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USE OF FERMENTED CASSAVA PEEL AND SALT SOLUTION ON THE SHELF LIFE OF RED TILAPIA FILLETS BASED ON THE NUMBER OF MICROBES AT LOW TEMPERATURE STORAGE

Penggunaan Larutan Fermentasi Kulit Singkong dan Garam Terhadap Masa Simpan Filet Nila Merah Berdasarkan Jumlah Mikroba Pada Penyimpanan Suhu Rendah

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ABSTRACT

This research was conducted to analyze the best salt concentration in the cassava peel fermentation solution to extend the shelf life of red tilapia fillets based on the number of microbes during low temperature storage (5°-10°C). Soaking red tilapia fillets using fermented cassava peel solution with various added salt concentrations consisting of 4 treatments, namely 0% (control), 2%, 3% and 4%, soaking for 30 minutes for each fillet according to the treatment. The parameters observed were the number of bacterial colonies and the degree of acidity (pH), each parameter was carried out in duplicate. For concentrations of 0%, observations were made on days 1, 3, 6, 7, 8, 9, while for concentrations of 2%, 3% and 4%, observations were made on days 1, 4, 7, 8, 9, 10, 11 and 12. The results of the study showed that soaking red tilapia filets using fermented cassava skin solution, namely adding 3% salt concentration, had the best effect on shelf life during low temperature storage with an acceptance limit of up to the 11th day with TPC value is 2,5 x 10^6 and a pH value is 6,5.

Key words: Filet, Salt, Cassava Skin, Microbes, pH

ABSTRAK

Penelitian ini dilakukan untuk menganalisis konsentrasi garam terbaik pada larutan fermentasi kulit singkong untuk memperpanjang masa simpan filet nila merah berdasarkan jumlah mikroba selama penyimpanan suhu rendah (5°-10°C). Perendaman filet nila merah menggunakan larutan fermentasi kulit singkomg dengan berbagai penambahan konsentrasi garam terdiri dari 4 perlakuan, yaitu 0% (kontrol), 2%, 3% dan 4%, perendaman selama 30 menit pada masing-masing filet sesuai perlakuan. Parameter yang diamati adalah jumlah koloni bakteri, dan derajat keasaman (pH), masing-masing parameter dilakukan dua kali ulangan. Untuk konsentrasi 0% dilakukan pengamatan pada hari ke 1,3,6,7,8,9 sedangkan untuk konsentrasi 2%, 3%, dan 4% dilakukan pengamatan pada hari ke 1,4,7,8,9,10,11 dan 12. Hasil penelitian menunjukkan bahwa perendaman filet nila merah dengan menggunakan larutan fermentasi kulit singkong yaitu pada penambahan garam konsentrasi 3% memberikan pengaruh terbaik terhadap masa simpan selama penyimpanan suhu rendah dengan batas penerimaan yaitu 11 hari 9 jam dengan nilai TPC 2,5 x 10^6 dan nilai pH 6,5.

Kata Kunci: Filet, Garam, Kulit Singkong, Mikroba, pH

INTRODUCTION

Tilapia has the potential for rapid growth and various benefits. The community's need for a source of animal protein, tilapia is promising in developing the fisheries sector with supportive climatic conditions. According to KKP data (2020), tilapia production in 2015 was 1,288,281 tons, in 2016 production was 1,114,156 tons, in 2017 it was 1,288,773 tons. In 2018 tilapia production reached 1,169,144 tons, this production amount has decreased amounting to 9.28% of the previous year's total production, and in 2019 tilapia fish production in Indonesia was 1,337,831 tons.

Red tilapia is sought after by the public because it has thick and delicious flesh like red snapper. One form that has the potential to be developed from red tilapia is fish fillet. Red tilapia has nutritional content, namely 16-24% protein, 0.2-22% fat and contains carbohydrates, minerals and vitamins (Rostini, 2007). The advantages of fish fillets are that they are free of bones and spines, easy to process, and long lasting (Saparianto, 2011). Fish fillets are also flexible to be converted into various products according to consumer desires. Tilapia filets have weaknesses, especially because their natural defenses have been damaged during the filet making process (Husni & Putra, 2018). Damage to fish fillets is generally caused by enzyme activity (autolysis), bacterial contamination, and oxidation (Apriani et al., 2013). So it is necessary to preserve the fish fillets.

