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To cite this article: Vanessa Natalie Jane Lekahena and Risno Jamin 2018 IOP Conf. Ser.: Earth Environ. Sci. 175 012003

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The Quality of Smoked Skipjack During Storage Time at Room Temperature

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Abstract. Fish is one of the foods rich in protein, omega-3 fatty acids, vitamins and minerals, which are beneficial to health. Fish and other fishery products are susceptible to the process of deterioration and decay due to the activity of microorganisms and enzymes contained in the fish meat so that processing and preservation need to be done to prevent the deterioration of quality and damage of fish. Smoking is a technique of preservation in the form of a combination of salting, heating and fumigation treatment so as to produce a durable product with a distinctive flavour. Research aimed to determine the quality of smoked skipjack during storage time at room temperature. This research was conducted through two stages: sample preparation and sample testing including pH, moisture content and total plate count as well as confirmation of molds for smoked skipjack stored at room temperature on day 0 to day 4. The results showed that storage time at room temperature significantly influenced the increase of pH value, moisture content and microbial growth of smoked skipjack as shown by regression equation of pH value $y = 0.300x + 6.057$ with $R^2 = 0.656$ and $r = 0.810$; moisture content $y = 3.627x + 39.693$, with $R^2 = 0.502$ and $r = 0.708$ and total plate count $y = 1.972 + 1.283x$ with $R^2 = 0.951$ and $r = 0.975$.

Keyword: smoked skipjack, storage time, room temperature

1. Introduction

Fish is one of the food products rich in nutrients such as proteins, omega-3 fatty acids, vitamins and minerals, so it has functional properties that are beneficial to health [1]. In addition, fish and other fishery products are also easy to experience the process of degradation and decay due to the activity of microorganisms and enzymes contained in the fish body [2], so that processing and preservation need to be done to prevent the deterioration of quality and damage of fish [3].

Smoking is a method of processing and preserving which is a combination of salting, heating and fumigation so as to produce durable products with a distinctive aroma and flavor derived from natural combustion of chemical compounds [4][5]. During smoking there is penetration of volatile compounds from wood burning to fish meat to produce products with specific flavor and aroma. In addition, the smoking process will produce products with long shelf life due to the activity of antimicrobial compounds derived from the smoke and there occurs inactivation process of fish meat enzymes that influence the quality of smoked fish. The chemical compounds of wood smoke like phenols (which act as antioxidants), organic acids, alcohols, carbonyls, hydrocarbons and nitrogen compounds such as nitrous oxide, aldehydes, ketones, esters, ether, attached to surfaces, penetrate into fish meat [6].

Skipjack fish (Katsuwonus pelamis) is a type of pelagic fish that are widely used as raw materials of smoked fish. The chemical composition of fresh skipjack meat consists of moisture 69.40%; fat 1.50%; protein 25.00%; ash 2.25% and carbohydrate 0.03% [7]. Like other types of fish, skipjack is also easily damaged and decayed, so to maintain the quality and durability can be done by smoking process. Smoking is a traditional technique of processing and preserving with high
temperature using simple equipment. Good smoked skipjack product must meet SNI 2725.2013 of quality standard that is minimum sensory of 7 (score 1-9), chemical composition with ± 60% of moisture content, 20% of fat, and 100% of histamine (maximum). Terms of microbes’ contamination is TPC $5.0 \times 10^4$ colony/g, E Coli $< 3$ APM/g, negative salmonella and mold $1.0 \times 10^2$ colony/g. Food products are good if they meet food safety standards and good shelf life. Shelf life is the time interval from the food in production to the time of consumption, which is still in a satisfactory condition on its physicochemical and sensory characteristics [8]. Aspects of sanitation, hygiene and storage processes are important factors in maintaining food safety standards and shelf life of the product so as to avoid product damage due to chemical, physical and microbiological changes. The aim of this research was to determine the quality of smoked skipjack products during storage at room temperature. The benefits of this research can be an input for the fishermen and community surrounding about the durability of the smoked skipjack during storage at room temperature and good storage process to maintain the quality of the smoked skipjack.

