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The author was born on 8th June 1999 at Ngawi, East Java. Her father was Istangin and her mother was Istiqomah. The author spent her childhood in Aisvah Kindergarten, and started her study at SDN 1 Kedunggudel Elementary School and graduated in 2011, then continued her study at SMPN 1 Widodaren Junior High School and graduated in 2014. The Author was graduated from the

SMAN 1 Widodaren Senior High School in 2017. In the same year, the author passed the SBMPTN selection for Agricultural and Biosystem Engineering Study Unive Progam of Brawijaya University in Malang. During college, the author was active laya in several student organizations and committees, such as UAKI (Unit Aktivitas Kerohanian Islam), Forkita (Forum Kajian Islam Fakultas Teknologi Pertanian), Java HIMATETA, KERABAT 2017, HARMONI 2018, PEMILWA 2018, and ICGAB (International Conference on Green Agroindustry and Bioeconomy) 2019.

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In the academic field, the author had passed for the PKM-KC in 2019 by the Ministry of Education of Indonesia. And in the same year, the author became the top 10 finalists for Technology Innovation in Malang and won a gold award in International Youth Scientific Seminar and Expo. The author also had the opportunity to take part in the Sakura Exchange Program at Miyazaki University, Japan. And in 2020 the author passed the palm oil research funding by BPDPKS e (Badan Pengelola Dana Perkebunan Kelapa Sawit). In addition, the author had jaya also been an assistant of laboratory activities for food processing and agricultural

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Unive Istangin, for my beloved mom, Istiqomah, for my sister Mariana Hidayati, for my lava brothers Nur Ali Mustofa and Ahmad Ibnu Syafi`i and for my cutie little sister Laila Maftukhatu Rosyidah. Thank you for always supporting me no matter what. Throughout this effort, my parents are a source of inspiration, kind help, steady supporters, and impressive, hardworking human beings ..!!

Last but not least, I dedicated this lovely work to myself. Thank you for having been strong to face every challenge on your path in order to set up the goals. Just continue to chase your dreams, Zub! No matter what happens or how Unive challenging the situations are. I learned that I have had to believe in myself, my ideas, and my dreams in order to accomplish the goals I have set out, and I need Unive to always believe that:

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Hereby state that,

The Thesis was originaly work of the author above. If in the future it is proven that this statement is not true, I am willing to be prosecuted according to the as Brawijaya applicable law.

AN,

Unive Malang, 27th Mei, 2021 Unive Sincerely,

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awijaya ZUBAIDAH WIDYA PUTRI. 175100200111014. Oil Palm Empty Fruit Bunches awiiava OPEFB) for Biodegradable Pot's Raw Materials as An Alternative Container for Sustainable Nurseries. Bachelor's Thesis. Supervisors: Dr. Ir. Musthofa Eutfi, MP and Darmanto. ST, MT. Java University SUMMARY Universitas The lack of management of Oil Palm Empty Fruit Bunches (OPEFB) waste lava harmed the development of the palm oil industries in the global market, whereas awijaya OPEFB contained high cellulose fiber and nutrients that could be used as raw awijaya material for biodegradable pots as an alternative container for sustainable awijaya awijaya nurseries. Recently the agriculture cultivation activities were still oriented on the awijaya use of polybags, which provided a negative impact to crops as well as to the awijaya environment. The former nursery polybags became a source of plastic wastes from the agricultural sector. Besides, the use of polybags had the potential to awijaya e reduce the level of plant tolerance to drought, cause roots damage, and bring lava awijaya awijaya difficulty in the transplanting process. This research aims to determine the effect awijaya of the biopot's materials composition and the effect of the addition of NaOH with awijaya awijaya different concentrations on the physicomechanical properties of biopots. The research method used in this research was an experimental method with a awijaya Factorial Completely Randomized Design (CRD), and the two factors used were awijaya awijaya the mass ratio of OPEFB to banana stems as raw materials, namely 100%:0%, 80%:20%, 60%:40%, 40%:60%, and 0%:100%. The concentrations of NaOH awijaya awijaya used were 3%, 5%, and 7%. An observation was done on biopots including the awijaya mass, moisture content, water uptake, biodegradation test, and tensile strength awijaya test. The results show biodegradable pots have a mass range from 9.58-18.48 grams, moisture content of 50.42%-65.89%, water uptake of 2.72%-4.82%, biodegradation potential of 40.54%-76.39%, and tensile strength of 8091-23418 Pa. The treatment combination of R2C2 (80% OPEFB: 20% banana stems; 5% NaOH) is the best treatment formulation due to having faster biodegradability also can support the durability of biodegradable pots through high tensile strength awijaya and water resistance. However, the fiber density of biodegradable pots needs awijaya some improvement caused by irregular fiber dispersion inside biodegradable awijaya pots. Brawijaya Universitas Brawijaya Universitas Brawijaya versitas Brawijaya Unive Keys Words: Oil Palm Empty Fruit Bunchess (OPEFB), Banana Stems, Java Biodegradable Pots (Biopots), NaOH, Nurseries Container Universitas Brawijava Universitas Brawijava

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universignment CHAPTER I INTRODUCTION WIJaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Background niversitas Brawijaya Universitas Brawijaya Universitas Brawijaya Oil palm (Elaeis guineensis) is a plantation commodity with a large amount unive of production and consumption in the world. Concerning the above condition, available Indonesia was the largest producer of oil palm by contributing 58% or as much as 43.5 million tons to total production in the world (United States Department of Unive Agriculture, 2020). It is recorded that the total area of oil palm plantations reached up to 14.3 million hectares with total CPO (Crude Palm Oil) production of 42.9 tons in 2018 and is predicted will increase continuously in the following years (Directorate General of Ministry of Agriculture of Republic Indonesia, 2019). As a commodity that is consumed globally, the CPO commodity became the e mainstay industry that contributed most significantly to Indonesia's economy with lava increasing national income and foreign exchange, which can be viewed from the value of CPO exports were worth US\$ 17.46 billion in 2014 (Rame, 2018).