Currently, low temperatures are usually used to preserve fish. However, additional ingredients are needed to increase the shelf life of fresh fish because their storage period is limited at low temperatures (Santoso et al., 1999) so it is necessary to use preservatives to increase the shelf life of fish fillets. Therefore, precautions are needed to make fish fillets last longer or extend their shelf life.

Currently, natural preservatives have been developed to utilize antimicrobial groups, especially peptides from gram-positive bacteria such as lactic acid bacteria, which have the potential to replace dangerous synthetic chemical compounds in the preservation process. These lactic acid bacteria have been proven to have antagonistic properties that are beneficial in food biopreservation and function as antibacterials, especially to stop pathogenic gram-positive bacteria (Jack et al., 1995). One of the benefits of biopreservatives derived from lactic acid bacteria (LAB) in food products is their ability to extend product storage time and reduce the number of unwanted microorganisms. Lactic acid bacteria are often found in organic materials that are high in carbohydrates, one of which is cassava skin, providing nutrition and producing energy to lactic acid bacteria which then increases the number of lactic acid bacteria (Novitasari et al., 2019).

Agro-industrial and agricultural waste in Indonesia in the form of cassava peel (*Manihot utilissima*) is very abundant but has not been utilized optimally. The potential for cassava peel in Indonesia reaches 3,327,188.6 tons per year (BPS, 2008). Based on recent research by Wachid et al. (2021), cassava peel content of 69.7% has potential as raw material for alternative growth media for lactic acid bacteria. In addition, the addition of NaCl salt plays an important role in the lactic acid fermentation process. NaCl salt functions as an environmental controller, namely a natural selector of microbes that play a role in fermentation. In addition, salt helps draw water and nutrients from tissues, while nutrients, especially sugar, provide a place for lactic acid bacteria to grow (Mustakin, 1993). This method allows the cassava peel fermentation solution which has carbohydrates as a medium for the growth of lactic acid bacteria assisted by the addition of salt to absorb directly into the cell tissue of the tilapia fillet, which is then stored at a low temperature to extend the shelf life. Therefore, this research was carried out which aims to utilize the large potential of cassava peel waste which has not been utilized properly to become a fermentation solution for cassava peel and adding salt as a microbial selector to produce lactic acid bacteria as a natural preservative for fish fillets and storage at low temperatures. (5-10°C).

METHODS

Time and Place

Research was carried out at the Fisheries Product Processing Technology and Biotechnology Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University in February 2024.

Tools and materials

The tools used in this research are Cool Box, Fiber Tub, Cutting Board, Filet Knife, Plastic Basin, Digital Scale, Knife, Glass Jar, Spatula, Measuring Cup, Capitan, Strainer, pH meter, Food Liquid Absorber, Cling Wrap, Plastic Containers, Refrigerator, Petri Dishes, Tweezers, Pipettes, Microtips, Test Tubes, Erlenmeyer Tubes, Wooden Rack, Mortar and Pestle, Incubator, Colony Counter, Autoclave, Bunsen, Hand Counter, Vortex, Gloves, Scissors, Stationery.B Meanwhile, the research materials included 17 live tilapia weighing 300-500 g/fish, cassava peel, salt, distilled water, Nutrient Agar (NA).

Research methods

The method used in this research was an experimental method with 4 treatments immersion in various salt concentrations of 0%, 2%, 3% and 4%. The treatment given was soaking red tilapia filets in cassava peel fermentation solution at different salt concentrations (from the weight of cassava peel waste) for 30 minutes.

