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EFFECTIVENESS OF LACTIC ACID BACTERIA SOLUTION CHALLENGE TEST BY USING DIFFERENT ENVIRONMENTAL CONTROLS CAVENDISH BANANA PEEL FERMENTATION RESULTS AGAINST MACKEREL FISH REVERSE BACTERIA

Efektivitas Uji Tantang Larutan Bakteri Asam Laktat dengan Menggunakan Pengendali Lingkungan Berbeda Hasil Fermentasi Kulit Pisang Cavendish Terhadap Bakteri Pembusuk Ikan Kembung

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ABSTRACT

Mackerel has an economical price, high market demand, and high catch yields so that it is widely used by the wider community compared to other types of pelagic fish, but it has disadvantages, namely that it is highly perishable because after being caught, the fish still undergoes a series of change processes before becoming rotten. Lactic acid bacteria can be applied to preserve fishery products by immersing them in a culture of lactic acid bacteria derived from fermentation. Cavendish banana peel fermentation contains secondary metabolite compounds that have the potential to be antimicrobial, anticancer and antidemartosis. Cavendish banana peels contain flavonoids, alkaloids, tannins, saponins and quinones. This research aims to determine the concentration of environmental controls between salt and vinegar in the Lactic Acid Bacteria fermentation solution from Cavendish banana peels which can provide effectiveness. lactic acid bacteria against mackerel spoilage bacteria. This research was carried out at the Fishery Products Processing Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University in January 2024. This research was carried out by testing Lactic Acid Bacteria from the fermented solution of Cavendish banana peels and spoilage bacteria from mackerel that was soaked for 15 minutes. using paper discs with 3 treatments and 9 repetitions. Observations were made at the 48th hour after incubation at a storage temperature in an incubator of 37^{o}C covering the diameter of the clear zone around the paper disc. The calculation results for estimating the addition of the best environmental control concentration were carried out by analyzing the data using the simultaneous F test followed by the Duncan test. The research results show that the best environmental control concentration addition for Cavendish banana peel fermentation as a source of Lactic Acid Bacteria against mackerel spoilage bacteria to extend shelf life is the addition of 3% salt with a pH of 4.4, a clear zone diameter of 21.37 mm and an effectiveness of 34 .1% which is categorized as very strong.

Keywords: Environmental Control, Challenge Test, Clear Zone, Spoilage Bacteria

ABSTRAK

Ikan kembung memiliki harga yang ekonomis, permintaan pasar tinggi, dan hasil tangkapan tinggi sehingga banyak dimanfaatkan oleh masyarakat luas dibandingkan dengan jenis ikan pelagis lainnya namun memiliki kekurangan, yaitu mudah rusak (*highly perishable*) karena setelah penangkapan, ikan masih mengalami serangkaian proses perubahan sebelum menjadi busuk. Bakteri asam laktat dapat diaplikasikan pada pengawetan produk perikanan dilakukan dengan perendaman pada kultur bakteri asam laktat yang berasal dari hasil fermentasi. Fermentasi kulit pisang *Cavendish* memiliki senyawa metabolit sekunder yang berpontesi sebagai antimikroba, antikanker, maupun antidemartosis. Kulit pisang *Cavendish* mempunyai kandungan seperti flavonoid, alkaloid, tanin, saponin dan kuinon. Riset ini bertujuan untuk menentukan konsenterasi pengendali lingkungan antara garam dan cuka pada larutan fermentasi Bakteri Asam Laktat (BAL) dari kulit pisang Cavendish yang dapat memberikan efektivitas bakteri asam laktat terhadap bakteri pembusuk ikan kembung. Riset ini dilaksanakan di Laboratorium Pengolahan Hasil Perikanan Fakultas Perikanan dan Ilmu Kelautan Universitas Padjadjaran pada bulan Januari 2024. Riset ini dilakukan dengan uji tantang Bakteri Asam Laktat yang berasal dari larutan fermentasi kulit pisang Cavendish dan bakteri pembusuk yang berasal dari ikan kembung yang direndam selama 15 menit menggunakan kertas cakram dengan 3 perlakuan dan 9 ulangan. Pengamatan dilakukan pada jam ke-48 setelah inkubasi dengan suhu penyimpanan pada inkubator 37^{o}C meliputi diameter zona bening disekitar kertas cakram. Hasil perhitungan pendugaan penambahan konsenterasi pengendali lingkungan terbaik dilakukan dengan menganalisis data menggunakan uji F simultan dilanjutkan dengan uji Duncan. Hasil riset menunjukkan bahwa penambahan konsenterasi pengendali lingkungan terbaik bagi fermentasi kulit pisang Cavendish sebagai sumber Bakteri Asam Laktat melawan bakteri pembusuk ikan kembung untuk memperpanjang masa simpan adalah penambahan garam 3% dengan pH 4,4, diameter zona bening 21,37 mm dan efektivitas sebanyak 34,1% yang dikategorikan sangat kuat.

