based ingredients. Fadhilaturrohmi (2016) used a laboratory-scale oven (Memmert) for 20 min at 150°C to bake Tanjung fish satay. Besides, Faithong et al. (2010) showed that oven beef jerky at 135°C for 15 min had good quality and a long shelf life up to 2 years. Faithong et al. (2010) used a temperature range of 40-100°C for 15-60 min. Sobhi et al. (2012) reported that heating for 21.6 min at 80°C could control chilli shrimp paste microorganisms. Based on the description, research was carried out to determine the properties of RTU shrimp paste affected by heating time.

## 2. Materials and methods

### 2.1. Materials

The ingredients used were raw/unheated shrimp paste block (8.4 × 6.4 x 2 cm). The shrimp paste was directly brought from a small-scale industry "Pesisir Samudra" Jerowaru, East Lombok which packed in a plastic bag and they were maintained at 4°C until analyzed. The microbial medium used were Plate Count Agar (PCA) (PGaA, Germany), medium Potato Dextrose Agar (PDA) (PGaA, Germany), medium Violet Red Bile Agar (VRBA) (PGaA, Germany), phosphate buffer, alcohol and distilled water.

### 2.2. Methods

The method used was experimental. The shrimp paste was heated using "Memmert" oven at 100°C for 20, 30, 40, 50, 60 and 70 min. The moisture content of the shrimp paste was determined gravimetrically according to the method of AOAC method (AOAC, 1990). Color testing to evaluate colour development of shrimp paste was carried out using a MiniScan EZ chromameter using a method described in a study (Hunt et al., 1991) using oHue which derived from oHue = tan -1(b/a) in the Hunter in L, a, and b colour space. The average value of the surface color of the samples was obtained by taking triplicate of measurement. Samples for sensory attributes were evaluated by 30 semi-trained panellists (BSN, 2016). Score range used in hedonic scale for appearance, aroma, taste, and texture were from 1 to 9 with the following ratings: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely. Total microbial content and coliform were determined by using the pour plate method (Fardiaz, 1992). Amount of 1 ml diluted suspension was inoculated on plate count agar (total microbial content) and violet red bile agar (coliform) plates and incubated for 48 h at 37°C. The confirmed coliform colonies were diameter 0.5 mm or larger, red-purple, and surrounded by areas showing bile salt precipitation. The total number of fungi was enumerated by 0.1 ml diluted suspension inoculated on potato dextrose agar and incubated at 37°C for 48 h. The number of colonies was counted and expressed as colony-forming units per gram (CFU/g).

### 2.3. Data analysis

The study was arranged factorial in completely randomized design (CRD) with 1 factor (Heating time) consisted of 7 treatments: control (without oven), 20, 30, 40, 50, 60 and 70 min. Each treatment was repeated three times. The data was analyzed using Co-Stat Software, then further tested for significance difference data with Tukey's HSD at 95% significant level (Hanafiah, 2012). Microbial properties were determined using a descriptive method.

## 3. Results and discussion

### 3.1. Moisture content

To meet consumer need, the ready-to-use shrimp paste should have moisture content which influences physical, sensory and microbial quality. The moisture content of RTU shrimp paste can be seen in Fig. 1. Based on Fig. 1, moisture content was varied between 30.82%- 41.57%. The longer the oven is used, the lower the moisture content of shrimp paste. The decreased level of water contained in ready-to-use shrimp paste due to the more prolonged the heating process is given so more water evaporates. In agreement with Ninthiyananthan et al. (2013), in every food processing that uses heat energy, the longer the time used, the energy released by the drying medium is higher, the evaporated water increases and causes the moisture content to decrease. Based on BSN (2016), the heating time ranged from 30 to 70 min meets the maximum limit requirement of moisture content of block solid bar shrimp paste at 35%.