2. Method

2.1. Preparation of Samples

The fresh skipjack fish were obtained from the local market in Ternate City. In the initial stages, the first washing is done using running water to clean the mucus, blood and dirt attached to the fish body, then the contents of the stomach, gills, fins are removed, and the fish are sliced; after that it is followed by the 2nd washing. Furthermore, fish slices were soaked with 2% salt solution for ± 20 minutes, before the smoking process. Besides maintaining the durability of fish, soaking the fish with salt solution is to dissolve the protein sarcoplasm in order to facilitate gel formation in fish meat during the smoking process. After the process of soaking the slices, fish meats are lifted, drained and dried, then it is proceeded to the smoking process with the temperature of smoking room ranges from 60-70 °C for ± 4 hours until the meat is really cooked. Then the meats are lifted, set aside and cooled. Once cool, the smoked skipjack is packaged in polyethylene plastic packaging and stored at room temperature from 0 to 4 days, followed by further testing conducted: pH [9], moisture content [10] and total plate count [11] as well as confirmation of fungi/mold to identify the process of degradation.

2.2. Statistics

Data on pH, moisture content and total plate count were analyzed using simple regression analysis [12], with the following equation:

\[ Y = a + bX \]

($Y$ is the predicted dependent variable, $a$ is the constant value, $b$ is the regression coefficient, and $X$ is the independent variable).

3. Results and Discussion

The main problem in handling processed and fresh food is the degradation of quality during storage time caused by the high level of moisture and nutrient content. The cause of the degradation in quality and the decay is due to the growth of microorganisms, so it requires good prevention and handling to maintain the quality and durability. Processing is one of the alternatives to maintain the quality by paying attention to food safety factors.

Fish is one of the most consumed foods by the community, because it is rich in protein content, unsaturated fatty acids (omega 3), vitamins, macro and micro minerals that have functional benefits for health [13]. Because it is rich in nutrients and high moisture content, fish easily experience the process of decomposition compared with other foodstuffs [1]. Fresh fish processing in the form of smoked fish can inhibit the process of quality degradation and fish decomposition. Skipjack is a type of fish that has been processed mostly into smoked fish, especially in the Ternate city. Durability and shelf life of local smoked skipjack generally is no more than 2 - 3 days if stored at room temperature.
3.1. Degree of Acidity

The degree of acidity (pH) is a parameter that states the level of acidity or alkalinity of a food. The pH test in this research is to find out the influence of storage time at room temperature to the pH of smoked skipjack product.

Figure 1. pH value of smoked skipjack during storage time

The average pH value of smoked skipjack (Figure 1) shows an increase during storage time from day 0 to day 4 which obtained 6.01 (H₀); 7.13% (H₁); 6.88 (H₂); 7.36 (H₃) and 7.40 (H₄). The longer the storage time, the more increasing the pH value will be, for the fish meat containing basic compounds such as ammonia, trimethylamine and other volatile compounds, which can lead to the process of glycolysis due to the action of enzymes [14].

Fresh and processing foods with high of pH value are susceptible to quality degradation and damaged by microbial growth, while at low pH conditions, the process of degradation is slow [15] because the pH of the product is acidic. The longer storage time may increase the pH value caused by enzyme activity in fish meat. In addition, enzyme activity is also influenced by the storage temperature; the higher the storage temperature, the more increasing enzyme activity will be [16]. The result of F test of pH value indicated that the longer storage time at room temperature had a very significant influence on the pH of the smoked skipjack fish with regression equation of \( y = 6.057 + 0.300x \) on the coefficient of determination of \( R^2 = 0.656 \); it means that the pH of smoked skipjack stored at room temperature is 65.6% affected by the time of storage, while 34.4% is influenced by other factors beyond the specified factor. Meanwhile, the correlation coefficient \( r = 0.810 \), indicating the longer storage time at room temperature has a very strong correlation to the increase of pH of the smoked skipjack product.

The pH value in this research meets good pH conditions for smoked fish products in accordance with SNI standard 2013 because pH for preserved fish products is between 6.0 and 8.0. Chamidah (2000) states that during the storage process occurs the decomposition of proteins into ammonia compounds, so that the pH value of food products during storage due to protein decomposition by proteolytic enzymes become lactic acid, carboxylic and sulfide; hence, even though the pH of smoked skipjack products increased during storage time, it will remain acidic to prevent rapid degradation of community.
3.2. Moisture content

Moisture content of a food greatly influences the quality and shelf life of the food, so the determination of moisture content of a food is very important for the processing and the distribution itself will get the right handling [17].

Water is the largest content in the fish body and is a means for the growth of microorganisms. The smoking process is a preservation technique that aims to remove moisture content in fish using high temperatures so as to extend shelf life. Moisture content of skipjack is influenced by temperature and smoking time, the higher the temperature and the duration of smoking, the more decreased the moisture content will be. This is because the free moisture contained in the fish body has evaporated in line with the higher temperature and duration of the smoking [18]. The process of smoking for 4 hours can reduce the moisture content until 49.64% [1], and it is not different from result of this research, which is 48.45%.