Kata Kunci: Bakteri Pembusuk, Pengendali Lingkungan, Uji Tantang, Zona Bening

INTRODUCTION

Mackerel is a fish that has important economic value and is widely consumed because it has high nutritional content. This is in accordance with research by Safrida *et al.* (2012), the protein content in mackerel meat is high (18.5%). The nature of marine and fishery products is highly perishable because after being caught, fish still undergo a series of changes before they become rotten. Naturally, the rotting process in fresh fish will take place in 3 – 7 days depending on the species, equipment or fishing method (Mahatmanti *et al.*, 2007). This is because the high water, protein and fat content in the fish's body is a suitable medium for the growth of putrefactive bacteria or other microorganisms.

Lactic Acid Bacteria can be applied to preserve fishery products by immersing them in lactic acid bacterial cultures derived from fermentation (Adhayanti *et al.,* 2018). Lactic Acid Bacteria can convert water-soluble carbohydrates to form lactic acid (Ratnakomala *et al.,* 2006). The lactic acid formed has the function of lowering the pH to pH 3 during the fermentation process and functions as a preservative which can inhibit the growth of spoilage microorganisms.

Fermentation of banana peels can produce lactic acid bacteria characterized by a yellow fermentation liquid. Proof of the presence of lactic acid bacteria in fermentation can be seen from the pH during fermentation (Khoriyah & Ardiningsih, 2014). Fermentation environmental control is intended to create environmental conditions where spoilage microbes cannot live, while fermentation microbes grow and develop well (Suprihatin, 2010). Salt (NaCl) and vinegar are ingredients that are widely used to control the fermentation process in various types of fishery products (Gao *et al.,* 2020). Environmental control can be carried out by adding

NaCl, acid compounds or LAB starter to the fermentation solution. The addition of up to 5% NaCl to the fermentation solution can create suitable environmental conditions for LAB to grow and reproduce. The addition of acid compounds will cause a decrease in the degree of acidity (pH) reaching an acidic pH of 3 in organic waste media so that it is suitable for LAB but not suitable for spoilage microbes (Meiliawati, 2017). Cavendish banana peel fermentation contains secondary metabolite compounds that have the potential to be antimicrobial (Supriati *et al.,* 2015), anticancer and antidemartosis (Atun *et al.,* 2007). This is because banana peels contain ingredients such as flavonoids, alkaloids, tannins, saponins and quinones (Saraswati, 2005). The carbohydrate content in Cavendish banana peel is 20% (Sukasih, 2018). The glucose content which is still quite high in banana peels is one of the main components in lactic acid fermentation.

The inhibitory power of an antimicrobial substance can be tested for its activity. Testing the antimicrobial activity of a compound or substance is intended to determine the substance's ability to inhibit growth or even kill certain microbes (Sulistijowati, 2015). According to Tortora *et al.* (1998), the antimicrobial activity test can be carried out using the paper disc diffusion method (Kirby Bauer). There are three mechanisms that can be used by antagonistic microbes to inhibit the activity of spoilage microbes, namely causing competition for food and space; environmental control; and secondary metabolite products.