However, the development of the palm oil industry in the global market is still constrained by the issue of a black campaign regarding the environment, sustainability, and society. One of the crucial aspects that are closely related to the environment is oil palm waste management. According to Dewanti (2018), there was at least 23% waste of oil palm empty fruit bunches (OPEFB) of Indonesia's total palm oil production, yet the handling of OPEFB waste only reached 10% of the total waste generated. On the other hand, non-strategic management and utilization of OPEFB waste can leave large emissions, which might potentially harm oil palm land and even have an effect on the environmental system (Rame, 2018). The availability of OPEFB will increase in ^{ve} line with the increasing production of Fresh Fruit Bunches (FFB). The utilization of OPEFB as one of the largest wastes of the palm oil industry needs to be done to increase productivity, added value, efficiency, and to have principles of environmental sustainability. Based on the chemical structures, OPEFB contained 38.76% cellulose, with fiber content reaching 72.67% (Dewanti, 2018). OPEFB could improve the physical, chemical, and biological performance of soil characteristics. In addition, OPEFB contained nutrients such as N (1.91%), K (1.51%), Ca (0.83%), P (0.54%), and Mg (0.09%) (Hayat and Andayani, 2014). The existence of cellulose and high nutrients cause oil palm empty fruit bunches Unive to have the potential to be used as biodegrdable pots raw material. Versitas Brawilava Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya According to Supraptiningsih (2012), other organic wastes that were awijaya abundant and affordable in the community environment were banana stems. This awijaya is because banana stems were underutilization by society after harvesting process. In general, banana stems are processed as animal feed or used as e fertilizer. Banana stems as organic waste could be used as an economical and awijaya potential source of natural fiber, because it had fairly high cellulose content, up to 65% (Jaya, 2011). Isolation of cellulose from natural fibers could be carried out awijaya awijaya using alkaline treatment (NaOH) by degrading the lignin content in the awijaya lignocellulosic structure of the fibers, thereby improving the quality and awijaya e phycomechanical properties of the fibers (Fitriasari et al., 2019). Universitas Brawijava awijaya awijaya ersitas In addition, agricultural cultivation activities in Indonesia are still be primarily oriented toward the use of polybags as planting container, especially in the awijaya Universery. According to Dewanti (2018), the use of plastic in Indonesia was available awijaya awijaya reaching up to 2.6 million tons per year, and polybags become one source of awijaya Unive plastic that were widely used in the agricultural sector for plant nurseries (Jaya, et ava awijaya awijaya al., 2019). Polybags made from raw materials polyethylene takes hundreds of awijaya years to decompose. Other than that, the use of polybag as container for planting awijaya awijaya in the nursery had the potential to reduce the level of plant tolerance to drought, Java awijaya as well as to cause root damage that occurs when the roots reached the bottom awijaya of the polybag. Trouble on the time of transfer (transplanting) is also a weakness awijaya awijaya of the use of polybags as a planting media (Salisu, et al., 2018). awijaya To replacing the non-renewable plastic container in the agricultural sector awijaya awijaya unive and to increase the quality of the plants produced from the nursery, an alternative environmentally friendly container for the nursery is needed. Organic nursery awijaya Unive container made from Oil Palm Empty Fruit Bunches OPEFB and the mixture of awijaya banana stems as a physical structure strengthening agent become a potential awijaya solution, at the same time answers the problem of oil palm solid waste awijaya ve management. awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Univer1.2 Broblems Universitas Brawijaya Universitas Brawijaya awijaya awijaya Based on the background above, the problems can be drawn as follows: awijaya 1. How is the effect of the composition of constituent materials to the Universitas Briphysicomechanical properties of biodegradable pots? 2. How is the effect of adding NaOH with different concentrations to the Universitas Br physicomechanical properties of biodegradable pots? Universitas Brawijaya Universitas Brawijaya 2 Universitas Brawijaya awijaya Universitas Brawijava Universitas Brawijava Universitas Brawijava

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awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Univer1.3.5 Research Objectives Brawijaya Universitas Brawijaya awijaya The objectives to be achieved by the research are as follows: Universital. Knowing the effect of the composition of constituent materials to the physicomechanical properties of biodegradable pots. Knowing the effect of adding NaOH with different concentrations to the Universitas Bphysicomechanical properties of biodegradable pots.va awijaya awijaya awijaya 1.4. Research Benefits as Brawijaya Universitas Brawijaya awijaya Universitas The benefits of research for various parties are as follows: Universitas Brawijaya awijaya ersitas Brawijaya awijaya 1. Government and Palm Oil Industry awijaya Universitias Bra. Can contribute to optimize the management of OPEFB waste. Brawlava awijaya Universitas Brib awijaya Biodegradable pots become a potential solution in dealing with and awijaya Universitas Brawijaya reducing OPEFB waste abundance. awijaya awijaya 2. Society awijaya Can reduce the use of polybags that cause environmental pollution. а. awijaya As a solution to overcome problems in the nurseries process with awijaya b. awijaya the application of technology, thus it can increase plant productivity. awijaya as Brawijava 3. Student awijaya a. The novelty of research idea can provide opportunities to improve an involve and involve an awijaya innovation related to the making of biodegradable pots and ecoawijaya agriculture. awijaya awijaya Universitä Problem Limits awijaya Universitas The limitations of the research problems are as follows:/a awijaya awijaya This research was conducted on a laboratory scale. awijaya Universitas 2. This research did not consider the type of banana plant in the banana java awijaya stems waste that was used as a mixture of biodegradable pots. awijaya awijaya 3. This research only analyzed the effect of the composition of the awijaya awijaya Universitas Bra constituent materials (OPEFB: Banana Stems: NaOH) to the available physicomechanical properties of biodegradable pots. awijaya awijaya Universitas 4. The soil conditions as burying media for the biodegradation test were java Universitas Bravconsidered the same. Universitas Brawijaya 5. This research did not pass the biodegradable pots applications test in Universitas Brathe plant nursery process ava Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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awijaya awijaya CHAPTER II LITERATURE REVIEW awijaya Universitas Brawijaya Universitas Brawijaya awijaya Unive 2.1as Nurserya Plant cultivation is generally done by procuring young plants (seeds), which awijaya could be started by sowing seed (generatively) or using the parent plant (vegetatively). Before the seeds are planted in cultivated land, it needs to be awijaya maintained in the nursery system to produce tree seedling that meets the awijaya Unive requirements of age, size, and certain gualities before transfer in the planting java awijaya awijaya field. The nursery was the process of providing plant materials derived from tree awijaya seeds or seeds from the vegetative part of the plant to produce plant materials awijaya awijaya that were ready to be planted on cultivated land (Susilo, et al., 2014). The plants awijaya that require a nursery stage generally have an intermediate until a long time awijaya Unive harvest cycle, as well as have relatively small seeds. awijaya awijaya Many types of forest plants require a nursery process first, before planting awijaya in the field, such as teak, mahogany, calliandra, and others. There are also many awijaya awijaya plantation crops in need of nurseries, such as oil palm, tobacco, and rubber. awijaya Some types of horticultural crops including chilies and tomatoes require a nursery awijaya process before ready to be planted in the field (Sumarni and Isnantyo, 2017). awijaya awijaya According to Harum and Soren (2010), the nursery maintenance process awijaya includes: awijaya Univer awijaya Watering awijaya 2. Weeding awijaya Fertilization (if needed) Univer3.it: awijaya awijaya 4. Pest and disease control Unive 5.ta Light control awijaya Unive 6. Sorting seeds awijaya versitas Brawijava Universitas Encludinava Oniversitas Brawijaya 7. Transfer of seeds versitas Brawijaya Universitas Brawijaya awijaya awijaya awijaya Unive 8 ta Acclimatization iversitas Brawijaya Universitas Brawijaya awijaya 9. Planting Universitas Bra awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya nive 2.2.5 Nursery Containers Media Vijava Universitas Brawijava awijaya Universitas Brawijaya 2.2.1. Plastic Container Media (Polybag) Universitas In the agricultural sector, polybags are generally used as a container media java to grow the seeds in the nursery process as well as to save agricultural land. In Unive the research of Pasir and Hakim (2014), it is said as a planting container media Universitas Brawijaya Universitas Brawijaya 4 Universitas Brawijaya Universitas Brawijaya awijaya

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for agricultural cultivation, polybags had several advantages i.e low price, rustresistant, durable, uniform shape, and easily obtained. But on the other hand, the use of polybags as planting container media is not eco-friendly because, during the transplanting of seeds in the field, farmers often throw away polybags and eventually pilled up into garbage or agricultural waste. Trash polybags are inorganic waste, which is difficult to break down by bacteria so it will not be destroyed if it is just left on the ground. Inorganic waste that is allowed to accumulate in the soil will lead to soil pollution which ultimately makes it difficult for plant roots to penetrate the soil. Furthermore, the microorganisms in the soil would continuously disappear, along with decreasing the water and minerals that nourished the soil. Regarding the condition above, it would make the plants difficult to grow because plants did not get enough nutrients (Nursyamsi, 2015).