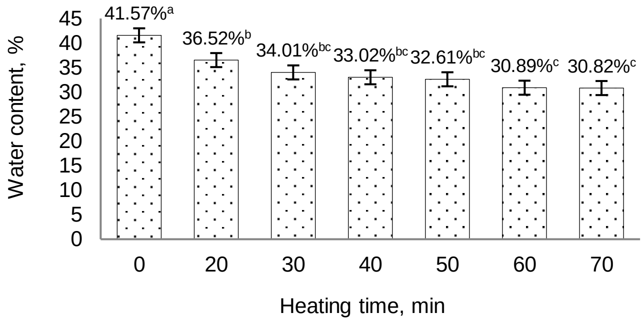


**Fig. 1**. Effect of heating time on the moisture content of ready-to-use shrimp paste

The moisture content in raw shrimp paste must be higher than heated shrimp paste. Daroonput et al. (2016) also showed that raw Thai traditional shrimp paste collected for the market has moisture content varied from 33.95 to 52.19%. It is assumed that low moisture content in the final product of RTU shrimp paste will also indicate low water activity which could be able to increase the self-life and preserve the product from spoilage at room temperature.

### 3.2. Measurement of color

Color measurement was carried out using a colorimeter. The colorimeter tool can detect the brightness/L of product. The value of L can be seen in Table 1, while the value of °Hue showed in Fig. 2. According to Table 1, it was found that the heating time did not give a significantly different effect on L value (brightness) of ready-to-use shrimp paste. Even though, the brightness of product was varied 38.30; 37.44; 37.50; 31.36; 34.02; 35.20 and 36.39. The highest L value was found in the un-heated shrimp paste, which was 38.30 while the lowest L value was with a duration of 40 min heating which was 31.36. The brightness value of ready-to-use shrimp paste obtained from experiments similar to the brightness of shrimp paste produced in several places in Thailand ranged from 34.1 to 46.7 (Kim et al., 2014) and 28.56 to 39.48 (Chuon et al., 2014).

**Table 1**. The effect of the heating time towards L value (brightness) of ready-to-use shrimp paste

| Heating time, min | Brightness, L |
|---|---|
| 0 | 38.30 |
| 20 | 37.44 |
| 30 | 37.50 |
| 40 | 31.36 |
| 50 | 34.02 |
| 60 | 35.20 |
| 70 | 36.39 |

Hue is a color gradation of the spectrum of light that is caught by eyes. Hue represents the dominant color wave of an image, or the center of the color tendency that arises from a combination of various color waves (Nielsen, 2010). The value of °Hue of ready-to-use shrimp paste can be seen in Fig. 2.

Based on Fig. 2, the overall treatment of the ready-to-use shrimp paste give reddish yellow color (yellow-red) and allegedly due to the influence of raw materials used for *rebon*. In the body of the shrimp, there is a polyphenol oxidase (PPO) enzyme which can affect the darkening of color in shrimp paste. Addition of salt (NaCl) can inhibit the action of the enzyme. The reddish color of shrimp paste is also influenced by astaxanthin pigment (64-98%) (Latscha, 1989) on the shrimp shell so that the pigment forms a red color. "Rebon" contains astaxanthin which is a type of xanthophyll carotenoids. Carotenoids are a group of organic pigments in orange or orange-red. The red color of rebon shrimp is formed due to the release of the astaxanthin bond from other components in the body of the shrimp, thus creating free astaxanthin. The release process catalyzes by enzymes from the bacteria and the shrimp itself (Khairina et al., 2016). According to Kobayashi et al. (2003), most of the shrimp's body contains astaxanthin. The astaxanthin content in frozen whole shrimp is 3.12 mg/100 g of wet weight.

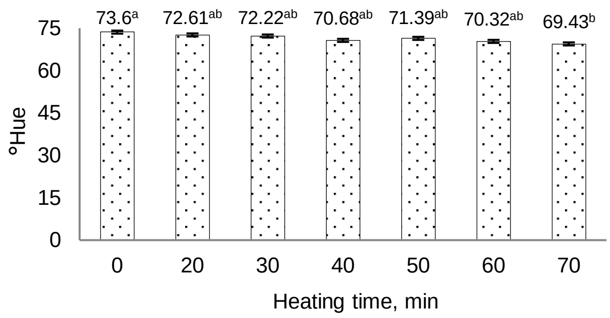


**Fig. 2.** Effect of heating time on the value of °Hue of ready-to-use shrimp paste

## 3.3. Sensory properties

Sensory properties of RTU shrimp paste were examined using hedonic test consisted of appearance, aroma, taste and texture parameters. The appearance value can be seen in Table 2, while the aroma, taste and texture can be seen in Fig. 3-5. The effect of heating time on the appearance of RTU shrimp paste can be seen in Table 2. Table 2 shows that heating time did not give a significant impact on the appearance of shrimp paste. Panelist preference was varied from 6-7 with criteria like slightly to like moderately. The non-significant different of panelist on the appearance was suspected due to its good presentation of all final product which was clean, specific shrimp paste. Effect of heating time towards aroma preferences of RTU shrimp paste can be seen in Fig. 3.