Observations of pH in preliminary research showed that Cavendish banana peels were fermented the control treatment was 4.0, the addition of 3 % salt concentration on day 5 produced a pH of 4.2, while the fermentation of Cavendish banana peels with the addition of 1% vinegar solution produced a pH value of 3.8. The nature of lactic bacteria grows at an optimum pH of 5.5 - 6.5 (Abdel-Rahman *et al*., 2013; Nousiainen *et al.,* 2004). Growth of lactic acid bacteria on Cavendish banana peel waste in the preliminary research, total exponential phase of lactic acid bacteria in the control was 13.5 x 10^6 CFU/ml at a salt concentration of 3% on day 5 it was 14.2 x 10^6 CFU/ml. Addition of 1% vinegar concentration of 14.6 x 10^6 CFU/ml.

Testing the effectiveness of lactic acid bacteria (LAB) from fermented banana peels using the disc paper diffusion method (Kirby Bauer) was carried out to determine the antibacterial ability against spoilage bacteria in mackerel after they rot. Based on the background above, the problem that can be identified is which environmental controller is the best for the Lactic Acid Bacteria (LAB) fermentation solution from Cavendish banana peels to provide the effectiveness of lactic acid on mackerel spoilage bacteria so the aim of this research is to determine the most environmental controller. both in the fermentation solution of Lactic Acid Bacteria (LAB) from Cavendish banana peels in order to provide the effectiveness of lactic acid bacteria against mackerel spoilage bacteria.

METHODS

Place and Time

This research was carried out at the Fisheries Product Processing Technology Laboratory at the Faculty of Fisheries and Marine Sciences, Padjadjaran University. When this research was carried out in January until February 2024.

Tools and Materials

The main equipment used to calculate the diameter of the disc is a caliper, pen, paper and ruler as a tool to record the diameter of the resulting clear zone. The materials used in this research were Cavendish banana peel waste, salt, vinegar, distilled water, alcohol, spirits, rotten mackerel (*Restrelliger branchisoma*) as the main ingredients in making fermentation solutions and inoculating putrefactive bacteria. Apart from that, this research also requires paper discs or blank disks, Nutrient Agar, tissue, cotton, brown paper, plastic wrap, aluminum foil and labels.

Research Design

The method used in this research is an experimental method. The experimental method is research that is systematic, thorough and logical to control a condition. Researchers manipulate stimuli, experimental circumstances or conditions, and observe the effects of treatment. In general, the aim of this research is to test the proposed hypothesis, predict experimental events and draw generalizations about the relationship between variables (Winarni, 2018). with the resulting data, the average diameter of the clear zone was analyzed using the F test statistic, then if there were differences, it was continued with the Duncan test with 3 treatments and 9 replications, the average value for each treatment was taken. that is:

- A : Test the challenge of spoilage bacteria for mackerel by soaking it in fermented Cavendish banana peels without the addition of fermentation environmental controllers (control)
- B : Challenge of spoilage bacteria for mackerel by soaking in fermented Cavendish banana peels with the addition of 3% salt
- C : Test to challenge spoilage bacteria for mackerel by soaking in fermented Cavendish banana peels with the addition of 1% vinegar.

The addition of 3% salt produces an optimal pH because adding salt that exceeds a concentration of 5% can also kill good bacteria so that fermentation cannot take place more optimally. The final concentration of salt usually given in the fermentation process is 2-5% (Hong *et al.,* 2021). Meanwhile, the addition of vinegar used in vegetable fermentation is no more than 5% (Adam *et al.,* 2014).

Hypothesis

The hypothesis in this research is that environmental controls are the most effective in the fermentation solution for Lactic Acid Bacteria (LAB) from Cavendish banana peels against spoilage bacteria for mackerel is the addition of 1% vinegar.

RESULT

Cavendish Banana Peel

The results of measuring the average pH of Cavendish banana peel fermentation waste in each treatment on day 5 with 9 replications are shown in Figure 1 following.