Cultivation of plants in polybags also has necessary drawbacks attention, including the factor of water availability and density of planting media. The availability of water greatly determines the results of plant production. Lack of water during the nursery process could cause stunted plant growth, withered and even plants die (Kusumawati, *et al.*, 2016). Besides, the use of polybags in the nursery process has a weakness. It is not efficient because people have to tear the polybags during the transplanting process. The tearing process could destroy the planting media and roots damage, which leads to stagnation after seedlings were transplanted. In addition, root damage during transplanting affected the adaptation process and plant growth in the field (Pudjiono, *et al*, 2012).

unive 2.2.2. Organic Growing Container Media

The organic growing container is a container for the planting process used to conduct nurseries as alternative polybags. An effort to reduce the use of polybags is carried out by developing planting media made from organic materials, such as straw, wood-bark, sawdust, coconut husk, reeds, and water hyacinth (Nugroho, *et al.*, 2013). The organic materials would be decomposed by microorganisms that could produce carbon dioxide (CO2), water (H2O), and minerals. The released minerals would become a source of nutrients for plants (Nugroho, *et al.*, 2013). The growing container media made from organic materials are known by several terms, such as organic block seedling and biodegradable pot (biopots).

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The use of organic planting containers began to be developed in the nursery and greenhouse industry because it had the advantage of being biodegradable, it could be degraded after the transplanting process on the ground (Rapa *et al.*, 2011). In the transplanting process, organic growing container could be used directly by burying it with the seeds in the ground. Thus was supposed to speed up and simplify the transplanting process, as well as was zero waste because it did not leave any wastes (Al-ahmed, 2020). As a good growing cointainer media, biodegradable pots must have physical, chemical, biological, and mechanical properties that suitable for plant growth. According to Saraswati (2012) in Pasir and Hakim (2014), the biodegradable pot at least could provide growing space for roots as well as being able to support plants, had good porosity, and had the ability to absorbed water (hygroscopic) so it could retain humidity and porosity. It also had good drainage and good aeration. Besides, it could provide macronutrients and micronutrients, and it must have also been free of fungi and pests.

Thus, biodegradable pots as an alternatives growing container media are expected to have low moisture content, low percentage of water uptake, relatively high tensile strength, and high degradation value. To support sustainable agriculture, the use of biodegradable pots is increasingly needed because biodegradable pots are eco-friendly, efficient, do not lead to roots damage, and can decompose quickly, so they do not have negative impacts on the environment. The properties of growing container media from oil palm solid waste are shown in **Table 2.1**.

vijaya Universitas vijaya Univer<mark>Table 2.1</mark> Properties o

Table 2.1 Properties of Organic Growing Container from Oil Palm Solid Wastes

| Universitas Bra | | Average Value | Universitas Brawijaya |
|---|---|--|---|
| Universitas Brave Univers No. Br Paramet Universitas Bravilava | ters Jaya e <i>t al.</i> (2019)* | Effendi (2012)** | Universitas Brawijaya Un Silalahi, Brawijaya LI (2017)*** Brawijaya |
| 1. Moisture Co | ontent 10.11-10.6% | 31.23-32.15% | 28.09-31.9% |
| Universi 2. Water abso | rption 129.25-155.48% | Universitas Brawijaya | Universitas Brawijaya |
| Universit3.s Massijaya | Universitas Brawijaya | Univer251.91 gawijaya | 192.67-218.09 gawijaya |
| Universit4.5 Thickness | | Univer 1.33 cmawijaya | Unit.13 cms Brawijaya |
| Universitas **) OPEFB, Universitas ***) OPEFB, Universitas Brawijaya | midrib and stem of palm c midrib and stem of palm Universitas Brawijaya | oil, newspaperBrawijaya Universitas Brawijaya Universitas Brawijaya | Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya |
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awijaya awijaya Universitas Brawijaya ^{ve} 2.3. Raw Materials for Making Biodegradble Pots niversitas Brawijaya 2.3.1. Oil Palm Empty Fruit Bunches, Universitas Brawijaya Universitas Brawijaya Universitas Oil Palm Empty Fruit Bunches (OPEFB) were left natural fibers after the process of separating the fruit from Fresh Fruit Bunches (FFB) (Rahmasita, et al., ve 2017). So far, the utilization of OPEFB waste is still very limited. The solution that is often used is to recycle the wastes. In the agricultural sector, the recycling process of Oil Palm Empty Fruit Bunches (OPEFB) waste is fixated on processing into compost. However, the OPEFB composting that contains lignocellulose took a long time. It might reach up to 3 months (Warsito, et al. Univer2016) Brawijaya Universitas Powijaya Universitas Brawijaya

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Source: Wardani (2013)

Flower Part

According to Salmina (2017), because the composting process took a Unive long time, most palm oil industries in Indonesia carried out open dumping and lava waste incineration in an incinerator as an effort to overcome the abundant unive wastes. However, that way had been banned by the government because it available harmed public health and the environment and not prospective solution to be applied continuously to overcome the abundance of Oil Palm Empty Fruit Bunches waste. The availability of Oil Palm Empty Fruit Bunches (OPEFB) in Java Indonesia will continuously increase in line with the increase in production of Fresh Fruit Bunches (FFB). In 2013, approximately 25 million tons of Oil Palm Empty Fruit Bunches were produced by Indonesia and would be continued to increase along with the increase in plantation areas (Erwinsyah, et al., 2015). Oil Palm Empty Fruit Bunches (OPEFB) is an organic material, which is cheap, decomposed, non-toxic, and is a natural fiber widely used for various purposes. Unive According to Erwinsyah et al., (2015), Oil Palm Empty Fruit Bunches (OPEFB) ava Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

Universitas Brawijaya awijaya awijaya had a chemical content that could be utilized to the maximum. The chemical composition of Oil Palm Empty Fruit Bunches (OPEFB) can be seen in Table 2.2 Table 2.2 Chemical Composition of Oil Palm Empty Fruit Bunches (OPEFB) Value (%) Herawan and Rivani Erwinsyah et al. Parameters ersitas Brawijava Uni(2012)as Brawijaya wijava Univ(2010) Univ5.22 tas Brawijaya Univers1.as BraExtract Universitas Brawijaya Unive7s78as Brawijaya awijaya Univers2.as BraAsh content iversitas Brawijaya Unive6.23 Brawijaya awijaya Univ2.00tas Brawijaya Univers3 as BraCelluloseUniversitas Brawijava Univ 37.50s Brawijava Uni 41:09 as Brawijava awijaya Inivers4.as Bra Hemicellulose ersitas Brawijaya Univers6.57s Brawijaya awijaya Universitas Brawijaya 69.33 as Brawijaya 5. Holocellulose awijaya rsitas 6. niversitas Brawijaya 29.37 26.69 Pentosan Solubility in 1% NaOH 29.96 24.69

Source: Erwinsyah, et al (2015)

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OPEFB fiber also contained organic elements such as C of 42.800-54.760%, K 2.285%, N 0.350%, Mg 0.175%, Ca 0.149% and P 0.028% (Erwinsyah, *et al*, 2015). These nutrients can be used as soil improvement components. Chemical components such as cellulose, lignin, and hemicellulose content in Oil Palm Empty Fruit Bunches (OPEFB) can be processed into highvalue products such as biofuel (bioethanol), lactic acid, cellulose acetate, microcrystalline cellulose, as well as biopolymers or bioplastics. In addition, many environmentally friendly products can be made lignin-based, such as sugar, polylactic acids (PLA) as a bioplastic material, lignin-based adhesive, activated carbon, vanillin of lignin, food additives, and others.

