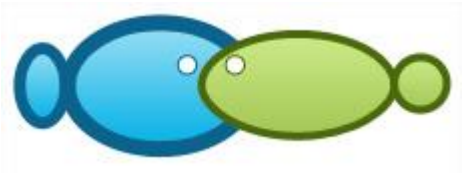

Fish processing in geothermal water at Payo Village, West Halmahera, North Maluku Province, Indonesia

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Abstract. Payo village, Indonesia, has natural potential in the form of geothermal waters in the coastal area. Geothermal water can be used as a fish processing media. However, utilization potential has not been optimal. Geothermal water sources are used for therapy and laundry washing by local people. The current study aims to determine a method of processing fish using geothermal water. The study used a modified oven specifically designed to have an air outlet at the bottom. The air outlet was made to facilitate steam and hot water to enter the oven, thus helping maturing the fish. Proximate analysis was conducted on the processed fish and included crude protein, water, crude fat and carbohydrate content. The results of the study obtained matured fish at an oven room temperature of 50°C in two hours. The geothermal water temperature was between 49.5-51.9°C. Proximate analysis results showed a water content of 64.8%, crude fat of 4.53%, crude protein of 25.6 and no carbohydrates in the processed fish.
Key Words: oven, proximate analysis, temperature.

Introduction. Indonesia has geothermal potential and volcanoes spread in various regions. This large natural potential has not been used optimally for industrial-based businesses or as tourism areas. Baksir et al (2018) explain that the spread of active volcanoes in Indonesia holds benefits that can be developed for industrial activities. North Maluku has the potential of geothermal natural resources that can be developed for the fish processing industry. Potential geothermal area with a fluid enthalpy of 1100 kJ kg^{-1} at a minimum fluid temperature of 179°C in Jailolo, West Halmahera Regency (Baksir et al 2018). Another geothermal potential is found in West Halmahera Regency, being a source of hot water. Geothermal water is located in Payo village, Jailolo District, West Halmahera Regency. This large geothermal potential has not been used optimally as a medium for the development of small and large scale industries, especially in the fisheries sector. Locals use the geothermal water source as a tourist attraction, although this activity does not provide optimal economic benefits. This is due to the lack of tourists from outside areas. The location of geothermal water is mostly utilized by the Payo village community for various therapies.

Information on geothermal potential in the North Maluku region was reported by Rosli (2005), who carried out a magnetic investigation of the Akesahu Island, Tidore geothermal area, North Maluku Province. Sundhoro (2005) conducted geothermal-based geological research in the Akesahu area, Tidore Islands, North Maluku. Research on the utilization of geothermal water for fish processing has been reported by Syuhada et al (2012), who carried out the design and testing of a fish dryer using geothermal energy sources. Freddy et al (2014) conducted research on processing fish (*Mystacoleucus padangesis*) using a liquid smoke intermediary media with different uses of different heat dryers.

Research on geothermal utilization for fish processing in Idamdehe Village, West Halmahera Regency was conducted by Baksir et al (2018), who stated that the process of

fish cooking takes 30 minutes with a geothermal steam temperature of 100°C, whereas fish maturation takes 1 hour with geothermal steam temperature of 100°C. Baksir et al (2018) also found that geothermal steam temperature increases with increasing excavation depth; at 20 cm depth, the temperature was 90°C, while at 30 cm depth, the temperature was 100°C. Fish processing activities through drying using the sun's heat and fumigation through firewood have been widely carried out. It could be advantageous to have a new method for drying fish using geothermal water. The potential utilization of geothermal water for fishery activities has not yet been carried out, to our knowledge. This is due to the lack of knowledge in the utilization of geothermal potential to become a fish processing and tourism instrument. Thus, a sustainable use approach is needed (Baksir et al 2018). The study aims to determine the processing (drying) of fish using geothermal water sources.

Material and Method

Study site. West Halmahera Regency is a geothermal potential area based on the Minister of Energy and Mineral Resources Decree No. 1787K/3/MEM/2007 with an area of 13580 ha (Ministry of Energy and Mineral Resources 2017). Payo Village is included in thegeothermal potential development area in West Halmahera Regency. It is administratively included in the Jailolo Subdistrict, West Halmahera Regency (Village Profile Document 2018) (Figure 1). This region has various natural resources and geothermal potential such as geothermal water. The village is included in 4 centers of aquaculture production for goldfish, milkfish and tilapia.