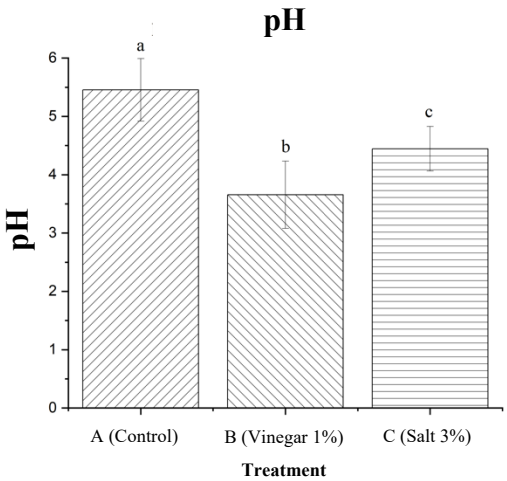


Figure 1. Measurement Results of the Average Degree of Acidity of Cavendish Banana Peel Fermentation Solution

Clear Zone Diameter

Cavendish banana peel fermentation solution can be seen in Table 1 below.

Table 1. Clear Zone Diameter Numbers of Cavendish Banana Peel Fermentation Solution Against Bacterial Spoilage of Mackerel Fish

Test	Control	Vinegar 1%	Salt 3%
1	6,10	14.55	21.33
2	4.91	11.67	24.69
3	5.99	12.27	23.77
4	5.80	10.00	20.62
5	6.64	10.08	20.67
6	7.18	13,16	21.43
7	6.91	8.72	20.23
8	6.53	9.97	20.38
9	6.41	9.22	19,21
Average	6.27	11.07	21.37
Interpretation	Currently	Strong	Very Strong

The average observation results of the diameter of the clear zone of the Cavendish banana peel fermentation solution against spoilage bacteria can be seen in Figure 2 below.

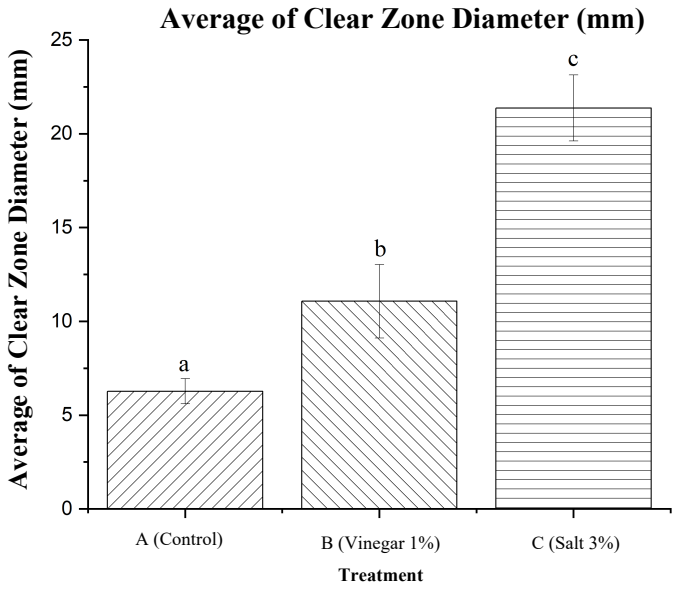
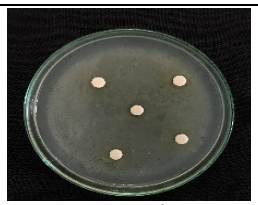
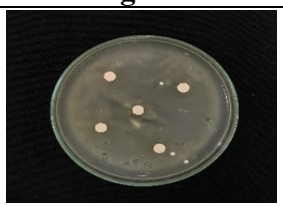
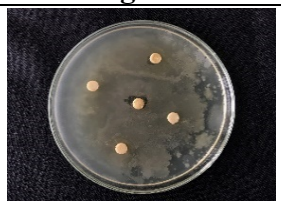
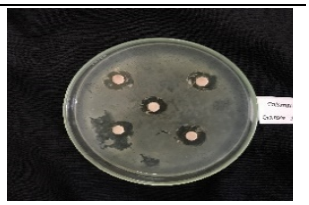
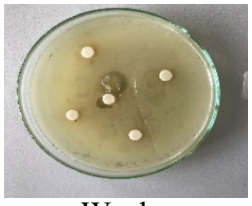
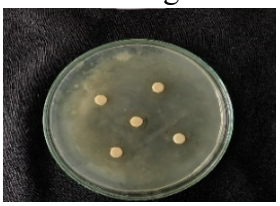
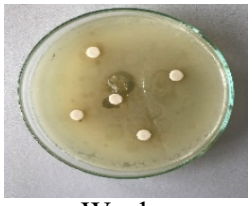
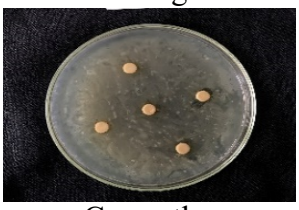
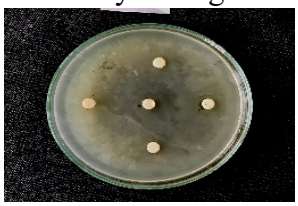
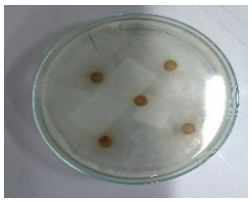
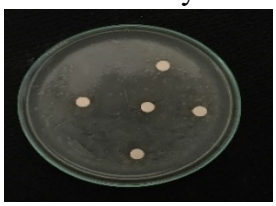
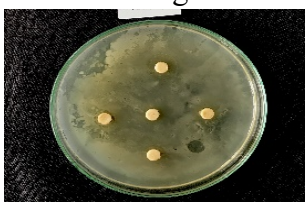
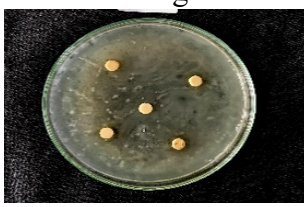
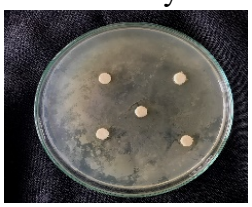
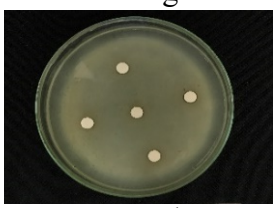