Procedure for Making Cassava Peel Fermentation Solution (modified Nisah et al., 2021)

Cassava skin is washed, brushed with clean water, and drained. Cassava skin is cut into 1 mm x 5 cm dimensions on a cutting board. The jars are sterilized and dried with a clean cloth. NaCl salt is weighed according to treatment: 2% (3 g), 3% (4.5 g), and 4% (6 g). Put 550 ml of distilled water (twice the volume of cassava peel) into the jar, add salt according to the concentration, stir well then add 150 g of cassava peel. The jar is closed (lined with brown paper) and labeled. Fermented for 5 days at room temperature.

Handling Live Tilapia (Afrianto et al., 2014)

Red tilapia from the market, packed in plastic bags filled with oxygen and water, stored in fiber tubs. Fish were acclimatized in fiberglass tanks with aerators for 2 days to reduce stress. Before filleting, live fish were transferred to a plastic bucket filled with water and ice cubes (10˚C) in a ratio of 1:2 to the weight of the fish for 10 minutes. The fish is then killed by storing it in a box containing ice cubes for 30 minutes.

Fillet Making

The fish head is cut diagonally on both sides behind the pectoral fins with a knife. Cut the fish tail straight from the base. To fillet the body of the fish, start from the base of the head, cut through the bone to the tail, then separate the fillet from the rib bones. Trim the edges of the fillet to remove the edges of the belly and back of the fish.

Application of Cassava Skin Fermentation Solution to Red Tilapia Filet (modified Nisah et al., 2021)

Red tilapia filets were soaked in cassava peel fermentation solution for 30 minutes according to the four concentrations tested. After draining, the filets are placed on mica plastic with an absorbent coating, then packed with cling wrap. The packaged filets are stored in the refrigerator at 5°-10°C.

Analysis Procedure

Total Number of Bacterial Colonies (SNI 2331.3:2015)

Take samples weighing 1 g from three parts of the fillet (near the head, middle and tail), then put them in a sterile container and add 9 mL of distilled water solution. Homogenize for 2 minutes with a 10-1 dilution. Use a sterile pipette to take 1 mL of homogenant and put it in a test tube containing 9 mL of distilled water solution, then shake it 25 times to homogenize. Repeat dilutions until you reach 10-4, 10-5, and so on. Insert 1 mL of sample into a sterile petridish in duplicate, then add 12-15 mL of NA agar, cover, and rotate repeatedly. Incubate the petridish for 48 hours, then count the number of colonies using a colony counter. To calculate the number of microbial colonies, the following equation formula is used:

$$N = \frac{\sum C}{[(1\,x\,n_1) + (0{,}1\,x\,n_2)]x(d)}$$

Information :
N = number of product colonies, expressed in colonies per mL or colonies per g.
∑C = number of colonies on all plates counted.
n1 = number of plates in the first dilution calculated.
n2 = number of plates in the second dilution calculated.
D = first dilution calculated.

Acidity Degree (pH) Test Analysis (modified Widiani, 2011)

Take 3 grams of tilapia filet meat, crush it until smooth with a mortar, then put it in a beaker containing 27 ml of distilled water and stir until homogeneous. Next, calibrate the pH meter by pressing the Cal button and dipping it into the pH buffer solution until it reaches pH 4 and pH 7. After that, dip the pH meter into distilled water for a few seconds, then into a sample of ground tilapia fillet. Wait until the pH reading stabilizes.

Data analysis

Analysis of pH (degree of acidity) data uses descriptive analysis, while TPC test data also uses descriptive analysis and is followed by curve fitting using Microsoft Excel. Next, to determine the maximum point of acceptance day limit, the roots of the polynomial regression equation were carried out using the Newton-Raphson method using MATLAB R2018a software.

RESULT

Total Number of Microbial Colonies

Testing for the number of bacterial colonies was carried out using the Total Plate Count (TPC) method. Knowing the number of microbes contained in fish fillets is an indicator to determine spoilage, whether or not a food product is suitable for consumption. The more rotten the fish, the greater the number of microbes contained in it. The number of bacterial colonies found on red tilapia filets after being soaked in fermented cassava skin solution and salt for 30 minutes stored at low temperature is presented in Table 1.