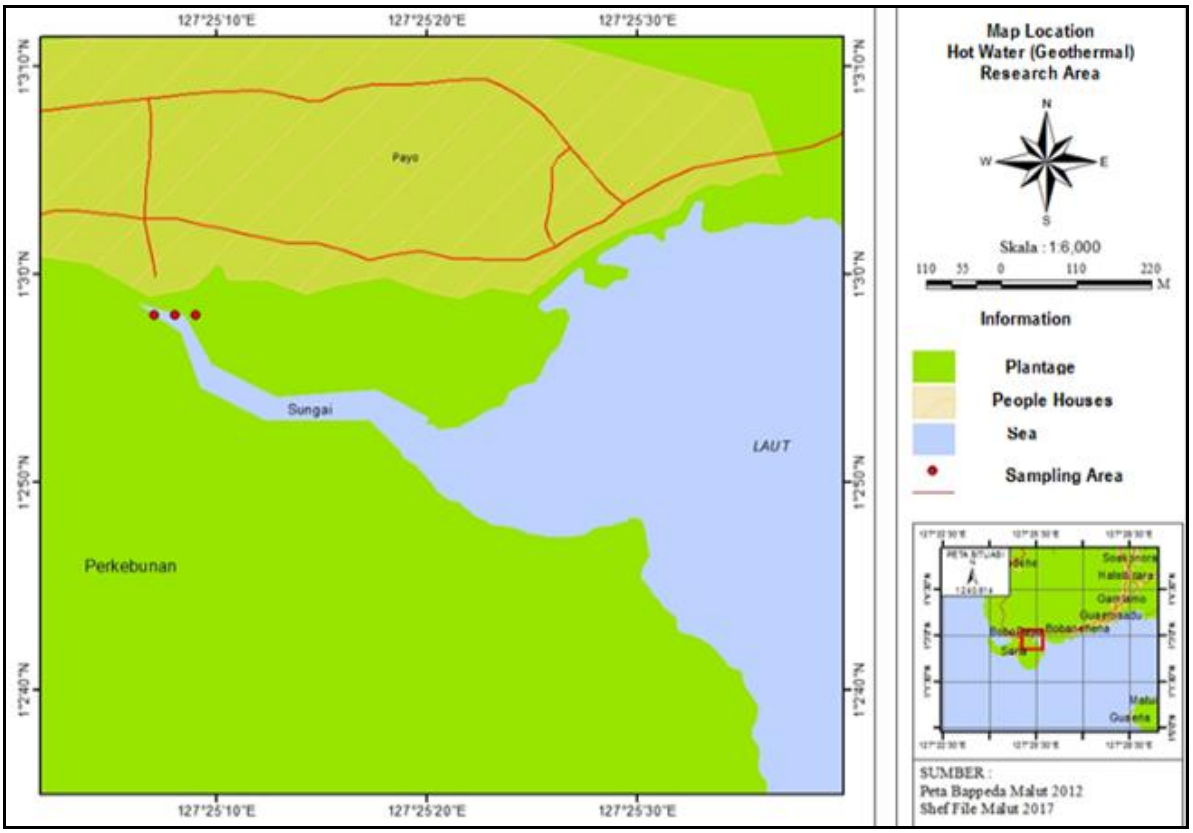

Figure 1. Research site in Payo Village

The people use geothermal water for bathing, washing clothes and treating disease. The potential of this hot spring is promoted as a local and national tourist visiting area at the Jailolo Bay Festival (FTJ), which is held every year. Foreign tourists take advantage of visits to the location of this geothermal water for therapy.

Materials. This study used anchovies (*Stolephorus indicus*) measuring 10 cm obtained from traditional markets. The tools used were an oven with a height of 15 cm, a length of 50 cm, a width of 30 cm and a foot height of 60 cm, an oven laying media with a height of 75 cm, a length of 52 cm and a width of 32 cm, a fish clamp (35 cm long), 20x15cm size tupperware and gloves.