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Unive 2.3.2. Banana Stems

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Banana (*Musa Paradisiaca*) is an annual plant that can bear fruits in all seasons. The most unutilized part of the banana plant is the banana stems. According to Martirawati (2017), the banana stem was one of the potential and strategic agricultural waste that categorized as organic waste. Besides, at a cost issue, it was relatively low in the process of acquisition and handling. In general, people used the banana stem waste as animal food, fertilizer, or handicrafts. However, considering that there is still a large amount of banana stem waste, alternative waste-treatment efforts are needed to handle banana stem waste appropriately.

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Figure 2.2 Banana Stems Source: Martirawati (2017) awijaya

Universitas Brawii The banana stem waste can be used as a source of fiber which has Unive economic value. The banana stem was a type of fiber that had good quality and lave potential to be used as an alternative making material for biodegradable pots, banana stem waste was one of the cheap materials and easy to obtained (Supraptiningsih, 2012). According to Prayoga (2016), banana stems which were called gedebog in Bahasa Indonesia were a pseudostem consisting of a layered midrib that functions as a support for banana leaves and fruit on a banana plant.

Banana stems contained more than 80% water and contained high glucose and cellulose. The α -cellulose contained in banana stems was up to 83.3% and available the lignin content was 2.97% (Bahri, 2015). The high content of cellulose in banana stems made it an organic material that was able to strengthen the e physical structure of biodegradable pots produced. Therefore, the banana stem laya has the potential to be used as a raw material or a mixture material for making biodegradable pots. The chemical composition of banana fiber according to the Building Material and Technology Promotion Council is shown in **Table 2.3**. Unive Tabel 2.3 Chemical Composition of Banana Fiber as Brawijaya Universitas Bra Chemical composition awijaya Universitas BrContent (%) iversitas Brawijaya wilava Lignin 5 - 10Cellulose 60-65 Universitas Brawijaya Universitas Brawij6va Hemicellulose Universitas Brawijaya Universitas Brawij0-15 Universitas Brawijaya ersWatePrawijaya Material and Technology Promotion Council (1998) in Syafaiisab Java Unive Source: Building Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava 9 Universitas Brawijava Universitas Rrawijava Universitas Rrawijava

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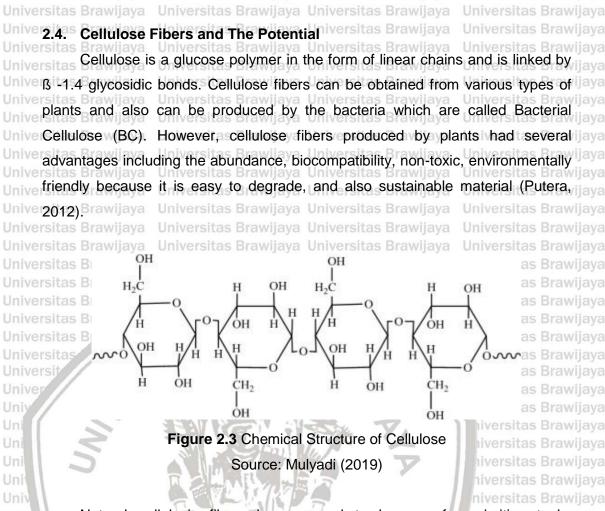
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Natural cellulosic fibers have served to humans for primitive tools, construction, and good for everyday life. Regarding growing concern for environmental protection and counteracting global warming, the utilization of Unive natural cellulosic fibers significantly increased due to as a renewable resource that possible to be used for the manufacture of recyclable products (Zimniewska, unive et al., 2011). Yet, according to Mulyadi (2019), the existence of cellulose in nature had never existed in pure form but was still associated with hemicellulose and lignin. It was called the lignocellulose structure. In the structure of lignocellulose, the existence of lignin and cellulose were bound to each other, that was, lignin became the cellulose wrapper. Following by Suryaningrum and e Reza (2018), the polymers of cellulose, hemicellulose, and lignin are tightly ava bonded by covalent and non-covalent bonds. Lignin binds to hemisellulose through covalent bonds, while the bond between cellulose and lignin is not clearly Unive known. Each glucose unit within the cellulose chain is joined to another by a C - Java O – C covalent bond flanked by two hydrogen bonds. This geometry appears a

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Universitas Brawijaya few frames of participation between covalent and hydrogen bonds in the selulosa structure (Altaner, et al., 2014). awijaya Universitas Brawijaya Universitas Brawijaya Universitas Furthermore, to break the cellulose chain bonds, the lignin content needs to Java be dissolved. The most common method for separating the structural chain between lignin, hemicellulose and cellulose in lignocellulose materials is called alkaline treatment. Moreover, alkaline treatment of cellulose fibers also aims to improve the cellulose fibers compatibility through hydrolysis of hydroxyl groups to increase the interface strength of the composites (Witono, et al., 2013). As reported by Fitriasari et al. (2019), alkaline treatment was used to break down the e glycosidic bonds within the cellulose that seemed to alter the cellulose properties, liava e thus, obtained the valuable cellulose derivatives. It as Brawijaya Universitas Brawijaya The demand for cellulose fibers nowadays was increasing along with the Unive increase in industry needs. Generally, cellulose was widely used as a raw material for paper, explosives, membranes, bioplastics, crafts material, and so on Unive (Sumada, et al., 2011). Following by Fitriasari et al. (2019) the wider utilization java and modification of cellulose fibers could be achieved through a good understanding of the structure and properties of cellulose fibers.

2.5. Sodium Hydroxide (NaOH)

Sodium Hydroxide (NaOH) is a compound that is commonly used in the alkaline treatment of pulping process from natural fibers for making composites or paper (Ahmadi and Sayed, 2019). The addition of NaOH will help the separation between cellulose fibers and non-cellulose fibers, thus it can increase the quality of fibers by increasing the cellulose content. This is called the delignification process (Ferreira, et al., 2021). The advantage of using NaOH as an alkaline treatment is that it is more efficient in time because NaOH reacts faster with lignin. It means that the time needed for the cooking process is quite shorter. Since lignin was a major inhibitor in the preparation of cellulose, the presence of high lignin was not expected in the pulping process, it preferred to have high cellulose in the pulp due to produce higher pulp yields and better strength (Fitriasari *et al.*, 2019). On the other hand, NaOH was selected for alkaline treatment due to easier to obtain, as well as the price was relatively low (Ahmadi and Sayed, 2019). The increase in the cellulose content became a key factor to improved the properties unive and quality of natural fibers (Witono, et al., 2013), that related to the water Universitas Brawijaya Universitas Brawijaya

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absorption capability and the plasticity of fibers, thereby facilitate the moulding process, increasing the contact between the fibers and the improve the strength of the composite (Fitriasari et al., 2019). According to Paskawati et al. (2010), in the pulping process (separating the fiber chain), the higher alpha-cellulose contained in the pulp was, the quality of the pulp produced would also be iversitas Brawijava Universitas Brawijava Universitas Brawijava increasingly good. NaOH is a chemical substance that is strongly alkaline and hygroscopic (absorbs water). In trade, it is better known as caustic soda in the form of a white solid or crystal. In the cooking process of cellulose fibers, NaOH also serves to ve remove unnecessary substances and the dirt attached to the fibers. The loss of unnecessary substances and impurities in the fiber will facilitate further processes and can inhibit the growth of fungi. However, because NaOH was corrosive which Unive could damage materials such as, textiles, leather, or paper, then in its use it lave might be paid attention to the concentration used (Widihastuti, 2005). On the Universities of NaOH as a cooking solution would cause available degradation of the cellulose content in the fiber. In its use, NaOH concentration was limited to a maximum of 15% (Paskawati et al., 2010).

