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Utilization of Tilapia Bone Gelatin as Biodegradable Packaging Material

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Abstract: ***The aim of this research is to determine the best concentration of gelatin to made biodegradable plastic with addition of aloe vera extract for knowing the best biodegradability value. The research was conducted from April to July 2018 at Laboratorium Pengolahan Hasil Perikanan Fakultas Perikanan dan Ilmu Kelautan Universitas Padjadjaran. The method used in this research is an experimental method with RAL 5 different treatments and 2 replications. The treatments named by gelatin addition is A (0%), B (5%), C (10%), D (15%), and E (20%). The parameters observed in this research include the test of transparency, thickness, tensile strength, biodegradability, and microbial inhibition zone.The data were analyzed with descriptive comparative method. Addition of tilapia bone gelatin with different concentrations had a significant effect (F_{count}> F_{table}) on the transparency, thickness, tensile strength, and biodegradable packaging biodegradation, but had not significant effect (Fcount <Ftable) on elongation. The result of this research show the best addition of gelatin to make biodegradable packaging is 10%, which produces biodegradable packaging with a transparency value of 0.7203, the thickness of 0.295 mm, tensile strength of 10.251 MPa, duration of degraded the package is 5 days, and elongation value of 38.25% which is the best value to approach the standard value of biodegradable packaging (SNI 7817:2104).***

Keywords: Biodegradable, gelatin, tapioca, tensile strength, inhibitory zone

1. Introduction

Food packaging is important to protect food ingredients from damage. In Indonesia, food packaging materials are generally made of plastic. However, the use of plastic as a packaging material has various environmental problems, namely its characteristicwhich is cannot be destroyed naturally (non-biodegradable), which causes a buildup of waste that pollutes the environment. Not only causingproblems in the environment, the safety aspects of synthetic polymers begin to be questioned, because in hot conditions monomer contamination occurs in the food [1].

Currently, biodegradable plastic has been developed as an effort to save the environment from the dangers of plastic. Biodegradable plastic is a plastic that can be naturally broken down by microorganisms into environmentally friendly compounds [2]. Biodegradable plastic can be produced by mixing starch with natural types of biopolymers which can improve the deficiencies of the physical properties of starch-based plastics. Natural biopolymers that can be used as packaging materials can be obtained from fishery products including those from fish bones.

The demand for tilapia fillets is very high. The fish fillet industry will produce various wastes, namely bones, leftover meat, scales, skin, and stomach contents. The most waste produced by the fish fillet industry is bone which can reach 5.5 tons per day [3], thus the tilapia bone waste can be processed into products that have added value. One product that can be produced from bone is gelatin. Gelatin can change reversibly from sol form to gel, expand in cold water, can form films, affect the viscosity of a material, and canprotect the colloidal system [4].Good food packaging must avoid the contamination of pathogenic bacteria that can reduce the quality of food. The way to anticipate contamination is to use antimicrobials in food packaging. One of the plants that has antimicrobial substances is aloe vera.

Meat from aloe vera plants contains saponins, flavonoids, tannins, and polyphenols. The function of flavonoids is as an antimicrobial and antibacterial agent. It means that it is effective for the addition of making biodegradable plastics so that the packaged products are more protected from the contaminationof pathogenic bacteria.Research on the addition of fish gelatin into biodegradable plastic formulations has not been widely studied, so a research is needed on the optimum concentration of fish gelatin in the manufacture of biodegradable plastics.

2. Research Method

This research was carried out from April to July 2018. The production of tilapia bone gelatin, the production of aloe vera gel, and the manufacture of biodegradable packaging took place at the Laboratorium Pengolahan Hasil Perikanan Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. Transparency testing was carried out at the Microbiology and Molecular Biotechnology Laboratory Faculty of Fisheries and Marine SciencesUniversitas Padjadjaran. Thickness testing was carried out at the Basic Physics LaboratoryFaculty of Mathematics and Natural SciencesUniversitas Padjadjaran. Tensile strength testing was carried out at the College of Textile Technology Bandung. Microbial inhibition zone testing was carried out at the Microbiology LaboratoryFaculty of Mathematics and Natural Sciences. Biodegradability testing wascarried out at the Faculty of Fisheries and Marine Sciences.