**Table 2.** Effect of heating time on the microbial content of RTU shrimp paste

| Heating time, min | Appearance |
|---|---|
| 0 | 5.80 |
| 20 | 5.90 |
| 30 | 6.50 |
| 40 | 6.60 |
| 50 | 6.50 |
| 60 | 6.53 |
| 70 | 6.80 |

Based on Fig. 3, the average score of panelists' assessments on aroma preferences tested ranged from 6 to 8 with criteria (like slightly to like very much). The lowest value of preference was found in the non-heating shrimp paste with a preference value of 5.70 with a like slightly criteria. While the value of the highest taste preference was obtained at a duration of 50 min with a favorite value of 7.50 with alike very much standards. Amino acids contributed significantly to the taste and aroma of salted shrimp paste (Pongsetkul et al., 2014). Panelists are very fond of the RTU shrimp paste aroma, which is oven-treated for 50 min because the oven process causes peptides and amino acids in the material to be hydrolyzed while sugar reduction is degraded. High temperatures with longer heating time also make the aroma of the shrimp paste stronger because the production of volatiles during cooking from amino acids in pyrolysis results in Strecker degradation to deamination or termination of amine protein bonds and decarboxylation or termination of carboxyl bonds resulting in a Maillard reaction (Putri, 2014). Kim et al. (2005) showed the taste of salted shrimp paste was influenced by Glutamate acid for umami. Sumardianto et al. (2019) confirmed that shrimp paste added with 10% sugar contain glutamate acid 23115.83 mg/kg.

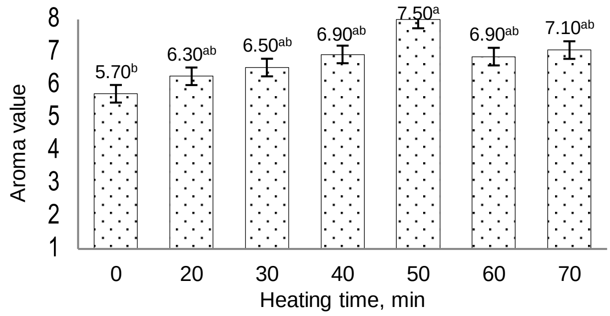


**Fig. 3.** Effect of heating time on the aroma of ready-to-use shrimp paste

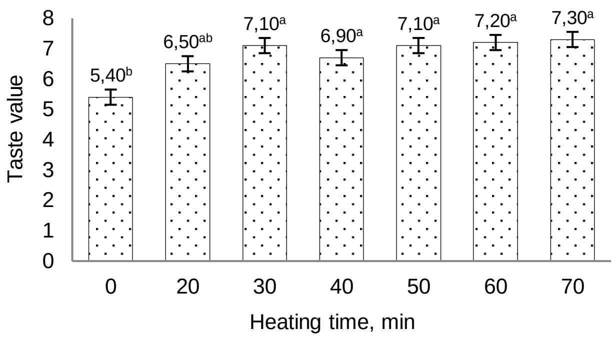


**Fig. 4.** Effect of heating time on taste preferences of ready-to-use shrimp paste

Treatment of heating time on taste preferences of ready-to-use shrimp paste can be seen in Fig. 4. Based on Fig. 4, it can be seen that the treatment of shrimp paste without heating is significantly different from shrimp paste heating treatment. The average value of panelists' assessment of taste preferences ranged from 5 to 7 with criteria (neither like nor dislike to like moderately). The lowest value of taste preference is found in non-heating processed shrimp paste with a value of 5.40 is neither like nor dislike or neutral criteria. While the highest value was obtained in heating processed shrimp paste with 70 min heating time with a value of 7.30 in like moderately criteria.