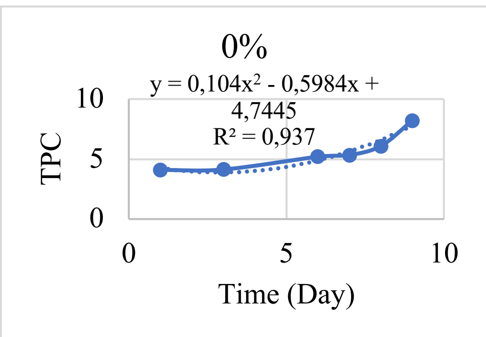
Table 1. Total Number of Bacterial Colonies from Each Soaking Red Tilapia Fillet Using a Fermented Solution of Cassava Peel and Salt During Low Temperature Storage (5°-10°C)

Day-to-Day Storage	Number of Bacteria (cfu/g) Red Tilapia Filet by Soaking Fermented Cassava Skin and Salt Solution			
	0%	2%	3%	4%
1	$1{,}2x10^4$	$4{,}6x10^3$	$4{,}5x10^3$	$5x10^3$
3	$1{,}3x10^4$	-	-	-
4	-	$1{,}9x10^4$	$1{,}8x10^4$	$2x10^4$
6	$1{,}5x10^5$	-	-	-
7	$2{,}1x10^5$	$2{,}8x10^5$	$1{,}3x10^5$	$3{,}5x10^5$
8	$\mathbf{1,2x10^6}$	$3{,}1x10^5$	$3{,}8x10^5$	$3{,}7x10^5$
9	$1{,}6x10^7$	$4{,}5x10^5$	$3{,}6x10^5$	$1{,}6x10^6$
10	*	$\mathbf{2x10^6}$	$1{,}6x10^6$	$\mathbf{2,9x10^6}$
11	*	$2{,}7x10^7$	$\mathbf{2,5x10^6}$	$1{,}7x10^7$
12	*	$5{,}4x10^8$	$2x10^8$	$1{,}7x10^8$

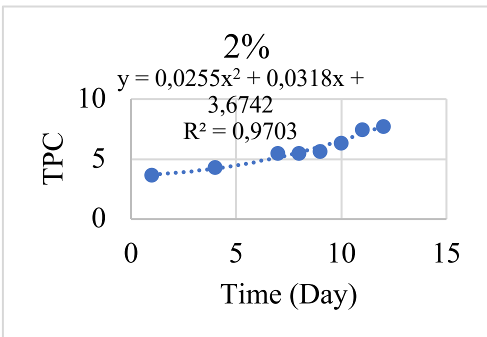
Information:
- - = TPC testing was not carried out
- • = TPC testing was not carried out because on the previous day the total number of microbes had reached the rejection limit

The total number of bacteria from all treatments for 12 days ranged from 1.2x10^4 cfu/g to 5.4x10^8 cfu/g and on the first day of storage ranged from 4.5x103 cfu/g to 1.2x10^4 cfu/g. Based on Conell (1990), bacterial colonies in food products that are safe for consumption are up to 10^6 cfu/g. Based on Table 1, it is known that when storing red tilapia filets by soaking in fermented cassava skin solution at low temperature storage, the storage limit (10^6) is different, namely at a salt concentration of 0% with a TPC value of 1.2x10^6 cfu/g of storage until the 8th day. , salt concentration 2%, with a TPC value of 2x10^6 cfu/g storage until the 10th day, salt concentration 3%, with a TPC value of 2.5x10^6 cfu/g storage until the 11th day, salt concentration 4%, with a TPC value of 2 .9x10^6 cfu/g storage until the 10th day