The method used in this research wasan experimental method that is the manufacture of biodegradable packaging with five treatments and two replications of tilapia bone gelatin concentrations of 0%, 5%, 10%, 15%, and 20% which wereadded with aloe vera extract as an antimicrobial agent as much as 6%.Research observations consist of physical tests in the form of transparency, thickness, tensile strength, and elongation. Meanwhile,the biological test is a bacterial inhibition zone test and biodegradability test. The analysis used in this research wasthe Complete Random Design (RAL) statistical test on the parameters of observing transparency, thickness, tensile strength, and elongation. If there is a real difference, then Duncan testing wascarried out. Meanwhile, the parameters of biodegradability test observation and bacterial inhibition zone test wereanalyzed descriptively.

3. Results and Discussion

Transparency

Transparency is the ability of a material to pass on light. Transparency is an aesthetic assessment in the marketing of food packaging. The transparency value shows the degree of clarity of a film [5]. Biodegradable packaging was tested using a spectropometer with λ550 nm. The results of the transparency test of biodegradable packaging based on gelatin concentration are presented in Table 1.

Table 1: Transparency Test Results for Biodegradable Packaging Based on Gelatin Concentration

Treatment (Gelatin Concentration)	Average	Degree of clarity (%)
A (0%)	$0{,}3042^{a} \pm 0{,}0217$	99,70
B (5%)	$0{,}5817^{bc} \pm 0{,}065$	99,42
C (10%)	$0{,}7203^{c} \pm 0{,}0792$	99,28
D (15%)	$1{,}0388^{d} \pm 0{,}0247$	98,96
E (20%)	$1{,}4868^{e} \pm 0{,}1537$	98,51

Remarks: The average treatment number followed by the same letter shows that it is not significantly different according to Duncan's multiple range test at the 5% test level.

Based on the results of the transparency test of biodegradable packaging based on the concentration of gelatin in each treatment, it can be seen that treatment A (without the addition of gelatin) has the highest degree of clarity of 99.70% and treatment E (addition of gelatin 20%) has the lowest degree of clarity, namely 98.52%. Biodegradable packaging without the addition of gelatin wasclearer than biodegradable with the addition of tilapia bone gelatin because the tilapia bone gelatin has a slightly yellowish color, so that with theaddition of gelatin with high concentration will produce biodegradable which is slightly turbid.

The resulting biodegradable transparency and clarity are influenced by the biodegradable thickness produced. [6] stated that film thickness will tend to increase with increasing concentration of active ingredients which also play a role in reducing the degree of clarity of the film produced.The transparency value contained in biodegradable packaging in this research rangedfrom 0.3042-1.4868. Guided by the LDPE plastic transparency value as a comparisonthat has a transparency value of 1.14 [7]. Thus, it can be concluded that the treatment of D biodegradable packaging with a value of 1.038 has the closest value to the LDPE plastic transparency value.

Thickness

Thickness is one of the important parameters that influences the formation of edible film or biodegradable and the purpose of its use is for coatings or packaging of products. In addition, film thickness is a physical property that is influenced by the concentration of dissolved solids in the film solution and the size of the printing plate used [5]. The measurement of biodegradable thickness was performed using a digital micrometer screw. Observations on the thickness of biodegradable packaging with the addition of gelatin are presented in Table 2.

Table 2: Observation Results of Biodegradable Packaging Thickness Tests Based on Gelatin Concentration

Treatment (Gelatin Concentration)	Average (mm)
A (0%)	$0{,}089^{a} \pm 0{,}011$
B (5%)	$0{,}230^{bc} \pm 0{,}004$
C (10%)	$0{,}295^{c} \pm 0{,}013$
D (15%)	$0{,}430^{d} \pm 0{,}011$
E (20%)	$0{,}535^{e} \pm 0{,}061$

Remarks: The average treatment number followed by the same letter shows that it is not significantly different according to Duncan's multiple range test at the 5% test level.

Based on the results of the biodegradable packaging thickness test in each treatment, it can be seen that treatment A has the smallest value of 0.089 mm and the treatment E has the largest value of 0.535 mm. Statistical test results showed that gelatin significantly influenced($F_{count} > F_{table}$) biodegradable thickness.