Figure 2. Average Observation Results of Clear Zone Diameter of Cavendish Banana Peel Fermentation Solution Against Bacterial Putrefaction for Mackerel

The results of the clear zone diameter from this research can be seen in table 2 below.

Table 2. Observation Results of Clear Zone Diameter

Test	**Control**	**Vinegar 1%**	**Salt 3%**
1			
	Currently	Strong	Strong

Test	Control	Vinegar 1%	Salt 3%
2			
	Weak	Strong	Very Strong
3			
	Weak	Strong	Very Strong
4			
	Weak	Currently	Strong
5			
	Currently	Currently	Strong
6			
	Currently	Strong	Strong
7			
	Currently	Currently	Strong
8			
	Currently	Currently	Strong
9			

Test	Control	Vinegar 1%	Salt 3%
	Currently	Currently	Strong

The Antibacterial Effectiveness of Lactic Acid Bacteria Resulting from The Fermentation of Cavendish Banana Peels and The Addition of Environmental Control Against Spoilage Bacteria for Mackerel (*Rastrelliger* sp.).

Cavendish banana peel fermentation against mackerel spoilage bacteria can be seen in Table 2 below.

Table 2. Effectiveness Numbers of Clear Zone Diameter of Cavendish Banana Peel Fermentation Solution Against Spoilage Bacteria for Mackerel

Treatment	Concentration	Average Zone of Inhibition (mm)	Effectiveness (%)
A (Control)	0%	6.27	1
B (Vinegar)	1%	11.07	17.6
C (Salt)	3%	21.37	34.1

DISCUSSION

Cavendish Banana Peel

Cavendish banana peel fermentation solution with the addition of different environmental controls had a significant effect ($P<0.05$) on the pH value. The decrease in pH during fermentation is influenced by microbial growth. The fermentation duration of 5 days shows that the total bacteria have increased because during fermentation the microbes will produce acidic conditions which cause the pH to decrease. The average value of the degree of acidity in the 3% salt addition treatment was 4.4. The nature of lactic bacteria grows at an optimum pH of 3.5 – 6.5 (Abdel-Rahman *et al*., 2013; Nousiainen *et al.,* 2004). Prolonged fermentation treatment will cause the pH to decrease further due to LAB activity in breaking down carbohydrates into lactic acid.