![Figure 2. Moisture content of smoked skipjack during storage time](image)

The average value of moisture content of smoked skipjack (Figure 2) during storage time from day 0 to day 4 is 48.45% (H\(_0\)); 39.71% (H\(_1\)); 49.24% (H\(_2\)); 58.05% (H\(_3\)) and 57.41% (H\(_4\)).

The result of F test of moisture content collectively shows that the duration of storage time has a very significant influence on moisture content of smoked skipjack with regression equation \( y = 39.693 + 3.627x \), where the coefficient of determination is \( R^2 = 0.502 \) meaning that 50.2% of moisture content of smoked skipjack products is influenced by storage time at room temperature, while 49.8% is influenced by other factors. The longer storage time at room temperature increases the moisture content of smoked skipjack product this is indicated by the correlation coefficient of \( r = 0.708 \), meaning that the increase of moisture content of smoked skipjack correlates strongly with the storage time of the product at room temperature, which is 70.8%.

Moisture content of smoked skipjack in this research ranges between 39.71% - 58.05%, and meet the SNI standard which is a maximum of 60%. This result is lower when compared with moisture content of smoked mackerel tuna which is 54.62 - 62.65% [19] and the smoked skipjack tuna produced in Kendari is 64.13 - 67.14% [6].

3.3. Total Plate Count

Testing total plate count (TPC) is one of the ways to determine the number of microbes of food products indirectly and this way is more accurate than the direct count under the microscope, as such way can determine the amount of microbes that live through its ability to form colonies on the media to be seen without the help of a microscope.
The growth of microbial/bacterial colonies increased during storage time at room temperature. Differences in the number of microbial/bacterial colonies are due to the differences in the components of bacterial and bactericidal fumes, especially phenol [20]. Logarithmic data of microbial/bacterial growth (Figure 3) is: 3.4130 ($H_0$); 4.7413 ($H_1$); 5.4074 ($H_2$); 6.6956 ($H_3$) and 8.8521 ($H_4$), which shows that the longer the storage time at room temperature, the higher the growth rate of microorganisms; this is related to the increase of moisture content and pH of the smoked skipjack during storage time.

The high moisture content and pH value of the product is a good medium for microbial/bacterial growth as their numbers are influenced by intrinsic and extrinsic factors such as pH, water activity (aw), equilibrium humidity ($E_h$), nutrition, biological structure, storage temperature, and relative humidity, as well as the type and amount of gases in the environment [13].

The result F test of TPC of smoked skipjack, showed that storage time had significant influence on growth value of microbial/bacteria with regression equation of $y = 1.972 + 1.283x$, on the coefficient of determination ($R^2$) = 0.951, meaning that 95.1% growth of microbial/bacteria in smoked skipjack product are influenced by storage time at room temperature, while 4.9% is influenced by other factors and the correlation coefficient is $r = 0.975$. These results indicate that the longer the storage time at room temperature, the higher the number of microbial growth of smoked skipjack products.

3.4. Confirmation of Fungi and Molds

Fungi and mold growth is one of indicators of food quality degradation in addition to the growth of microbial/bacterial count. Rancidity of smoked fish is often caused due to the growth of fungi or molds, because those can grow in foods with low moisture content Montiel et al. (2012) reported that the growth of fungi in fish can cause rancid odors and changes of texture [21].

The result of observation of fungi/molds growth showed negative result meaning that there was no growth of fungi and mold in smoked skipjack product until 4$^{th}$ day of storage time. This is suspected as a result of smoked skipjack products stored at room temperature packing smoked fish using plastic packaging and being closed tightly to prevent contamination. Angela et al., (2015), said that microbes and bacteria, in the process of metabolism require oxygen; product packaging can inhibit the penetration of oxygen in the product so that microbial activity becomes limited due to lack of oxygen availability [16]. Meanwhile, according to Murniyati and Sunarman, (2000) bacteria and yeast need higher moisture content than mold, therefore mold is often found in semi-dried foods, where bacteria and yeast cannot grow [22].
4. Conclusion

The results of this research indicate that the duration of storage of smoked skipjack at room temperature has a significant influence on the increase of pH value, moisture content and the growth of microbes and fungi/molds. The smoked skipjack products stored at room temperature until the 4th day still meet the standard quality of smoked skipjack product in accordance with SNI no. 2725.2013 on the parameter of moisture content, pH and fungi/mold [23].

5. Suggestion

Further research on the determination of shelf life of smoked skipjack at different temperature and time is supposed to use of vacuum packing to know the influence of the use of packaging to shelf life of smoked fish product.

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