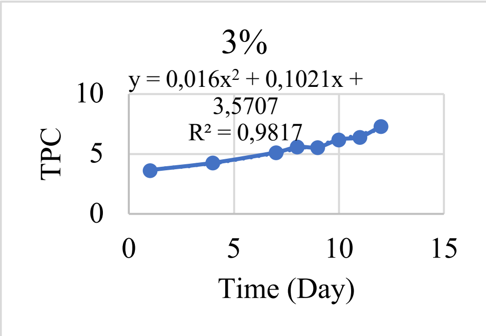
Completion of the system of polynominal regression equations resulting from curve fitting is continued with the Newton Rapshon method using the Matlab application which produces the x value, namely the square root value which is the value of the time (days) where it reaches the critical value or maximum point value of TPC (10^6). The following is Figure 1 of the results of the fitting curve in each treatment:



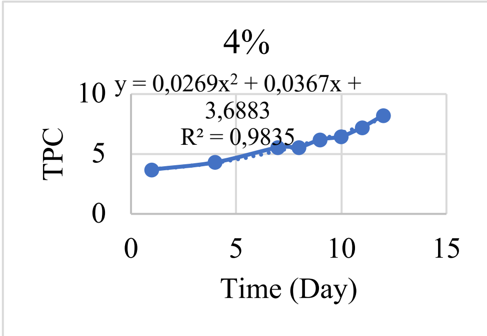
(a) Salt Concentration 0%



(b) Salt Concentration 2%



(c) Salt Concentration 3%



(d) Salt Concentration 4%

Figure 1. Fitting Curve Graph for Each Concentration

Based on the results of creating Figure 8, the fitting curve of the relationship between time (days) and the TPC data results, we obtained a polynomial regression equation and produced data resulting from Newton Raphson calculations. Based on the results of Newton Raphson calculations using the Matlab application, the optimal storage time (days) according to the maximum point of the fitting curve is 0% salt concentration, the square root value of x = 8.2509 is obtained or has a storage limit of up to 8 days 8 hours, salt concentration is 2% value square root x = 10.8138 or has a storage limit of up to 10 days 19 hours, a salt concentration of 3%, the value of the square root of x = 11.7931 or a storage limit of up to 11 days 19 hours, and a salt concentration of 4%, the value of the square root of x = 10, 4344 or has a storage limit of up to 10 days and 10 hours. Based on the modeling results, the shelf life of red tilapia filets by soaking in fermented cassava peel solution and salt at low temperature storage obtained the longest shelf life when the salt concentration was added to 3%.

Degree of Acidity (pH)

The pH value is one of the parameters that can determine the level of acidity in fish fillets which can then be used as a parameter for the level of freshness in fish fillets. The pH test in the research is supporting data for the growth of bacteria in red tilapia fillets. The results of testing the pH of red tilapia fillets by soaking in a fermented solution of cassava skin and salt during low temperature storage can be seen in Table 2.

Table 2. Average Value of the Degree of Acidity for Each Red Tilapia Fillet Soaking Using Cassava Peel Fermentation Solution During Low Temperature Storage

Day-To Storage	Salt Concentration in Cassava Peel Fermentation Solution (%)			
	0	2	3	4
1	6,2	6,3	6,15	6,25
3	5,7	-	-	-
4	-	5,85	5,8	5,9
6	6,0	-	-	-
7	6,25	6,1	5,95	6,1
8	6,4	6,2	6,0	6,25
9	**6,5**	6,35	6,1	6,3
10	*	6,4	6,35	6,45
11	*	**6,45**	6,4	**6,55**
12	*	6,75	**6,5**	6,8

Information:

- = no pH measurement was carried out
• = pH measurements were not carried out because on the previous day the total number of microbes had reached the rejection limit

Based on the results of the polynomial regression calculation modeling and completed by the Newton Rapshon method, the acceptable pH is related to the results of the TPC (106) acceptance limit, namely a salt concentration of 0%, a storage limit of up to 8 days and 8 hours with a pH value of 6.5, a salt concentration of 2% for up to 10 days. 19 hours with a pH value of 6.45, 3% salt concentration up to 11 days 19 hours with a pH value of 6.5, 4% salt concentration up to 10 days 10 hours with a pH value of 6.55. The research results based on Table 6 explain that the value of tilapia fillets soaked in a fermented solution of cassava skin and salt during 12 days of storage has varying values ranging from 5.7-6.8.