In the study of bagasse delignification using NaOH as a delignificator of Java 2%, 4%, 6%, the results showed a reduction in lignin levels of the highest in the 6% NaOH treatment. Lignin level fell by 32% from 17.65% to 11.9% (Gunam, et ava al., 2011). Another research was also carried out by Nasruddin (2012) and Dewi, et al (2019) respectively in the cellulose delignification process from OPEFB weighed 500 grams with NaOH solution of 2%, 4%, 6%, and 8%. The result showed that, at a concentration of 8% NaOH, lignin content decreased from 22.158% to 2.361%. Whereas the delignification of banana stems with NaOH concentrations of 1%, 2%, and 3%, showed a point yield optimum delignification at 3% NaOH to produce a final lignin level of 2.637% and cellulose by 80.713%. From the research above, it is known that NaOH solution was commonly used in layar the cellulose delignification process, but the optimum concentration of NaOH in e cellulose delignification for OPEFB and banana stems is still unknown. Therefore, liava based on the best results from the literature above, it is used as a benchmark for the NaOH concentration used in this research. Universitas Brawijaya Universitas Brawijaya Universitas Brawijava¹²niversitas Brawijava Universitas Brawijava Universitas Rrawijava Universitas Rrawijava

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Tapioca flour is starch from the extraction of cassava tubers (Manihot utilissima Pohl) that had been washed and dried. The main content of tapioca flour was starch (Bulkaini, et al., 2020). Starch content in tapioca flour was higher Unive than cornstarch, rice flour, and glutinous rice flour (Ramona, et al., 2011 in available) Septianti, et al., 2016). Because of its high starch content, tapioca was widely used as an ingredient for thickeners, fillers, and binders in the food industry Univer(Astawan, 2009). Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya In addition, tapioca flour had the potential to be used as a natural adhesive. Unive The advantage of tapioca adhesive was that it had water absorption, good ava adhesive strength and it was easily obtained and not harmful to health (Jumiati, 2020). According to Rafi (2010), tapioca flour used as an adhesive needed to be Unive converted into a colloidal gel through the process of warming up. Starch that awijaya turns into a gel was irreversible, where the starch molecules would stick together Unive and form lumps resulting in increased viscosity value.

Lina's research (2010), by making briquettes with 10% (m/v) tapioca adhesive, showed the optimum result and the increased briquette quality. While in the study of Akhir, et al. (2018) on the made of Environmentally Friendly Seedling Containers (WSRL) from newspaper raw materials using 8% and 12% (w/w) tapioca adhesive, it showed the best result on 8% tapioca adhesive. Therefore, based on the best results from the literature above, it is used as a benchmark for the tapioca adhesive concentration used in this research at 10% University of concentration (m/v). The various types of natural adhesives can be seen in AL A 15 Table 2.4.