According to the panelists, the longer the heating causes the saltiness in the shrimp paste to decrease because the longer the heating process results in the decreasing of moisture content which is 30.82%. Low moisture content causes the surface of the paste to be covered by salt crystals but does not eliminate the salt content contained in the oven paste (Rosida and Enny, 2007). The presence of salt crystals on the surface is thought to have the ability to reduce saltiness because panelists taste the inside and the edge of the paste. Salt is a hygroscopic mineral that is soluble in water and minerals with a high melting point of 80.1°C so that the longer the heating process results in lower moisture content, but the solids will increase.

Treatment of heating time on texture preference of RTU shrimp paste can be seen in Fig. 5. The non-oven treatment (0 min) is significantly different from the heating treatment as shown on the average value of panelists' assessment of texture preferences ranged from 6-7 to criteria (like slightly to like moderately). The highest texture preference value was obtained at 70 min oven duration with a value of 7.20 with like moderately criteria. Panelists assessed that the texture of the shrimp paste without heating process (0 min) had a slightly wet and soft texture due to the high moisture content in the shrimp paste by 41.57% which was certainly different from the oven shrimp paste that has a thick and solid texture due to the heating process of the material.

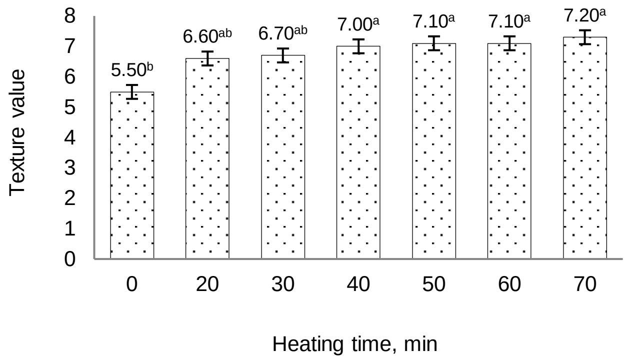


**Fig. 5.** The effect of heating time on texture preference of RTU shrimp paste

According to Sereno et al. (2007), heating is a process of removing water from an ingredient towards equilibrium moisture level with the surrounding air so that the moisture content will decrease which result in a drier and denser product. With more prolonged heating, the moisture content in the material tends to evaporate. The longer the time used, the energy expended by the drying medium is higher so that more water is evaporated (Buckle et al., 2010).

**Table 3.** Effect of heating time on the microbial content of RTU shrimp paste

| Heating time, min | Total of microbes, CFU/g |
|---|---|
| 0 | $>1.0\times10^6$ |
| 20 | $1.41\times10^4$ |
| 30 | $1.40\times10^4$ |
| 40 | $5.93\times10^3$ |
| 50 | $3.85\times10^3$ |
| 60 | $2.83\times10^3$ |
| 70 | $<1.0\times10^2$ |

## 3.4. Microbial properties

Microbiological properties determination consisted of total microbes, fungi and coliform. Microbial cell count can be seen in Table 3, 4 and 5. The longer the heating process, the more it was able to reduce the total of microbial growth, as shown in the following Table 3. The highest total of microbes was found in the shrimp paste without heating process, namely $> 1.0 \times 10^6$ CFU/g (>log 6). The number of microbes found in shrimp paste without heating process approached the number of microbial obtained in shrimp paste from several locations in South Kalimantan of log 5.36 (Khairina et al., 2016). Kobayashi et al. (2003) showed that the total Lactic Acid Bacteria in Indonesian shrimp paste ranged from $10^4$ to $10^6$ CFU/g. The heating treatment is proven to reduce the number of microbes in shrimp paste. The lowest microbial content was found in shrimp paste which was given for 70 min of oven treatment, namely $<1.0 \times 10^2$ CFU/g. The decrease in the total number of microbes with the duration of the oven was caused by the heating process given to materials with high temperatures (100°C) causing evaporation of moisture content in the material. The longer the drying time causes more of water evaporation so the moisture content in the material gets lower. Besides, with the increasing amount of heat energy carried by air due to the longer drying time, the amount of mass of liquid evaporated from the surface of the shrimp paste increases (Yunita and Rahmawati, 2015). In general, microbial growth is good when the moisture content is around 80% of the material. If the moisture content in the material is removed, there is no more water that microbes can use to grow. Based on total microbial growth, the total number of microbes in the oven period did not exceed the maximum limit of microbial contamination in fishery products (BSN, 2009), namely $1.0\times10^5$ CFU/g.