Methods. This study used a modified tool specifically designed by adjusting it to field conditions. The bottom of the oven remained open to facilitate the entrance of steam and hot water, helping the process of fish cooking (Figure 2). The fish maturation was done by laying the fish on an oven mat, and inserting the mat in the oven. The oven was closed and placed in contact with the geothermal water media. The process of ripening the fish was from morning to afternoon. Observation and data collection was conducted hourly. The process was repeated for 6 days, to obtain the correct maturation time. Environmental parameters measured were water temperature (with a digital water thermometer), soil temperature (with a soil survey digital tester 4 in 1), oven room temperature (digital thermometer), soil pH (with a digital soil analyzer), water pH (with a digital pH tester) and salinity (Brix refractometer). The dried fish was subjected to a proximate analysis to determine the levels of crude protein, crude fat, water, and carbohydrates (Isa et al 2015; Thaha et al 2018).

Figure 2. Modified oven used in the study.

Data analysis. Research was conducted using the field experiment method, by manipulating one or more independent variables in real situations (Kerlinger 1986; Ghazali et al 2014). Data was tabulated using Microsoft Excel, analyzed descriptively, and presented in the form of graphs, diagrams and tables.

Results and Discussion

Fish processing in geothermal water. The process of ripening the fish took 2 hours at a maximum oven room temperature of 50°C. There were 3 repetitions (Figure 3). The results showed that the fish was matured in 2 hours, with the temperature of geothermal water released fluctuating between 49-51°C. The criteria for the condition of dried fish are known based on the smell and texture of the meat. The fish with an initial temperature of 0°C was placed in the oven, with a water temperature of 50.5°C that steadily increased the oven room temperature. The oven room temperature rose to 25°C at 10.00, at a hot water temperature of 49.5°C, the fish still being undercooked. At 11.00, the oven room temperature was constant, 50°C, and the fish dried. The second and third repetitions confirmed the first result. The increase in temperature of the room was slow, because it depends on the conductivity of hot water and hot water steam to the body of the oven.

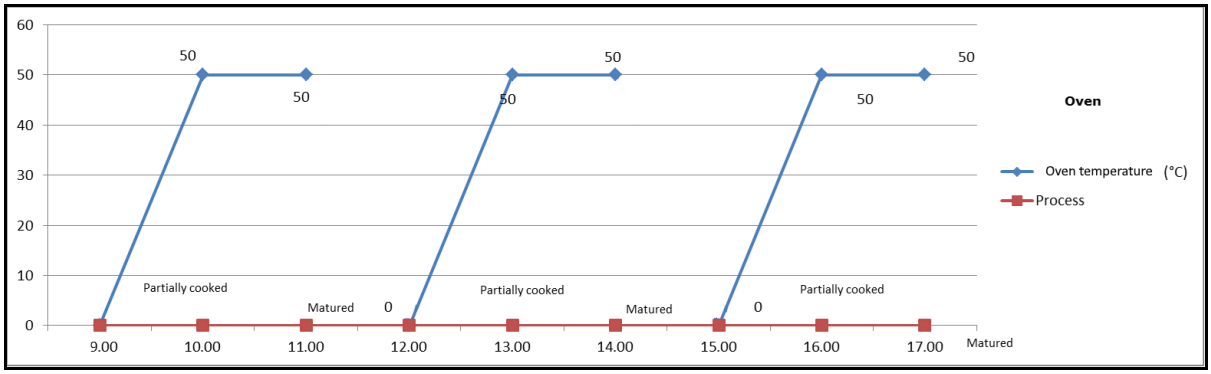

Figure 3. Fish drying in the modified oven.

Fish proximate analysis results. The results of the fish proximate analysis are presented in Table 1. The content of fat in anchovies was 4.53%, there was 35.6% crude protein, 64.8% water content and 0% carbohydrates. The values of the nutritional contents showed that anchovy samples could be utilized for human consumption. The fish maturation carried out for 2 hours can only eliminate as much as 35.2% of the water content. The air humidity and geothermal water vapors cause the transfer of heat with a high water content, thus slightly soaking the flesh, and preventing a better drying process. Other parameter values that were found showed that the sample of anchovy which was processed using a modified oven did not show repetitions presented similar values in terms of proximate analysis.