DISCUSSION

Total Number of Bacterial Colonies

Based on research results, all red tilapia filet treatments have an acceptance limit of more than 5 days, in accordance with the statement by Liviawaty & Afrianto (2010), which revealed that tilapia stored at a temperature of 5°C has a shelf life of around 5-6 days, which means that this soaking is successful. being a natural preservative and influencing the growth of microbial numbers even with different reception days. The contents of cassava skin during fermentation have the potential to be used as prebiotics because they contain quite high amounts of oligosaccharides and crude fiber, which can be nutrients for lactic acid bacteria to grow. According to Selviana et al. (2019), cassava peel contains oligosaccharides in the form of 0.12% inulin, 0.003% maltopentose, 0.06% raffinose, 1.99% mannose, 1.39% sucrose and 0.01% arabinose, the oligosaccharides contained in cassava peel can fermented by lactic acid bacteria and can be used as a starter to provide nutrients for microbial development.

Red tilapia filets soaked in fermented cassava peel solution without adding 0% salt have the fastest storage time, namely up to 8 days 8 hours with a TPC value of $1.2x10^6$ cfu/gram. The use of cassava peel fermentation solution without the addition of salt or 0% cannot grow optimally, which results in the growth of putrefactive bacteria at a salt concentration of 0% increasing compared to other treatments, because salt is important in the fermentation process which has the function of inhibiting the growth of undesirable types of microorganisms. and for lactic acid as an environmental control. The working mechanism of the cassava peel and salt fermentation solution which produces lactic acid bacteria is by attracting liquid to the vegetable tissue and then reducing the water content of the food so that it can inhibit the growth of spoilage microorganisms (Kusnandar, 2011).

The concentration with the longest storage limit is 3% salt concentration, namely 11 days 9 hours with a TPC result of $2.5x10^6$ cfu/gram, this shows that the addition of 3% salt is able to inhibit the growth rate of bacteria for the longest compared to other treatments according to research by (Setiawan et al., 2013) the optimal salt concentration in fermented vegetables and fruit is between 2-3%, where the appropriate salt concentration has more optimal effectiveness and function, will stimulate the growth of LAB and suppress the growth of unwanted bacteria. The storage limit for a salt concentration of 2% with a TPC value of $2x10^6$ cfu/gram is 10 days 19 hours, this is because the lower the salt concentration, the higher the water content and not as many nutrients and water is attracted by small amounts of salt (Nakdiyani & Batubara, 2019). A salt concentration of 4% with a TPC value of $2.9x10^6$ cfu/g has a storage limit of up to 10 days and 10 hours, in accordance with research by Barani et al. (2023), fermented water gourd kimchi with the addition of salt concentration with the result that total LAB in water gourd kimchi with a salt concentration of 4% had less total LAB than other treatments.

Based on the results of observations during the research, it shows that even though natural preservatives have been given, namely soaking in a fermented solution of cassava peel and salt and storing at low temperatures (5˚-10°C), not only LAB grows but there is also a population of putrefactive bacteria and it is suspected that there are types of bacteria that can live in cold temperatures which can reduce the quality of red tilapia fillets. The groups of bacteria that can spoil food in the refrigerator are psychrophilic and psychrotrophic bacteria (Supardi & Sukamto, 1999). Another factor in increasing the total bacterial content in red tilapia fillets during storage is because fish flesh is an excellent substrate for bacteria because it provides compounds that can be a source of nitrogen, carbon and other nutrients for their living needs (Hidayah et al., 2015).