The results of the research, which shows the relationship between the addition of environmental controls and the acidity levels obtained, are presented in Figure 7. It can be seen that on average, with the addition of 3% salt, lactic acid increased until the 5th day, namely 4.4. As fermentation time increases, lactic acid bacteria continue to grow and reproduce so that the enzyme lactic dehydrogenase produced increases and more lactic acid is produced. The same trend in Figure 7 shows variations in substrate concentration, namely lactic acid which is formed the most or the optimum treatment is 3% salt with a result of 4.4, followed by control, namely 5.5 and finally the addition of 1% vinegar, 6.4. The decrease in pH that occurs in agar media directly or due to the production of bacteriocins is an important factor in inhibiting the growth of putrefactive bacteria. H_2O_2, one of the metabolic products of lactic acid bacteria, can also inhibit the growth of spoilage microbes (Rujiah & Apriyanto, 2017).

In the vinegar treatment, 1% acetic acid is produced by the activity of Acetobacter aceti. These bacteria are aerobic in nature, where to obtain energy, microbes use glucose or other organic substances as a substrate to be oxidized into carbon dioxide and water (Waluyo, 1984). According to Mappiratu & Bakhri (2013), the initial stage of alcohol oxidation will produce acetaldehyde and the next stage will produce vinegar or acetic acid. According to Daulay & Rahman (1992), vinegar has a long shelf life due to its acetate content. Acetic acid can inhibit the growth of spore-forming bacteria that cause food poisoning and can prevent methoxin-producing mold. The results of measuring the average pH of 1% vinegar were 6.4. This is due to the long fermentation time. The length of fermentation time will affect the fermented product produced. A fermentation time that is too short will produce little product because the substrate is not completely degraded, while a fermentation time that is too long will result in acetic acid being oxidized to carbon dioxide and water. In the Cavendish banana peel fermentation

process, if it is allowed to continue, the acetic acid level will decrease. This is caused by acetic acid which is further oxidized to CO_2 and H_2O. Muafi (2004) states that acetic acid under optimal conditions at a certain time, bacterial activity has begun to decrease along with the reduction in substrate, resulting in a decrease in acetic acid levels because acetic acid has been further oxidized to CO_2 and H_2O.

In the 3% salt treatment, the salt concentration will affect the pH level along with the fermentation rate. The organic acid content produced due to the addition of Lacto Acid bacteria resulted in a rapid decrease in the pH of the Cavendish banana peel fermentation solution. The decrease in pH during fermentation can occur more slowly and occurs gradually, which can stabilize acidity that is too high so that it remains safe for consumption and does not interfere with digestion in the body (Chang *et al.,* 2011). The addition of 3% salt produces an optimal pH because adding too much salt can kill good bacteria so that fermentation cannot take place more optimally. The final concentration of salt usually given in the fermentation process is 2-5% (Hong *et al.,* 2021). The addition of salt in the fermentation process will also significantly influence the compounds that will produce amino acids, peptides, volatile compounds, acid compounds, sugars and metabolite compounds (such as carbohydrates, proteins and lipids) (Lee *et al.,* 2022). Fermented Cavendish banana peels made with salt have better sensory properties than fermented Cavendish banana peels with vinegar. This may be caused by differences in the proportions of Lactic Acid Bacteria and coccus type yeast, the two most important groups of microorganisms for fermentation that produces Lactic Acid Bacteria.

Clear Zone Diameter

Based on the results of Duncan's further tests, it was found that the treatment with the addition of the 3% salt environmental controller was significantly different from the treatment with the addition of the 1% vinegar environmental controller and the control at a significance level of 5%. This means that the 3% salt treatment is significantly different from all treatments at the 5% significance level. The observation results show that all lactic acid bacteria from all treatments resulting from fermentation Cavendish banana peel is able to inhibit the growth of bacteria that spoil mackerel (*Rastrelliger* sp.). According to Davis & Stout (1971), the classification of bacterial growth inhibitory responses has an interpretation that if the inhibitory zone <5 mm is said to be weak, 5-10 mm is said to be moderate, 11-20 mm is said to be strong and >20 mm is said to be a very strong inhibitory response . Soaking the control treatment of Cavendish banana peel fermentation solution , 1% vinegar and 3% salt shows that there is an inhibition zone in the Cavendish banana peel fermentation solution. with an average diameter of the inhibition zone of 6.27 mm; 11.07 mm and 21.37 mm with medium resistance response; strong and very strong. The smallest inhibitory zone was in the control treatment with an average clear zone diameter of 6.27 mm (medium) and the largest inhibitory zone was in the 3% concentration salt treatment with an average clear zone diameter of 21.37 (very strong). The higher the concentration of environmental controls that are suitable for Lactic Acid Bacteria in fermentation, such as adding 3% salt which is close to the optimal pH for the growth of Lactic Acid Bacteria, the greater the active compound content, thus the larger the area of the inhibition zone formed (Putri, 2021).