Biodegradable in treatment A has a lower thickness value than biodegradable which had been added with gelatin. This is because the thickness of biodegradable is influenced by the amount of total solids in the solution and the volume of the mold. According to SNI 7188.7: 2016 in [8] the value of biodegradable packaging thickness is 0.25-0.41 mm. The thickness of biodegradable packaging in this research that meets the thickness standard is treatment C with a value of 0.295 mm. Whereas when viewed from Duncan's further test of the value of thickness, treatment B and C are not significantly different so it can be concluded that treatment B and C still meet the thickness value of the standard set.

The thickness of biodegradable packaging in this research is not much different from the results of [9], namely the manufacture of biocomposite edible films from gelatin/BCMC with gelatin concentrations of 6%, 8%, 10%, and 12% having a thickness of 0.20-0.48; as well as [10] which has the results that the characteristics and stability test of gelatin-based edible films with 10%, 12.5%, 15%, 17.5%, and 20% gelatin concentrations have a thickness of 0.14-0 , 43 mm.

Tensile Strength and Elongation

Tensile strength is the maximum pull that can be achieved until the film can survive before breaking up [11]. Measurements of tensile strength were carried out using an Instron tool at a speed of 500 mm/minute. The results of the tensile strength test of biodegradable packaging are presented in Table 3.

Table 3: Test Results of Tensile Strength of Biodegradable Packaging Based on Gelatin Concentration

Treatment (Gelatin Concentration)	Average (MPa)
A (0%)	8,550^{a} ± 0,036
B (5%)	10,158^{a} ± 0,422
C (10%)	10,251^{ab} ± 1,482
D (15%)	13,192^{b} ± 0,228
E (20%)	14,601^{c} ± 1,157

Remarks: The average treatment number followed by the same letter shows that it is not significantly different according to Duncan's multiple range test at the 5% test level.

Based on the results of the tensile strength test of biodegradable packaging, the average tensile strength obtained from each treatment can be seen that treatment A has the lowest tensile strength value of 8.550 MPa and treatment E has the highest tensile strength value of 14.601 MPa. The results of variance showed that the addition of gelatin was significantly different (F_{count}> F_{table}) to tensile strength. Based on the results of the Duncan's statistical further test for tensile strength values, it was found that treatment A was not significantly different from treatment B, C, and D. Treatment D was not significantly different from treatment C. Treatment E was significantly different from treatment A, B, C and D .

Biodegradable tensile strength values increased in each treatment which showed that gelatin as a mixing biopolymer tends to increase the value of tensile strength in certain formulations. This is because gelatin can form hydrogen bonds between chains so that biodegradable becomes more dense which results in more interaction of hydrogen contained in biodegradable so that the bonds between chains will be stronger [12].

According to [13] the tensile strength of LDPE (low-density polyethilene) plastic is 8.6-17.3 MPa and the value of tensile strength produced still meets the standard value of LDPE plastic tensile strength except in treatment A because the tensile strength is below 8, 6 MPa which is 8.550 MPa.

The tensile strength value produced by biodegradable packaging in this research is greater than [14] research which is equal to 4,266-5,710 MPa. However,the tensile strength of this study is lower than [15] research, which is 17,4034-39,6341 MPa.

Measurement of tensile strength is usually followed by measurement of percentage of elongation. Percent length (elongation) is the percent increase in length of film material measured from the initial length at the time of withdrawal to break [16]. The results of biodegradable packaging elongation test are presented in Table 4.

Table 4: Biodegradable Packaging Elongation Test Results Based on Gelatin Concentration

Treatment (Gelatin Concentration)	Average (MPa)
A (0%)	2,94^{a} ± 1,149
B (5%)	13,25^{a} ± 8,132
C (10%)	38,25^{a} ± 10,96
D (15%)	32,25^{a} ± 27,931
E (20%)	9^{a} ± 2,828

Remarks: The average treatment number followed by the same letter shows that it is not significantly different according to Duncan's multiple range test at the 5% test level.