Degree of Acidity (pH)

The pH value on the 1st day of observation ranged from 6.15–6.3 which can be seen that the value was still high before finally decreasing, because on the 1st day the fillet was still adjusting because it had just undergone a change from fresh fish to fillet in accordance with the statement Liviaawaty, (1999) stated that the initial pH value of freshwater fish death was around 6.17-7.04, another factor was also that soaking in fermented cassava peel solution as a natural preservative had no real effect on its absorption of the pH of red tilapia fillets on the 1st day of storage.

On the third and fourth days, the pH of the red tilapia filet decreased to become more acidic, ranging from 5.7-5.9, this was due to chemical changes in the fish flesh starting with a decrease in pH which occurred due to the activity of the glucokinase enzyme in the fish's body. This enzyme breaks down glycogen into lactic acid which plays a role in reducing the pH of fish meat (Afrianto et al., 2014). Apart from that, it forms organic acids, especially lactic acid, which grows optimally as a natural preservative. Seen from Table 2, the pH value using the addition of salt (2%, 3%, 4%) has a lower acceptable pH value compared to the control treatment. This is influenced by the presence of LAB activity which is more effective when salt is added in the fermentation process because it has the ability to lower the pH. The addition of salt not only functions as a preservative agent but also helps in creating optimal environmental conditions for LAB growth, which in turn increases acid production and results in a significant decrease in pH. In accordance with research by Suprihatin & Dyah (2013), lactic acid can be obtained from the fermentation process of cabbage waste, namely the lactic acid produced can lower the pH and increase the acidity so that it can function as an ingredient to inhibit the growth of microorganisms.

Based on Table 6, the pH value of red tilapia fillet based on the day of receipt, the number of microbes (10^6) is still classified as fresh, namely 0% salt concentration with a pH value of 6.5, 2% salt concentration with a pH value of 6.45, 3% salt concentration. with a pH value of 6.5 and a salt concentration of 4% with a pH value of 6.55 in accordance with the statement which states that the pH value of fresh fish meat is in the range of 5.8–6.6 or close to a neutral pH value of 7.0 (Fadhli et al., 2022). It is determined that the fillet is still fresh and can be consumed because the pH conditions are still good for the growth of LAB even though spoilage bacteria have started to grow. According to research by Oktaviani (2004), the pH value of red tilapia filets given L. plantarum stored at low temperatures ranged from 5.95 to 6.90. This proves that in this study, based on the pH value, it was still suitable for consumption on the acceptance limit day. Determination of the shelf life of red tilapia filets based on the pH value, apart from being based on the storage days limit (10^6), was also supported when the aroma test of red tilapia filets still had a neutral odor and no different odor was detected.

On the day after the acceptance limit, the quality of the tilapia filets began to decline due to the growth of lactic acid decreasing due to being unable to compete with spoilage bacteria which had increased and the acceptance was rejected and could not be consumed. For 0% salt concentration after the storage limit day it has a pH value > 6.5, 2% salt concentration has a pH value of 6.75, 3% salt concentration has a pH value > 6.5 and 4% salt concentration has a pH value of 6.8 in accordance with the optimum range of pH values for the growth of putrefactive bacteria ranging from 6.5 to 7.5 (Fardiaz, 1992). This increase in pH is related to glycogen reserves in the fish's body. Apart from that, the pH of red tilapia fillets increases during storage due to the evaporation of important compounds and preservatives (Berhimpon, 1995). The decrease in quality, apart from increasing pH, is accompanied by a change in different aroma, this is because the amount of ammonia is increasing, besides that the fat oxidation process produces an undesirable rancid aroma and changes the color of the meat to brown (Junianto, 2003).

Recapitulation of Research Results

Packaging the tilapia fillets using plastic wrap and storing them in the refrigerator at a low temperature (5˚-10ºC) is done to reduce the dominance of external factors, but it must also be given natural preservatives so that the quality does not decline quickly and can be inhibited which will result in a longer shelf life. long. Based on the results of the TPC test and the degree of acidity (pH), the acceptance day limit based on the TPC and pH test parameters can be seen in Table 3.