In line with research by Eldo & Theopillus (2015) who conducted research on the inhibitory test of kepok banana peel fermentation on the growth of *Staphylococcus aureus* bacteria, it was shown that kepok banana peels were effective against bacterial growth. *Staphylococcus aureus* appears to have an inhibitory response from the fermentation of kepok banana peel with the average inhibition zone at a concentration of 25% being 5 mm, at a concentration of 50% being 10 mm and at a concentration of 75% being 16 mm. There are differences in the level of inhibition of various concentrations because the higher the

concentration of kepok banana peel fermentation , the greater the active ingredient content, so that the area of the inhibition zone formed is also greater.

Cavendish banana peel contains flavonoids which function as antioxidants which are able to prevent oxidation of body cells (Utami, 2013). According to Sabir (2005), it is stated that flavonoids cause damage to the permeability of bacterial cell walls, microsomes and lysosomes as a result of the interaction between flavonoids and bacterial DNA. According to Naim (2004), flavonoids have lipophilic properties so they may damage bacterial cell membranes. Other research proves that flavonoids disrupt cell membrane permeability and inhibit the binding of ATPase and phospholipase enzymes. The antibacterial mechanism of flavonoids is by inhibiting energy metabolism, namely by inhibiting the use of oxygen by bacteria. Flavonoids inhibit cytochrome C reductase so that metabolic processes and macromolecular biosynthesis are hampered (Cushnie, 2005).

Tannin compounds related to its ability to inactivate microbial adhesins, enzymes and transport proteins on saponin cell membranes which can cause leakage of proteins and enzymes from inside the cell. According to Cowan (1999), the antibacterial ability of tannins is related to the transport of cell covering proteins. Tannins also form complexes with polysaccharides. The mechanism of saponin's action as an antibacterial is by causing leakage of proteins and enzymes in cells. Saponin compounds are antibacterial because their surface active substances are similar to detergents, as a result saponin will reduce the surface tension of bacterial cell walls and damage membrane permeability. Saponin diffuses through the outer membrane and vulnerable cell walls then binds to the cytoplasmic membrane, disrupting and reducing the stability of the cell membrane. This causes the cytoplasm to leak out of the cell, resulting in cell death (Rijayanti, 2014).

The clear zone in the area of the paper disc in each treatment proves that the Cavendish banana peel fermentation solution in the control treatment, the addition of 1% vinegar and 3% salt has antibacterial compounds such as bacteriocin which has a single inactivation which mean One molecule Bacteriocins will kill a cell bacteria indicator. Bacteriocins also prevent the synthesis of intact peptidoglycan, thus cell walls bacteria will weakened And As a result, the bacteria undergo lysis. There is accumulation of metabolites primary form sour lactate, ethanol and carbon dioxide or due to secondary metabolites in the form of compounds h i drogen peroxide and bacteriocins enable inhibitory activity. Bacteriocin is a protein that is in bacterial cells, so one way to obtain it is to lyse bacterial cells (Tallei *et al.,* 2019). Bacteriocin Which is protein compounds which is excreted by bacteria which inhibits the growth of other bacteria, namely bacteria pathogens that generally are not unstable and unable to withstand conditions media certain growth .

The Antibacterial Effectiveness of Lactic Acid Bacteria Resulting From The Fermentation of Cavendish Banana Peels And The Addition of Environmental Control Against Spoilage Bacteria For Mackerel (*Rastrelliger* sp.)