Based on the results of biodegradable elongation testing in this research, it can be seen that the highest elongation percent value is in treatment C (10%) at 38.25% and the lowest elongation percent value is in treatment A (0%) at 2.94%. The results of variance analysis showed that the addition of gelatin concentration had no significant effect (F_{count}<F_{table}) on the percent elongation value. This is because the percent elongation value is influenced by the concentration of the plasticizer [17], while in this research the amount of plasticizer that is glycerol wasused for each treatment equally. Plasticizer is able to reduce fragility and increase the flexibility of polymer films by interfering with hydrogen bonds between adjacent polymer molecules so that the intermolecular tensile strength of the polymer chain is reduced [18].

Biodegradability Test

Biodegradability tests werecarried out to determine the biodegradable film's resistance level to decomposing microbes, soil moisture, temperature, and physical chemical factors found in the soil [18]. This test was carried out using the Soil Burial Test method, namely the method of planting samples in the soil. The results of the biodegradability of biodegradable packaging were presented in Figure 1.

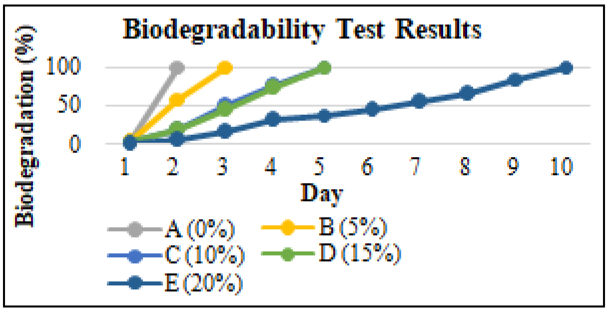

Figure 1: Results of Observation on Biodegradability Test of Biodegradable Packaging Based on Gelatin Concentration

Based on Figure 1, the results of biodegradability tests showed that biodegradable packaging of tapioca with the treatment of concentrated gelatin deposited in the soil could be completely degraded after land filling was carried out for 10 days at most indicated by biodegradable sheet damage. The higher addition of gelatin concentration gives longer degradation results, but in the C and D treatment the same degradation time is 5 days. This is presumably because the tensile strength of treatment C is not significantly different from treatment D, so the density of the film is almost similar to the properties of gelatin and tapioca which absorb water making biodegradable packaging easily decomposed by the soil [19]. In treatment E, the film was rigid and caused polymer remodeling by microorganisms to take longer. [20] said that a decrease in biodegradation rate can be caused by fewer parts of polymer molecules which can be attacked by microorganisms if bioplastics are rigid or not flexible.

Microbes that help the degradation process in the soil are pseudomous and bacillus which break the polymer chain into its monomers [21]. The results of biodegradation of this research are faster than the research by [19] which added the concentration of gelatin powder 0%, 5%, 10%, and 15% to the characteristics of PET used in sago starch mixture which had a degradation time of 40 days.

Visual changes that occur in each treatment are characterized by texture damage where the film becomes softer. The plastic that hadbeen completely decomposed appearedto be disintegrated and shaped as a lump that blends with the soil. It is suspected that it is due to the raw material used wasgelatin which is easy to interact with water and microorganisms that affect its properties [22].

Microbial Inhibitory Zone Test

Based on the results of the research, it was shown that the effect of the proportion of aloe vera as much as 6% into the formulation of biodegradable packaging with modified tapioca starch base material and tilapia bone gelatin on biodegradable antibacterial activity on *Staphylococcus aureus* showed the inhibition zone presented in Figure 2.

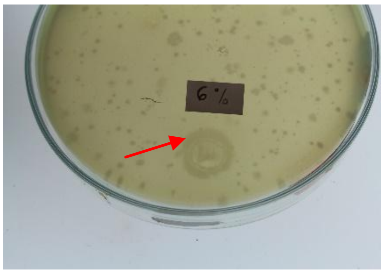

Figure 2: Inhibitory Zone of Biodegradable Antibacterial Activity by Adding Aloe Vera Gel to *Staphylococcus aureus* Bacteria

The film tested for its antibacterial activity was film with a proportion of 15% gelatin-6% aloe vera. After that, the diameter of the clear zone of the film was seen using a ruler [23]. The difference in the results of the measurement of the antimicrobial inhibition zone of the control treatment and treatment with the addition of aloe vera in Figure 2 shows the presence of an inhibition zone with a diameter of 9 mm, 10 mm, and 12 mm. The emergence of inhibitory zones is influenced by the content of natural antibacterial substances in aloe vera gel in the form of phenols and flavonoids [24].