Table 3. Overall Observation Results of Red Tilapia Filet

Observation	Salt Concentration			
	0%	2%	3%	4%
Reception Day Limit for Total Bacterial Colonies Based on TPC (10^6)	8 days	10 days	11 days	10 days
Reception Day Limit for Total Bacterial Colonies Based on Newton Raphson	8 days 8 hours	10 days 19 hours	11 days 19 hours	10 days 10 hours
Number of Microbes at Acceptance Limit (10^6)	$1{,}2x10^6$	$2x10^6$	$2{,}5x10^6$	$2{,}9x10^6$
Acceptance Limits for Degrees of Acidity (pH) Based on Newton Raphson	6,5	6,45	6,5	6,55

Based on Table 3 on the storage of red tilapia filets based on research conducted by soaking in fermented cassava skin solution for 30 minutes and storing at a low temperature of 5˚-10ºC, it has been proven to be effective in preserving or inhibiting spoilage in all salt addition treatments, namely having a storage limit or still being able to be consumed based on the results. TPC (10^6) until days 8, 10 and 11. In accordance with Diyamtoro's statement (2008) and at a temperature of 5ºC it lasts for 5-6 days. This means that the storage provided by the cassava peel fermentation solution lasts for 2-5 days.

Based on calculations using the Newton Raphson method to find out in detail the time based on the relationship between TPC results and storage time, the results obtained were, treatment with a salt concentration of 0%; 8 days 8 hours with a TPC value of $1.2x10^6$ cfu/g and a pH value of 6.5, salt concentration of 2%; 11 days 7 hours with a TPC value of $2x10^6$ cfu/g and a pH value of 6.45, salt concentration of 3%; 11 days 19 hours with a TPC value of

2.55x10^6 cfu/g and a pH value of 6.5, salt concentration of 4%; 10 days 10 hours with a TPC value of 2.9x10^6 cfu/g and a pH value of 6.55.

During storage, red tilapia filets will continue to experience a decrease in freshness until they finally rot and rapid degradation will result in a short shelf life. The reduction in freshness in fillets cannot be stopped, but can be slowed down by using natural preservatives. This research uses a fermented solution of cassava peel and salt which produces lactic acid bacteria. LAB is a microorganism that is safe to add to food because it is non-toxic and does not produce toxins. BAL is able to produce lactic acid as the final product of carbohydrate breakdown, as well as produce hydrogen peroxide and bacteriocin (Afrianto e al., 2006).

The longer the storage period, the quality of red tilapia fillets decreases due to the presence of microorganisms, enzyme activity and oxidation within the fish's body. The spoilage process is related to the length of storage period and an increase in the number of microbes in tilapia fillets which will result in the pH of the fillets also tending to increase. This shows that microbial activity during storage contributed significantly to the increase in pH of tilapia fillets. Murniyati & Sunarman (2000) stated that bacterial action begins almost simultaneously with autolysis, where microbes convert amino acids from protein autolysis into ammonia, and carbohydrates into alkaline ammonia. When the pH becomes alkaline, the activity of lactic acid bacteria will decrease and then it will stop.

Determination of shelf life using salt concentration in this study was based on the observed parameters, namely total bacterial colonies and degree of acidity (pH). The best results in this study were with the addition of 3% salt concentration because at the acceptance limit TPC (10^6) had a longest shelf life of up to 11 days. 19 hours compared to other treatments. Red tilapia filets soaked in fermented cassava skin with the addition of 3% salt had a total bacterial colony of 2.5x10^6 cfu/g and a pH value of 6.5.

CONCLUSION

Based on the research results, it can be concluded that soaking red tilapia filets using a fermented cassava skin solution and adding a salt concentration of 3% of the weight of cassava skin can have the best effect on the shelf life of red tilapia fillets during low temperature storage. Cassava peel fermentation solution with a salt concentration of 3% is able to extend the shelf life, namely with an acceptance limit of up to 11 days 19 hours with a bacterial count of 2.5 x 10^6 and a pH value of 6.65 based on the Total Plate Count test and degree of acidity.

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