Cold Smoking Equipment Design Of Smoked Fish Products With Closed Circulation Using Temperature And Concentration Monitoring System Based On Arduino Uno

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Abstract. This study aims to develop a cold smoking equipment by improving the air circulation system in a fish smoking equipment with the position of the fish hanging vertically. The components used are DS18b20 sensor, MQ-2 sensor, arduino microcontroller, LCD, micro SD. Cold smoke testing is done by monitoring the temperature and concentration of smoke. The type of fish used in this study is the type of flying fish (Decapterus). The analysis used to determine the outcome of cold-smoked fish is water content. The results showed that the average temperature in the smoking room was (23.18-44.81)°C. While the smoke concentration obtained is (230-252) ppm Temperature and smoke concentration as desired and the results of the sensor data recording are stored in micro SD. The average value of the water content of smoked fish is (25.53% -32.45)%. The lowest water content of smoked flying fish is 25.53% at 6 hours fogging duration and the highest water content of floating fish is 32.45% at 3 hours fogging duration.

1. Introduction
One of the processed products favored by the people of Indonesia and abroad is smoked fish. Fish is included in the category of fast decay so that the value of the quality of fish freshness is an important factor to consider. Therefore, the decline in the value of the quality of fish freshness will reduce the value of nutrition and the value of fish selling power.

The growth of the fisheries subsector becomes an important role as a contributor to production equipment in various parts of Indonesia, but not all regions of Indonesia can be fulfilled from the development of existing technology. As a result of uneven fish distribution, proper processing is needed for fish distribution in Indonesia.

Processing can make fish durable and allow it to be distributed from production centers to consumers. The existence of high temperatures, fish meat becomes cooked without being processed first [7]. Fish production in the last 20 years has only been processed (around 23-47)%). Processing in the form of salted fish, smoked fish, and boiled fish. The amount is mostly processed traditionally like conventional smoking. Isamu (2012) defines smoking is the process of penetration of volatile compounds in fish which produced from burning wood and producing products with specific taste and aroma [6]. Flyfish composition after smoked has phenol content depending on the process applied to the smoking, duration, and temperature in the smoking chamber will affect the smoked fish yield [10].
The technique of smoking fish is generally known by the public there are two, namely hot smoking and cold smoking. Hot smoking process usually often called fish baking [2]. According to Syam, on hot smoking, the storage temperature is around (70-100) °C [8], while cold smoking is around (15-50) °C [1]. The hot smoking for drying process takes place quickly, while the cold smoking for drying takes place slowly. The water content produced by cold smoking is relatively low, so cold smoking can be applied for long-lasting preservation [1].

Central Java is the center of fishermen and fishing both small and medium scale which has the potential to produce processed fish products. Tegal, one of the cities that is directly adjacent to the Java sea, has the potential to produce fisheries that are worth developing. Fishery product processing is still done traditionally in the form of the home industry [5]. Fish smoking in Tegal City currently still uses smoking houses. Judging from these conditions, of course, the smoking equipment used has not been equipped with a temperature monitoring system and the concentration of smoke, the smoke produced cannot be managed properly so that it impacts on health and the environment. Swastawati explains that the smoke emitted irregularly can also affect the level of fish maturity, and the resulting texture becomes less attractive. This happens because the smoke that comes outbreaks down more in the environment than is absorbed in the body of the fish. Then the need for tools that can help for the processing of smoked fish [14].

Progress in Science and Technology is currently experiencing a very rapid increase. The technology certainly cannot be separated from the use of a sensor and transducer microcontroller. The advantage of this microcontroller technology is that it is a digital measurement and automation tool with an LCD display [12]. Sensors and transducers are currently made into innovation and creativity that can be applied to a tool for experimentation. The instrumentation system used to make measurements has an input in the form of the actual value of the variable being measured, and output in the form of a measured variable value as shown in Figure 1 [14].

![Figure 1. Measurement System Diagram](image-url)

The results of advances in science and technology have provided convenience and benefits for the community. As research conducted by Fansuri (2011) has designed microcontroller-based cold smoking equipment for fish products. The results of trials on this cold smoking equipment showed a stable temperature concentration value with an average (29.71-39.29) °C, the voltage released from the smoke sensor to measure smoke concentrations ranged from 4.11 to 4.33V. The time needed to smoke the tuna until cooked is 31 hours. The fuel used is a mixture of rambutan wood and coconut shells. The organoleptic test results of smoked fish that the taste is good and not tasty. Smoked fish can last one week. The water content of smoked fish is 51.91%, the water content of smoked fish that has been produced has fulfilled SNI with a maximum value of 60% [3].