Baksir et al (2018) say that high geothermal steam temperatures can quickly remove water from the body of the fish. Water drying quickly helps the fish maturation by shortening its time period. The high oven room temperature is influenced by the entry of water through a water hole located under the oven and by the steam formed. The fish maturation is influenced by the temperature of the surrounding environment. Baksir et al (2018) said that the stability of the environmental temperature is very influential on the process of fish maturation.

Similar research in utilizing geothermal sources for fish processing was carried out by Baksir et al (2018) using *Selaroides leptolepis* in Idamdehe village, West Halmahera Regency, where fish maturation took 30 minutes with a geothermal steam temperature of 100°C. The research results are similar to those of Maulana (2010), where the drying process required to produce salted fish took 8 hours using a modified oven with 3 fuels, namely kerosene, wood, and methane, but the resulting room temperature was different, 80-90°C. Oven drying tools are made using aluminum and zinc, because these materials are able to transfer heat quickly and is resistant to corrosion. Majanasastra (2016) explains that aluminum and zinc are mediums that have good rust resistance, heat conduction and electricity conduction.

Different research results were reported by Hatta et al (2019), who used a drying system with a hybrid method that found that drying using hybrid energy is relatively shorter, between 8.5-13 hours, than drying traditionally, which takes 3 days with high sunlight intensity. Differences in results were also reported Bintang et al (2013), where the maximum temperature achieved in a solar dryer was 50°C, with a maximum outside temperature of 38°C. Bintang et al (2013) found that the fish drying time was 14 hours and it reduced the water content of fish with 37%.

Table 2

Comparison fish proximate test

No	*Samples*	*Water content (%)*	*Crude fat (%)*	*Crude protein (%)*	*Carbohydrate*	*Sources*
1	*Stolephorus indicus*	64.8	4.53	25.6	0	Current study
2	*Stolephorus indicus*	-	-	38.12-41.79	-	Amarullah (2012)
3	*Paraplotosus albilabris*	49.64 - 60.63	10.18-16.65	18.48-27.32	-	Mardiana et al (2014)
4	*Oreochromis niloticus*	-	2.21-6.84	-	-	Isa et al (2015)
5	*Stolephorus* spp	59.35–63.70	2.46-4.93	25.55-28.68	-	Fahmi et al (2015)
6	Fish meat	8.76	48.07	17.01	-	Pitunani et al (2016)
7	Fish	-	12.21-15.27	6.63-8.11	68.3-74.53	Thaha et al (2018)

The results of this study show that maturation or drying of fish is faster using geothermal water sources. The process of rapid maturation/drying of fish is caused by the 2 main sources of heat entering the modified oven, geothermal water and hot steam originating from hot water. The source of water and geothermal steam entering the oven influences the acceleration of the flow of fish's water content out of the body, thereby affecting the maturation time of the fish. Fish exposed to geothermal water vapor for a long time can ripen due to high geothermal steam temperatures (Baksir et al 2018).

The value of water content found exceeds the SNI (Indonesian National Standard) threshold. Mardiana et al (2014) said the percentage of maximum moisture content set in SNI is 60%. The value of water content in each sample is not the same. A higher moisture in the texture of an ingredient shows a higher percentage of water contained in it (Winarno 1997). Crude protein is in normal percentages. The value of anchovy fat from proximate test results is high (Table 2). Fahmi et al (2015) said that a higher fat content could potentially increase the rate of fat oxidation occurring.

The difference in results (Table 2) is caused by the treatment in the process of maturation of different fish and the use of different fish samples. Another difference is due to the use of different drying media and heating sources. However, overall, it shows that the variables found are in normal conditions and can be utilized by the community as a source of food. Anchovy meat has a protein content suitable to be used as raw material for fish protein isolates. This condition shows that anchovies processed in geothermal water have good nutritional values.

Conclusions. Fish processing using a modified oven takes 2 hours with the temperature of geothermal water released fluctuating between 49-51°C. Proximate test results of processed fish show a water content of 64.8%, a crude fat content of 4.53%, a crude protein content of 25.6% and no carbohydrates, showing that anchovies processed in geothermal water have a normal chemical composition.

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