| Table 2.4 The Ty | pes of Natur | al Adhesiv | es | awijaya | Unive | rsitas Brawijaya |
|--------------------------------|----------------------|---------------|----------|-----------------------------|---------------------|---------------------------------------|
| Universitas Types of | Water | Ash (%) | Fat | Protein (%) | Crude | ^S Carbon ^{wijaya} |
| Universita Adhesive/a | Unive(%) | Brannjaya | · (%) ∣ | itas Brawijaya | Friber | rsita (%) rawijaya |
| Universitas Material ya | Universitas | Brawijaya | Univers | itas Brawijaya | (%) vei | rsitas Brawijaya |
| UniversTapioca flour ya | Univ 9.84as | Bra 0.36/a | U1.50 | itas 2.21 wijaya | 0.69/ei | sit85.20awijaya |
| UniversCorn flourvijaya | Univ10.5215 | Bra 1.27ya | 4.89 | itas 8.48 wijaya | 1.04ve | sit73.80awijaya |
| Univer Rice flour | Univer.58as | Bra 0.68va | 4.53 | itas 9.89 _{wijaya} | 0.82 _{ve1} | sit76.90 awijaya |
| Wheat flour | 10.70 University | Bra 0.86 | 2.00 | 11.50 itas 11.50 | 0.64 | sitaa zoawijaya |
| Sago flour | 14.10 Universitas | 0.67 | 1.03 | 1.12 | 0.37 | 82.70 |
| Universitas Brawijaya | Universitas | Source: Ju | mati (20 | itas Brawijaya | Univer | sitas Brawijaya |
| Universitas Brawijaya | Universitas | Brawijaya | Univers | itas Brawijaya | Univer | sitas Brawijaya |
| Univer2.7.5 Previous F | Researches | Brawijaya | Univers | itas Brawijaya | Univer | sitas Brawijaya |
| Universitas Brawijaya | Universitas | Brawijava | Univers | d waste has be | Univer | sitas Brawijaya |
| Universitas Brawlaya | on the utilization | tion of oil p | aim soi | d waste has be | en don | e by many jaya |
| Unive researchers. Ho | wever, no r | esearch d | iscusses | s the use of | OPEFB | as a raw jaya |
| Universitas Brawijaya | Universitas | Brawijaya | Univers | itas Brawijaya | Univer | sitas Brawijaya |
| Universitas Brawijaya | Universitas | Brawijaya | 3 nivers | itas Brawijaya | Univer | sitas Brawijaya |
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|----------------------|--------------------|--|--|--|---|
| 9 | awijaya | | | | ijaya Universitas Brawijaya |
| | awijaya | Univermaterial for | biodegradable pots wi | th a mixture material o | f banana stems. Table |
| a | awijaya | Universitas Braw | ijava Universitas Braw | Im solid waste that has | ijaya Universitas Brawijaya |
| <u> </u> | awijaya | Unive 2.5 present | s the utilization of oil pa | Im solid waste that has | been performed. Brawijaya |
| n./ | awijaya | | | | ijaya Universitas Brawijaya |
| L L | awijaya | | | | ijaya Universitas Brawijaya |
| it. | awijaya | Researche | | | ijaya Universitas Brawijaya |
| repository.ub.ac.id | awijaya | Universites braw | ijaya oniversitas brav | ijaya Methodsitas Braw | ijaya Resultsitas Brawijaya |
| d | awijaya | Unive <u>rsitas Braw</u> Jaya, <i>et al</i> | Palm oil fiber. The steps | This research aims to | The result shows the |
| re | awijaya | (2019) | include preparation of | analyzing the addition | moisture level of |
| | awijaya | Universitas braw | raw materials, chopping | of natural adhesive on | organic pots ranged |
| | awijaya | | fibers to 0.5 cm, adding | organic pots, as well | |
| | awijaya | | natural adhesive, heating until viscous, | as analyzing physical properties, moisture | with water absorption between 129.25- |
| | awijaya | Universitas Braw | and moulding process. | content, water | 155 48% And the |
| | awijaya | | | absorption and level | hedonic test shows |
| | awijaya | Universitas Braw | | of liking to organic pots | acceptance highest |
| | awijaya | Universitas Braw | | generated through the hedonic test, hedonic | |
| | awijaya awijaya | Universitas Braw | | au alitu | ijand texture:rsitas Brawijaya ijaya Universitas Brawijaya |
| | awijaya | Universites | TAS | RD | ijaya Universitas Brawijaya |
| | awijaya | Effendi | OPEFB, Mlidrib and | To analyzing the | The result shows there |
| | awijaya | (2012) | stem of Palm oil. The | influence of the | was a response on |
| | awijaya | Univ | steps include preparation of raw | different composition of constituents and | parameters pH value, C/N ratio, but it was |
| | awijaya | Uni | materials, washing | dosage NaOH was | not on rsitamass, vijava |
| | awijaya | Uni 🛛 N | process, chopping to 2- | used on the green | thickness, ersitas and vitava |
| | awijaya | Uni | 5 cm, first boiling phase | polybags design in | moisture content of |
| | awijaya | Unit | for 2-3 hours, second | parameters pH, C/N | green polybag. |
| | awijaya | Univ | boiling phase, pulping process, adding | ratio, mass, moisture content, and thickness. | niversitas Brawijaya |
| | awijaya | Univ | adhesive, moulding, | | Universitas Brawijaya |
| | awijaya | Unive | and sunlight drying for 2 | | Universitas Brawijaya |
| | awijaya | Univer | days. | | Universitas Brawijaya |
| | awijaya | Universilalahi | OPEFB, Midrib and | To analyzing the | The result shows the |
| | awijaya | Unive (2017) | stem of palm oil and | influence of different | use of palm oil waste |
| | awijaya | Universita | newspapers. The steps | composition | highly influence Bonwijaya |
| | awijaya | Universitas | include preparation of | constituents and | parameters pH_value, wijaya |
| | awijaya | Universitas B | raw materials, chopping to 2-5 cm, first boiling | dosage of NaOH was used on the green | C/N ratio, moisture, and mass. While |
| | awijaya | Universitas Bra | phase for 1-2 hours, | polybags design in | dosage NaOH only dave a response to |
| | awijaya | Universitas Braw | second boiling phase | parameters pH, C/N | |
| | awijaya | | for 30 minutes, pulping, | ratio, mass, moisture | |
| | awijaya | | | | C/N ratio parameters. |
| | awijaya | Universitas Brawi Universitas Brawi | sunlight drving for 2-3 | ijaya Universitas Braw ijaya Universitas Braw | ijaya Universitas Brawijaya ijaya Universitas Brawijaya |
| | awijaya awijaya | Universitas Braw | days. | ijaya Universitas Braw | ijaya Universitas Brawijaya i jaya Universitas Braw ijaya |
| A | awijaya awijaya | Universitas Braw | | rijaya Universitas Braw | |
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| JA's | awijaya | Universitas Braw | | rijaya Universitas Braw | |
| I L | awijaya | Universitas Brawi | Second and the Second and a second fraction of the second fraction of the second s | ijaya Universitas Braw | |
| RAWIJAYA RAWIJAYA | awijaya | Universitas Brawi | | ijaya Universitas Braw | |
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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya CHAPTER III RESEARCH METHOD awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Time and Location of Research Universitas Brawijaya This research was conducted at the Processing and Process Technique of Food and Agricultural Products Laboratory, Department of Agricultural Engineering, Faculty of Agricultural Technology, Brawijaya University, Malang in awijaya Jniversitas Brawijaya Universitas Brawijaya March-May 2021. Universitas Brawijaya Universitas Brawijaya awijaya awijaya Tools and Materials Brawijaya Universitas Brawijaya awijaya 3.2. awijaya 3.2.1. Tools awijaya awijaya Universitas 1. Machete to chop OPEFB and Banana stems awilaya Universitas B awijaya A pot with a diameter of 22 cm as a container for boiling Ingredient awijaya awijaya materials awijaya Starco brand digital scale to weigh the mass of ingredient materials 3. awijaya Measuring cup to measure the volume of boiling water inversitas Brawijaya 4. awijaya awijaya Blender with a volume of 1.5 liters to blend the ingredient materials 5. A stove that is used as a heater when boiling the ingredient materials 6. awijaya A bucket with a diameter of 30 cm as a container for washing ava 7. awijaya ingredient materials Biodegradable pots mould with dimensions of 5 x 8 x 9 cm and 4 x 7 x 8. awijaya awijaya 8 cm awijaya 9. Oven to dry the biodegradable pots awijaya 10. Thermometer to measure water temperature during boiling erstas Brawlava awijaya 11. Glass stirrer for homogenization of NaOH solution ya 12. Beaker glass as a container for making NaOH solution inversitias Brawlava awijaya Universitias 13. Plastic box of 13 cm height as a container in Biodegradition test 14. Soil as burying media in Biodegradation test awijaya Universitas 15. Aluminum foil for wrapping Biodegrable pots during drying process Brawijaya awijaya 16. PCE-FM 500 N mechine to measure the tensile strength awijaya awijaya awijaya awijaya 3.2.2. Materials Universitas Brawijava Universitas Brawijay OPEFB as raw material for making biodegradable pots that were Universitas E Universitas Bravobtained from PT. Sawit Arum Madani, Blitar awijaya 2. Banana stems as a mixture material for making biodegradable pots Universitas Brasthat ware obtained from Gadang, Malang Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya **15** niversitas Brawijaya awijaya Ilniversitas Rrawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

Universitas Brawijaya awijaya awijaya 3. Sodium Hydroxide (NaOH) crystal PA as an alkaline treatment to break awijaya Universitas Brawijaya Universitas Brawijaya Universitas Bra down the fibers (pulping) ijaya Universitas Brawijaya Universitas 4.1 Tapioca flour as adhesive ava Universitas Brawijaya Universitas Brawijava Universitas Brawijava Universitas Brawijava Universitas 5 Aquadest as a solvent Universitas Brawijava Universitas 6 a Water to boil ingredient materials iversitas Brawijaya Univer3i3 as Research Methodsitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Universitians This research used a factorial Completely Randomized Design (CRD) awijaya which consists of 2 factors and 3 replications. 1st Factor was the raw materials awijaya Unive composition consisting of 5 levels, namely: iversitas Brawijava awijaya Universitas B1. R1 : 100% OPEFB awijaya awijaya 2. R₂ : 80% OPEFB + 20% Banana Stems awijaya Universitas B3. R₃: 60% OPEFB + 40% Banana Stems awijaya awijaya 4. R₄: 40% OPEFB+ 60% Banana Stems awijaya 5. R₅ 100% Banana Stems awijaya awijaya While 2nd Factor was the concentration of Sodium Hydroxide (NaOH) consisting awijaya of 3 levels, namely: awijaya awijaya 1. C₁ : 3% (m/v) NaOH awijaya 2. C₂: 5% (m/v) NaOH awijaya 3. C₃: 7% (m/v) NaOH awijaya awijaya With this design, 15 treatment combinations will be obtained. The combination of awijaya the treatment can be seen in Table 3.1. SPSS packages were used for data awijaya University analysis. Analysis of Variance (ANOVA) was applied to test for differences awijaya between various experimental factors then followed by DMRT (Duncan's Multiple awijaya Range) to determine the effect of the independent variables (both of composition awijaya of the biodegradable raw materials and NaOH concentration) on the dependent awijaya variables which are the tested parameters (mass, moisture content, water uptake, awijaya Unive tensile strength, and biodegradation test). Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Unive Table 3.1 Treatment Combinations lava Universitas Brawijava awijaya Univer OPEFB+Banana Unive R1 as Brawij R2 Universit R3 Brawijava R4 niversita R5 rawijava awijaya Stems awijaya Universitas Brawijaya Universitas Brawijaya NaOH Brawliava Universitas Browijaya Univ R_1C_1 as Braw R_2C_1 Universi R_3C_1 rawija R_4C_1 iversit R_5C_1 awija ya Univ R_1C_2 as Braw R_2C_2 Universi R_3C_2 rawija R_4C_2 iversit R_5C_2 awija ya Universitas Biczwijaya Univ R_1C_3 is Braw R_2C_3 Universi R_3C_3 rawijay R_4C_3 iversit R_5C_3 awijaya Universitas BiGsvijaya Universitas Brawilava rersitas Brawijaya. Universitas Brawijaya – Universitas Brawijaya Universitas Brawijava¹⁶niversitas Brawijaya Universitas Brawijaya Ilniversitas Rrawijava Universitas Rrawijava Universitas Rrawijava awijaya