The development of tools still has advantages and disadvantages, the results of the development of these tools now still have significant shortcomings, such as there are still gaps in the fumigation chamber causing some smoke to come out, the position of the smoked fish is not hung so it needs to be flipped manually, then there needs to be developed so that the fogging process evenly and data storage are still connected directly using a laptop or computer.
2. Research Methods

2.1. Research Time and Place
This research was conducted on April 23 - November 24 2019. Software and hardware and tool design were carried out at the Physics Laboratory of the Walisongo State Islamic University, Semarang. The field test was carried out in Muarareja Village, Kec. Tegal Sari, Tegal City, Central Java Province.

2.2. Hardware System Design
The system designed on this device is divided into 3 main parts. Namely the input consisting of a sensor DS18b20 and sensor MQ-2, the processor consists of Arduino uno and the output portion of Liquid Crystal Display (LCD) and Micro SD.

![Figure 2. Hardware System Design.]

2.3. Software System Design
Software design using Arduino IDE (Integrated Development Environment). Arduino IDE is software that functions to configure the arduino uno microcontroller board which contains a text editor for writing code.

2.4. Research Procedure
The cold smoking equipment for smoked fish products is designed to use Arduino Uno as a microcontroller, devices connected to Arduino Uno are DS18b20 sensor, MQ-2 sensor, relay, real time clock, liquid crystal display (LCD) and micro SD. Each has a different function in the cold smoking equipment working system.

DS18b20 sensor and MQ-2 sensor as a detector for temperature and smoke concentration. The sensor will read the temperature of the smoking room and send digital data to Arduino Uno for processing after it is forwarded by a 12 volt AC fan.

The 12 volt fan is a temperature control device and the smoke concentration is controlled by Arduino as a microcontroller. Two fans in the smoking room will work optimally if the temperature in the smoking room is <15 °C and will work minimally when the temperature in the smoking room> 45 °C. The 12 volt AC fan is controlled by a relay that works according to the temperature data that is input to Arduino Uno via the display.

The display is a temperature and smoke concentration monitoring device that is read by the DS18b20 sensor and the MQ-2 sensor. This display uses a Liquid Crystal Display (LCD) and the data will be stored on a micro SD.

3. Results And Discussion

3.1. Testing of the Smoking Equipment
Equipment testing is done by looking at the workings of the DS18b20 temperature sensor and MQ-2 sensor, whether the temperature value of the DS18b20 sensor is vulnerable according to the desired specifications. MQ-2 sensor testing can be done by looking at the output value of the MQ-2 sensor.
This value can be converted to smoke density in ppm. The equation used to convert digital values to parts per million (ppm) values.

3.2. Design Results of Cold Smoking Equipment

The design of cold smoking equipment for smoked fish products with a temperature monitoring system and the concentration of smoke is divided into 3 parts, namely the kiln (smoke making), smoke distribution pipes, and the smoking room. The following design of cold smoking can be seen in Figure 3.

![Figure 3. Cold Smoking Equipment](image)

The smoking room functions as a container for the material to be smoked. Made of galvanized with a size (70x40x40) cm. There is a glass in front of the smoking area which aims to make it easier to see the fish in the smoking room. Then in the smoking room there are 2 shelves to hang the fish with a distance between rack 1 and 2 is ± 20 cm. The smoking room has two 12 volt AC fans, a fan used (5x5x2.5) cm [12]. Between shelves one and two there is a DS18b20 temperature sensor and a MQ-2 sensor. The right outside of smoking there is a component box that functions to place components and electrical circuits, such as Arduino Uno, RTC, LED, LCD, micro SD, and relay. The size of the component box (15x10) cm. Display smoke chamber can be seen in Figure 4.

![Figure 4. (a) Fish Smoking Glass (b) Component Box (c) Sensor (d) Shelves and Fans in the Fish Smoking Room](image)

The smoking process of this equipment is a coconut shell that is burned at the incinerator, produces smoke, then the smoke enters the pipeline connecting the smoke chamber and the incinerator. The smoke goes to the smoking room because it is inhaled by a 12 volt AC fan. The bottom 12 volt AC fan, which amounts to 2 pieces, will turn on when the temperature is less than 15 °C. if the temperature in the smoking room is above 45 °C, one of the fans will turn off. Smoke entering the smoke chamber is then recorded by the DS18b20 sensor and the MQ-2 sensor. Data recorded on the temperature and smoke sensors are then stored in micro SD. The position of the fish to be smoked by hanging on a rack in the smoking room. The position of the fish can be seen in Figure 5.
Figure 5. Position of Flying Fish Before Smoked

Viewed from Figure 5, the purpose of the fish is hung vertically, so that fish during the smoking process does not need to be alternated. Smoked fish evenly cooked. This research was conducted 4 times with variations in smoking time. The duration of smoking is 3 hours, 4 hours, 5 hours and 6 hours. The following is a display of smoked fish results can be seen in Figure 6.