The results of a comparison of the effectiveness of Lactic Acid Bacteria resulting from the fermentation of Cavendish banana peels which inhibit the growth of mackerel spoilage bacteria in Table 2 show that the highest antibacterial effectiveness was in the treatment of adding salt with a concentration of 3%, namely with an effectiveness figure of 34.1%. The minimum inhibitory concentration was determined based on the smallest concentration of the Cavendish banana peel fermentation solution that was still able to inhibit the growth of mackerel spoilage bacteria.

From the test results it was found that the Cavendish banana peel fermentation solution with the addition of 3% salt which had an effectiveness rate of 34.1% showed the strongest antibacterial activity compared to the addition of 1% vinegar which had an effectiveness rate of 17.6% and the control with an effectiveness rate of 1% in Inhibits the growth of mackerel

spoilage bacteria. This is because the secondary metabolite compounds contained in the Cavendish banana peel fermentation solution with the addition of 3% salt have antibacterial activity such as flavonoids, tannins, saponins and quinones and the addition of salt results in the growth of lactic acid bacteria and suppresses the growth of unwanted bacteria (Hutchins, 2006).

One of the antibacterial activities of Lactic Acid Bacteria comes from the bacteriocin they produce, namely enteriocin. Lactic acid bacteria are the species that produce the most effective bacteriocins for treating disease (Gani *et al.,* 2018). The addition of 3% salt, which is more suitable to environmental conditions for Lactic Acid Bacteria than the addition of 1% vinegar, can also facilitate the diffusion process so that it is more effective in inhibiting the growth of spoilage bacteria in mackerel. The production of bacteriocins can be different due to different formation systems and their ability to diffuse in agar is also different. The main target of bacteriocins is the cytoplasmic membrane of bacterial cells because the initial reaction of bacteriocins is to damage membrane permeability and eliminate proton motive force (PMF), thus inhibiting energy production and protein or nucleic acid biosynthesis (Gonzales *et al.,* 1996).

The target of bacteriocin action is the cell cytoplasmic membrane by damaging membrane permeability and inhibiting energy production, protein biosynthesis and nucleic acids. This results in membrane potential disturbances in the form of destabilization of the cytoplasmic membrane, so that the cell becomes weak, which has an impact on the formation of holes or pores in the cell, resulting in leaks in the cytoplasmic membrane, which has the effect of inhibiting cell growth or death (Sawitri *et al*., 2013).

Pathogenic bacteria found in the body of mackerel include *Pseudomonas aeruginosa*, *Bacillus cereus*, *Klebsiella pneumonia*, and *Escherichia coli* (Sartika *et al.,* 2020). This can result in a decrease in fish quality due to bacteria breaking down the fish's body parts (Batubara *et al.,* 2022). According to research by Fibriarti *et al.* (2018) who researched the effectiveness of lactic acid bacteria on the shelf life and quality of snapper fish (*Lutjanus campechanus*). The optimum effectiveness figure for lactic acid bacteria which can inhibit the growth of pathogenic bacteria in marine fish such as salmon, snapper and tuna is >30% while >1 -29% there is still a possibility that pathogenic bacteria dominate. So treatment with the addition of 3% salt is an effective treatment.

CONCLUSION

Based on the results of research that has been carried out, it can be concluded that Lactic Acid Bacteria resulting from the fermentation of Cavendish banana peels with control treatment, the addition of 1% vinegar and the addition of 3% salt can inhibit the growth of bacteria that spoil mackerel with control treatment producing a pH of 5.5 with a clear zone diameter 6.27 mm and the effectiveness is 1% which is categorized as moderate inhibitory activity for spoilage bacteria in mackerel. Meanwhile, the treatment with the addition of 1% vinegar produced a pH of 6.4 with a clear zone diameter of 11.07 mm and an effectiveness of 17.6% which was categorized as strong inhibitory activity for mackerel spoilage bacteria. The best treatment, namely adding 3% salt with a solution pH of 4.4, is the most effective treatment which produces a clear zone diameter of 21.37 mm with an effectiveness of 34.1% which is in the activity category. The inhibition of spoilage bacteria in mackerel is very strong which can be used to extend the shelf life.

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