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3.4. Research Implementation
 3.4.1 Making Biodegradable Pots
 1. Preparation of Raw Materials and Tools
 The raw materials used in this research were OPEFB and banana stem as a mixture material. The total amount of raw materials needed to make one biodegradable pot was 50 grams. 1.260 kg of OPEFB and banana stems as much as 0.990 kg were required to make 45 samples of biodegradable pots. NaOH used in the form of solid crystals PA (Pro Analysis) was further dissolved with distilled water according to the concentration used. While the tools needed were: blender, pot, machete, digital scale, stove, glass stirrer, thermometer, beaker glass, measuring cup, aluminum foil, and biodegradable pots mould.

2. Raw Materials Copping

Oil Palm Empty Fruit Bunches (OPEFB) and banana stems were chopped using a machete. The length of the OPEFB fibers and the banana stems fibers that had been chopped measured 1-2 cm.

3. Raw Materials Washing

Ab

Oil Palm Empty Fruit Bunches (OPEFB) and banana stems that had been chopped were washed to reduce the amount of dirt attached to the raw materials. Washing was done by soaking the raw materials in a bucket and manually rubbing on the surface then rinsed clean.

Universita4. Drying

a Universitas Brawijaya aya Universitas Brawijaya aya Universitas Brawijaya aya Universitas Brawijaya aya Universitas Brawijaya

Universitas BOil Palm Empty Fruit Bunches (OPEFB) and banana stems that had been java awijaya washed dried in the sunlight for 2 x 24 hours to reduce the moisture content awijaya in the materials, thus the raw materials could last for a long time storage awijaya awijaya Universitabefore biodegradable pots making process sitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Universita5. BFirst Phase Boiling as Brawijaya Universitas Brawijaya awijaya According to Jaya, et al. (2019) and Silalahi (2017), making biodegradable pots involves two phase of boiling process. In the first fhase of boiling, OPEFB fiber and banana stems fiber were boiled accordingly treatment composition. The first phase boiling aimed to soften raw materials Universitas Brawijava Universitas Brawijava Zniversitas Brawijava Universitas Brawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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Universitas Brawijaya and remove dirt that might still be attached to the materials. Comparison between raw materials and volume of water used during boiling was 50 Universit grams: 1 liter, or until the materials submerged. Boiling was carried out for an lave hour at a temperature of 95° - 105° C. The temperature and boiling time were selected based on the results of the pre-research, because under these conditions, soft and clean OPEFB fiber and banana stems fiber have been obtained. The boiling water then was discarded and the materials were sitadrainedijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universit 6. BSecond Phase Boiling Continue Universitas Brawijava Universitas Brawijava In making biodegradable pots, the second phase boiling aimed as an alkaline treatment. The second phase boiling was carried out at a temperature of 95° - 105° C for 30 minutes. The temperature and boiling time lava were selected based on the results of the pre-research, to avoid corrosion of the pan caused by adding NaOH solution during boiling process. Water needed to boil biodegradable pots composition material was 1 liter for every 50 grams of biodegradable pots (OPEFB and banana stems). Each composition of the constituent materials was poured into a pot that had been filled with water and boiled. NaOH solution was added according to the concentration of each treatment in making biodegradable pots, namely 3%, ava 5%, and 7%. And stirring was done occasionally during the boiling process. The addition of NaOH aimed to break the bonds between cellulose fibers with the lignin contained in the materials. After the boiling process, remove the water in the pot and drain materials to separated cellulose with lignin that had been degraded. Thus, the cellulose content in the material increased. as Brawlava 7. Pulping

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awijaya awijaya Versites BOPEFB and banana stems were boiled and then mashed using a blender Java awijaya by adding 10% (m/v) tapioca adhesive in grams/milliliters unit. OPEFB and awijaya banana stems were then mashed until became pulp and mixed evenly. awijaya awijaya Addition of solution tapioca flour aimed as a natural adhesive to strengthen awijaya the bond between the fibers. After the blending process, the pulp materials were boiled again for 5 minutes or until viscous. The length of boiling time was selected based on the results of pre-research. And the results of the versitaboiling process would produce a pulp. Inversitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya¹⁸niversitas Brawijaya awijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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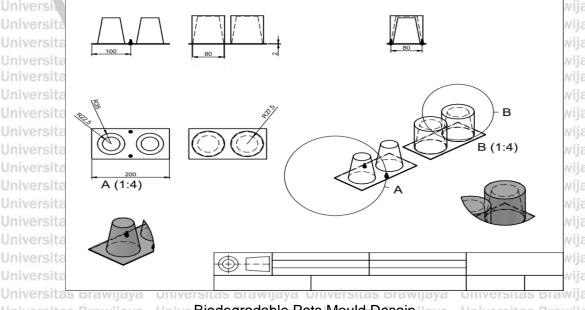
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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universit 8. Biodegradable Pots Moulding ya Universitas Brawijaya Universitas Brawijaya awijaya Universitias BAfter the pulping process, the pulp of biodegradable pot's raw materials then went into the moulding process. The biodegradable Pots mould was Universit made of an iron plate with a thickness of 2 mm, 20 cm long, and 10 cm wide which consists of 2 parts, namely the outer mould and inner mould (press) with holes at the bottom to facilitate the discharge of the remaining awijaya awijaya biodegradable pots pulp and water. The outer mould had a bottom diameter awijaya of 5 cm, top diameter of 8 cm, and a height of 9 cm, while the inner mould awijaya Universit that was used as the press had a diameter of bottom 4 cm, top diameter of 7 java awijaya awijaya cm, and height of 8 cm. So it was expected that wet biodegradable pots have a uniform section thickness of 5 mm side and bottom thickness of 1 cm, with awijaya Universit the size of biodegradable pots moulded, was 5 x 8 x 9 cm, which was awijaya awijaya following the size of the organic pot on the global market. awijaya

> Before the moulding process, the mould was coated with aluminum foil that had been smeared with cooking oil to facilitate the biodegradable pots moulding process. Biodegradable pots pulp was slowly poured into the outer mould according to the shape of the mould, then affixed the inner mould as a lave press and pressed retaining, thus the remaining pulp and the remaining water could exit through the hole in the mould. As the result, biodegradable pots were obtained in uniform thickness and dimensions.



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Figure 3.1 Biodegradable Pots Mould Source: Personal Documentation 9. Biodegradable Pots Drying

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The biodegradable pots drying process was carried out by drying the biodegradable pots in sunlight for 2 x 7 hours until half-dry to reduce the amount of surface water on biodegradable pots, then oven-dried at temperature 105° C for 24 hours to obtain a constant mass to determine the moisture content.