Figure 6. Smoked Fish Results With Long Smoke (a) 3 Hours, (b) 4 Hours, (c) 5 hours (d) 6 hours

Figure 6 shows the results of smoked fish using cold smoking equipment. Judging from the color texture of brownish smoked fish. Taste and aroma of concentrated smoked fish and tender fish meat.

3.3. Results of Cold Smoking Equipment Test

Testing cold smoking equipment is done by controlling the smoke chamber. Testing the temperature and concentration of smoke carried out to find out how long the process of smoking fish and to find out how much the temperature and concentration of smoke in the smoke chamber. The following results of testing the temperature in the smoking room can be seen in Figure 7.

Figure 7. Temperature Chart of the Smoke Room
The x-axis in Figure 7 is the time of data collection and the y axis is the temperature in the smoking room. The temperature in the smoking room ranged between (23.18 °C - 44.81 °C). The results of the lowest temperature observation were 23.38 °C and the highest temperature was 44.81 °C. The increase in temperature is due to the addition of charcoal fuel in the combustion place, so the distribution of heat and smoke is more so that the temperature in the smoking room increases. The decrease in temperature is because the charcoal in the incinerator is not sufficient to distribute heat and smoke into the smoking room. The temperature sensor test results can be said that the DS18b20 temperature sensor works well according to the desired specifications. In addition to testing the temperature sensor MQ-2 sensor testing is also performed to detect the concentration of smoke in the smoke chamber. Smoke concentration and smoke velocity in the smoke chamber will determine the quality of smoked fish [10]. The following results of monitoring temperatures in the smoking room can be seen in Figure 7.

![Figure 7. Temperature Graph of Smoked Fish](image)

Figure 8. Graph of Smoke Concentration Test Results

The x-axis in Figure 8 is the time of data collection, while the y-axis is the Analog Digital Converter (ADC) value which is changed in units of parts per million (ppm). Based on observations during smoking for 3 hours, 4 hours, 5 hours and 6 hours, it can be seen that the concentration of smoke in the smoking room is (230-252) ppm. To get optimal results, the smoke concentration is expected to be above 100 ppm in the smoking process.

### 3.4 Water Content Analysis of Smoked Fish

The analysis used in this study was the water content in smoked fish. Food durability has a close relationship with water content. The lower the water content in food is expected to be more durable food ingredients. The content of water content in food affects the resistance of food ingredients to microbial attack. Water is a suggestion for microorganisms to develop so that the smoking process has the aim of reducing the levels of water in fish [14]. The lower the water content the slower the growth of microbes so that food is durable [16]. The results of the cold smoking water content of flying fish are presented in Figure 9.

![Figure 9. Water Content Graph of Smoked Fish](image)
Based on Figure 9 the average water content of smoked fish is (25.53% - 32.45)%. The average length of a fish is 16.7 cm and the average weight of a fish is 192.3 gram. There are 10 fish in the smoking room. The lowest water content of smoky fish is 25.53% which occurs at 6 hours of smoking and the highest water content of smoked fish is 32.45% which occurs at 3 hours of smoke fogging. The efficiency of the time needed to bloat the flying fish to the water content is 6 hours compared to 3 hours of smoking. This means that the longer the smoking, the lower the water content in smoked fish.

Previous research by Fansuri (2011) used tuna with 31 hours of smoking. The value of water content of smoked tuna is 51.91%. The difference in body shape of the two different types of fish can affect the decrease in water content. The decreased water content of swift fish is faster because of flying fish have a slim body [3]. This was confirmed by Fauzi (2011) who stated that the type, shape, and size of the fish, the temperature of the ignition and the duration of smoking greatly influenced the smoked fish yield [4].

4. Conclusions

Cold smoking equipment for smoked fish products with closed circulation using an Arduino Uno based temperature and smoke monitoring system has been created. The design of cold smoking equipment is divided into three parts, namely the incinerator, smoke distribution pipes, and smoking chamber. The result of the temperature in the smoking room is the lowest temperature of 23.18 °C and the highest temperature is 44.81 °C. Smoke concentration in the smoking room is (230-252) ppm. Temperature recording data is stored on a micro SD card. The average results of the lowest water content value of smoked flying fish are 25.53% occurred at 6 hours smoking duration and the highest water content of smoked fish is 32.45% occurred at 3 hours fogging duration. The efficiency of the time needed to bloat the flying fish to the water content is 6 hours compared to 3 hours of smoking. This means that the longer the smoking, the lower the water content in smoked fish.

Suggestion

Suggestions, it is necessary to develop further about cold smoking equipment and the need for additional alarms to find out the fuel that has run out and used different types of fish and can be developed with ozone technology for preserving fish with longer shelf life.

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