Aloe vera gel consists of polysaccharides. Most of these polysaccharides function as natural barriers to moisture and oxygen (which can accelerate food damage) and can also improve food safety [25]. As in the research of [26] concerning the addition of Aloe vera L. with breadfruit flour and canna on the characteristics of edible films, it was said that the inhibitory zone of edible film will increase along with the added aloe vera gel.

Conclusions and Recommendations

Conclusions

Based on the results of the research, it can be concluded that the addition of tilapia bone gelatin with different concentrations significantly influenced(Fcount> Ftable) the transparency, thickness, tensile strength, and biodegradable packaging biodegradation, but there wasno significant effect ($F_{count}<F_{table}$) on elongation. The best tilapia bone gelatin concentration was found in treatment C (10%) which produced biodegradable packaging with a transparency value of 0.7203, thickness of 0.295 mm, tensile strength of 10.251 MPa, duration of biodegradation for 5 days, and elongation value of 38.25% which best biodegradable packaging standard value. The results of antibacterial research on biodegradable packaging with the addition of aloe vera gel as much as 6% has been proven to inhibit the development of *Staphylococcus aureus* bacteria as indicated by the presence of inhibitory zones in the test sample.

Recommendation

Based on the research that has been done, the suggestionthat can be given is further research on the optimum concentration of plasticizer to improve the value of elongation of tilapia gelatin biodegradable packaging is needed.

References

[1] Kinasih, D.N, Prasetyaningrum. A, dan Wardhani.F.D.N,“Characteristics of Bioactive Edible Films from Alginate and Beeswax Composites as Biodegradible Food Packaging Materials” Chemical and Process Engineering Seminar. Semarang, Indonesia,2010.

[2] Martina, S. P., Masturi, Yulianti, I,”Analysis of Biodegradable Plastics Made from Rice Aking", Jurnal Ilmu Pendidikan Fisikapp.9-12, 2016.

[3] Dadang WI, Suhendar Y, Mardi T, Purbany E, Imam, Ike, “Sudah Saatnya Nila Berjaya". www. Google.Com/Nila. Html, 2007 [Accessed: Feb 18, 2018]

[4] Nurilmala, M, M. Wahyuni, H. Wiratmaja, “Improvement of Added Value of Tuna (*Thunnus* sp) Bone Waste into Gelatin and Physico-Chemical Analysis”,Jurnal Buletin Teknologi Hasil Perikanan IX (2), pp.22-33, 2006.

[5] Mustapa, R., Restuhadi, F., Efendi, R,“Utilization of chitosan as a base for making edible films from starch of yellow sweet potatoes”,Jurnal Online Mahasiswa Fakultas PertanianIV (2) pp. 1-12,2017.

[6] Warkoyo, B. Rahardjo, Djagal, W. M, dan Joko N, “Physical and Mechanical Properties of Edible Film and Barrier Based Starch Kimpul Bulbs (Xantosoma Sagithi) Which Are Incorporated with Sorbat Potassium”,Jurnal Agritech XXXIV (1), pp. 1-9, 2012.

[7] Rosalina, V,“Chitosan as a Basic Material for Making Edible Films by Adding Cassava Starch (Manihot Esculenta Crantz)”,Essay Faculty of Agriculture. Universitas Riau. Pekanbaru, 2015

[8] Basu, B. and Desai, P, “Design and Evaluation of Fast Dissolving Film of Domperidon”, International Research of Pharmacy III (9) pp. 134-145,2012.

[9] Ningwulan, M. P. S, “Making Biocomposite Edible Film From Gelatin / Bacterial Cellulose Microcrystal (BCMC): Concentration Concentration Variations, Fillers, and Sonication Time”Essay Department of

Chemical Engineering. Universitas Indonesia. Indonesia, 2012.