The results of the analysis in Table 4 show that the longer the heating process, the more it was able to reduce the total growth of fungi. Based on Table 4, the highest total of fungi ($3.2\times10^3$ CFU/g) was found in shrimp paste without heating process because the shrimp paste in a raw condition so that the microbial contaminants that are likely from the beginning of the paste have not died out as a whole. Thermal processing might able to kill or reduce the microbe. Sobhi et al. (2012) explained that the used an oven at 80°C for 21.6 min completely eliminated yeast and fungi of chilli shrimp paste. Based on the data (Fig. 1), although it has gone through the drying process, the raw shrimp paste still contains high moisture content which is equal to 41.57% which can be used for microbial growth. High moisture content might also cause high water activity (Aw). If the Aw value of the material increases according to the level of Aw needed by the microbes, then the microbes will grow and the material will become damaged. Water activity for the growth of decay fungi in food, which is 0.80 (Faithong et al., 2010).

**Table 4.** Effect of heating time on the total fungi of ready-to-use shrimp paste

| Heating time, min | Total of fungi, CFU/g |
|---|---|
| 0 | $3.2\times10^3$ |
| 20 | $<1.0\times10^2$ |
| 30 | $<1.0\times10^2$ |
| 40 | $<1.0\times10^2$ |
| 50 | $<1.0\times10^2$ |
| 60 | $<1.0\times10^2$ |
| 70 | $<1.0\times10^2$ |

The absence of detected fungi ($<1.0\times10^2$ CFU/g) in shrimp paste treated with an oven is caused by evaporation of water content during heating process. Muchtadi et al. (2010) reported that drying causes a decrease in the moisture content of the material and its water activity (Aw) so that it does not allow active microbes. Also, water is a suitable medium for microbial growth. The heating process at high temperatures kills the growth of fungi because most fungi include mesophilic groups are sensitive to high temperatures (Putri, 2014). The growth of fungal species is usually at 20-30°C (mesophilic groups) (Santos et al., 2017) so that sensitive to high temperature.

**Table 5.** Effect of heating time to a total of coliform of ready-to-use shrimp paste

| Heating time, min | Total of coliform, CFU/g |
|---|---|
| 0 | $<1.0\times10^1$ |
| 20 | $<1.0\times10^1$ |
| 30 | $<1.0\times10^1$ |
| 40 | $<1.0\times10^1$ |
| 50 | $<1.0\times10^1$ |
| 60 | $<1.0\times10^1$ |
| 70 | $<1.0\times10^1$ |

Table 5 shows that the total coliform found in all treatments are very low at about $<1.0\times10^1$ CFU/g. There were no coliform bacteria in the RTU shrimp paste, probably due to hygienic processing or sanitation conditions of the workers, equipment and water used in clean condition. Also, the heating gave a high temperature greatly affects the growth of coliform bacteria. Coliform bacteria are gram-negative bacteria that have relatively thinner cell walls that are sensitive to heat. The maximum temperature of growth of coliform bacteria is 30-37°C so that heating of 100°C can kill the coliform bacteria. The heating process was able to cause no detection of the growth of coliform bacteria.

Coliform bacteria are bacteria that become indicators of water and food sanitation. Therefore, to ensure that ready-to-use shrimp paste products that have good microbiological quality must detect coliform contamination. Although this bacterium is not pathogenic, its presence indicates the presence of other pathogenic bacteria so that the coliform bacteria must be suppressed entirely (BSN, 2009).

## 4. Conclusion

The properties of ready-to-use shrimp paste were influenced by heating time of controlled oven. The heating time affects moisture content, °Hue (the color produced by the product), sensory of aroma, taste and texture but has no significant difference on sensory appearance. Shrimp paste heated for 50 min at 100°C is the best treatment in terms of moisture content, physical color, sensory, and microbial properties with criteria of moisture content of 32.61%, typical aroma that is very favored, distinctive flavor of the paste, preferred texture, reddish-yellow color as well as total microbes, fungi and coliforms below the maximum limit of contamination which are allowed by Indonesian National Standards.

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## Conflict of interest

The authors declare there is no conflict of interest in this study.

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