[10] Sari, D. I., Fitriana, M., Mulyadi, R. R., dan Hidayati, L, "Characteristics and Physical Stability Test of Edible Preparation of Ethanol Extract Film of Kasturi Stem (Mangifera Casturi Kosterm) Based on Gelatin" Prosiding Seminar Nasional dan Presentasi Ilmiah Perkembangan Terapi Obat Herbal pada Penyakit degeneratif. I (1) pp. 8-17. 2014

[11] Purwanti, A, "Analysis of tensile strength and plasticitization of Sorbitol chitosan plasticized",Jurnal Teknologi III (2) pp. 99-106, 2010.

[12] Setiani, W., Sudiarti, T., dan Rahmidar, L, "Preparation and Characterization of Edible Films from Starch-Chitosan Starch Poly", Jurnal ValensiIII (2) pp. 100-109, 2013.

[13] Nadarajah, K, "Development and Characterization of Antimicrobial Edible Dessertation" Department of Food Science. University of Paradeniya, 2005.

[14] Sompie, M., Surtijono, S. E., dan Rimbing, S, "Characteristics of Edible Films from Gelatin Legs in Village Chicken Legs"Prosiding Seminar Nasional Pengembangan Unggas Lokal di Indonesia, 2015.

[15] Gela, D. T,"Characteristics of Edible Film from Gelatin Horse Skin (Equus Caballus) and its Application for Food Packaging"Essay Facultyof Sains and Technology. Universitas Islam Negeri Alauddin Makassar. Indonesia, 2016.

[16] Nurindra, A.P., Alamsjah, M.A., dan Sudarno, "Characterization of Edible Films from Lindur Mangrove Propagul Starch (Bruguiera Gymnorrhiza) with the Addition of Carboxymethyl Cellulose (CMC) as Plasticizers", Jurnal Ilmiah Perikanan dan Kelautan VII (2) pp. 125-132, 2015.

[17] Qiu-Ping Zhong and Wen-Shui Xia, "Physicochemical Properties of Edible film and Preservative Film from Chitosan/ Cassava/ Starch/ Gelatin Blend Plasticized with Glycerol",*Journal Food Technol. Biotechnol* XLVI (3) pp. 262-269, 2008.

[18] Hidayati, S., Zuidar, A. S., dan Ardiani, A, "Application of Sorbitol in Biodegradable Film Production from Nata De Cassava", Jurnal Reaktor. XV (3) pp. 196-204, 2015

[19] Resalina, Basa S.M, Yetri, Y, "The Effect of Addition of Gelatin Powder on the Mechanical and Biodegradability Properties of Polyethylene Mixed Plates of Sulfate and Sago Starch", Jurnal Fisika Unand. II (1) ISSN 2302-8491, 2013.

[20] Pulungan, M. H., Mulyadi, A. F., dan Qayyum, N, "Making Maizena Edible Film and Antibacterial Activity Test (Study of Glycerol Concentration and Beluntas (Pluchea Indica L.) Leaf Extract)", Jurnal Teknologi dan Manajemen Agroindustri V(3) pp. 149-158, 2016.

[21] Matondang, T. D. S., Wirjosentono, B., dan Yunus, D, "Manufacture of biodegradable Packaging Plastics from Polypropylene Maleic Anhydride Tergrafting with Palm Oil Sago Starch Fillers" Jurnal Valensi III (2) pp. 110-116, 2013.

[22] Firdaus, F. dan Chairil, A, "Potential of Tapioca Starch Industry Solid-Liquid Waste as Biodegradable Plastic Film Raw Material", Jurnal Sain-teknologi LOGIKA I (2) pp. 38-44, 2004.

[23] Darmanto, M., Atmaja, L., dan Nadjib M, "Antibacterial Analysis Study of Gelatin-Chitosan Film Using Staphylococcus aureus" Thesis ProceedingsInstitut Teknologi Sepuluh Nopember. Surakarta, Indonesia, 2011.

[24] Yang, J., R. Gadi and T. Thomson, "Antioxidant Capacity, Total Phenol And Ascorbic Acid Content Of Noni (Morinda Citrifolia) Fruits And Leaves At Various Stages Of Maturnity", Micronesica XLI pp. 167-176, 2011.

[25] Hasanah, Alimatul, "Application of Aloe vera L. Coating to Increase the Save of Callina Papaya Fruit (Caria papaya L.)" Essay Facultyof Agriculture Engineering. Institut Pertanian Bogor. Bogor, 2017.