3.4.2 Testing Parameters

1. Biodegradable Pots Mass

The mass measurement of Biodegradable pots was carried out using a digital scale and expressed in grams. Measurement data of biodegradable pots mass will be processed by the ANOVA (Analysis of Variance) test.

2. Moisture Content Test

The moisture content test was carried out by ISO 287: 2017 Paper and board - Determination of moisture content of a lot - Oven drying method with weighed the wet biodegradable pots as the initial mass (m_i) and oven at 105° C for 24 hours, then weighed until the mass was constant as the final mass (m_f). The calculation of the moisture content aimed to determine the level of ability of the material to withstand the quality of the attack microorganisms and fungi during storage. The higher the levels of water, microorganisms, or fungi have the potential to grow, thus it could cause the damage or decay of the biodegradable pots during the lifetime storage. The moisture content of the biodegradable pots was calculated using the equation as follows: Universitian B Moisture Content (%) = $\left[\frac{m_i - m_f}{x}\right] \times 100\%$ sites. ersitas Brawijaya mi ya Universitas Brawijaya Universitas Brawijaya Universitas Bra Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava20 niversitas Brawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

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Universitas Brawijaya ta Note: wijaya m_i: Initial mass of biodegradable pots before oven (grams) Universita mr: Final mass of biodegradable pots after oven (grams) wijava ersit 3. BWater Uptake Test as Brawijaya Universitas Brawijaya The water uptake test showed the ability of the material to absorb water to determine the level of water resistance indicated by the percentage addition of the sample mass from the swelling phenomena during the immersion process, carried out according to ASTM D570-98 Standard for water absorption by weighed dry mass of biodegradable pots sample (m_d), then the sample size 3 x 3 cm² soaked for 24 hours at a room temperature until became saturated and drained until there was no surface water left behind. The next step is to re-weighed the sample to found out the wet mass (m_w). The water uptake test indicated the level of mechanical resistance of the biodegradable pots when grown in wet soil. Therefore It is expected that biodegradable pots have good water resistance, by slightly absorbing water, thus it ought to has a low percentage of water uptake. To determine the percentage of water uptake can be known by using the following equation:

Note:

 m_d : Dry mass of the sample before immersion (grams) m_w : Wet mass of the sample after immersion (grams)

4. Biodegradation Test (Soil Burial Test)

The biodegradation test aimed to determine whether the biodegradable pots are well degraded in nature indicated by percentage loss of the sample mass during the soil burial test. Based on ASTM D5988 – Standard for determining aerobic biodegradation in soil, biodegradation test was carried out by burying the sample of biodegradable pots in the soil (soil burial test). The soil used was topsoil type at a maximum depth of 10 cm from the surface area, which has enough nutrient content. The soil was placed in the container plastic with small holes on the bottom and each side to improve air and water circulation. Sample size 3 x 3 cm² buried in the soil for 21 days at a soil depth of 10 cm from the surface and placed outdoors. Then the loss mass of sample was observed every week to find out the kinetics of loss mass. After testing, the samples were cleaned with distilled water, dried in an oven at

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Universitas Brawijaya awijaya awijaya 105° C for 2 hours, and weighed every 30 minutes until the mass of the awijaya sample was constant to determine the degradability of biodegradable pots and to compare the condition of the sample before and after buried. The degradation value was carried out based on the gravimetric method and niversitaexpressed in percent units: rawijaya Universitas Brawijaya Degradation Potential (%) = $\left[\frac{m_i - m_f}{m_i}\right] x \ 100\% \dots$ Universitas B(3)vilava itas Brawijaya awijaya awijaya m_i : Initial mass of biodegradable pots sample before burying (grams) awijaya Universita mr: Final mass of biodegradable pots sample after burying (grams) inversitas Brawijava awijaya Universitas Brawijaya Universitas Devijaya Universitas Brawijaya awijaya 5. Tensile Strength Test awijaya

> Tensile strength testing of biodegradable pots was carried out at the Processing and Process Engineering of Food and Agricultural Products Laboratory used PCE-FM 500 N. Based on ASTM D3039 Standard Test Method for Tensile Properties of Polymers Matrix Composite Materials, tensile strength test performed on specimens with dimensions of 25 x 2.5 cm² and a thickness of 2.5 mm. The tensile strength test was carried out by clamping the specimen to the grips while given an ever-increasing graded axial load to a test sample up to the point of failure. The tensile test simulates natural pressure exerted by the environment against the biodegradation pots. The value of tensile strength is calculated using the equation:

Note:

Universita σ : Tensile strength value (N/m²)

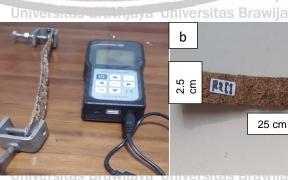
Universita F : Load when failure (N)

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A : Cross-section area of the specimen (m²)

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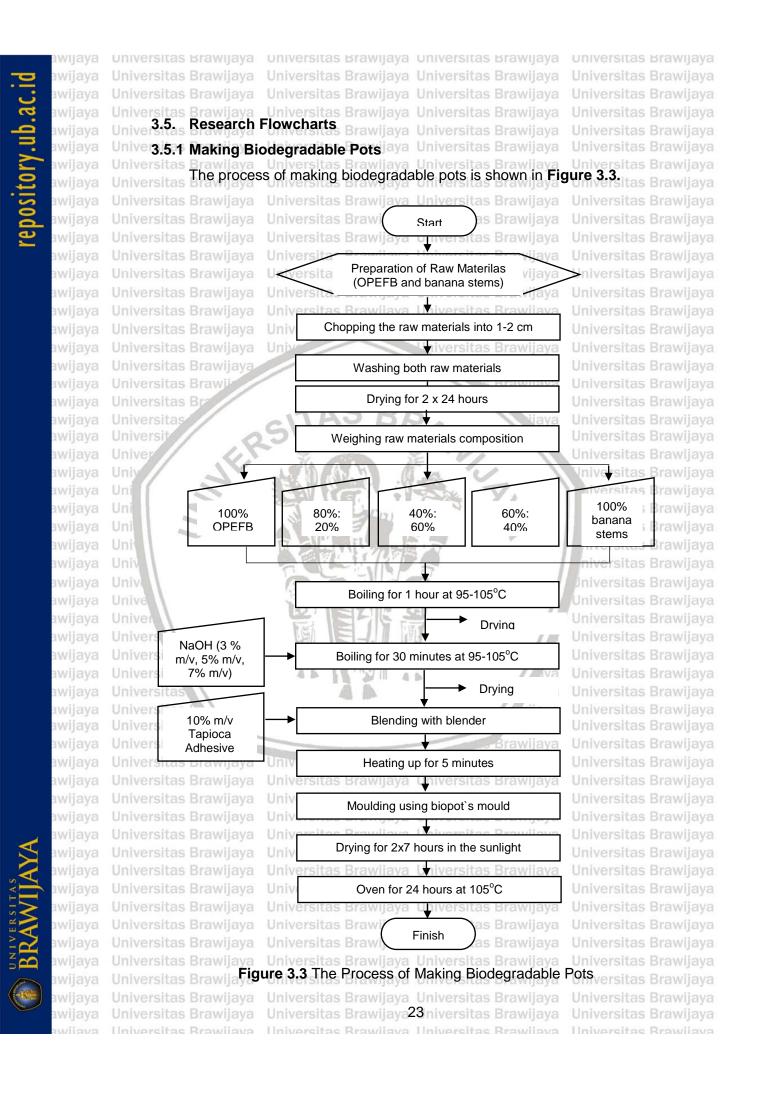


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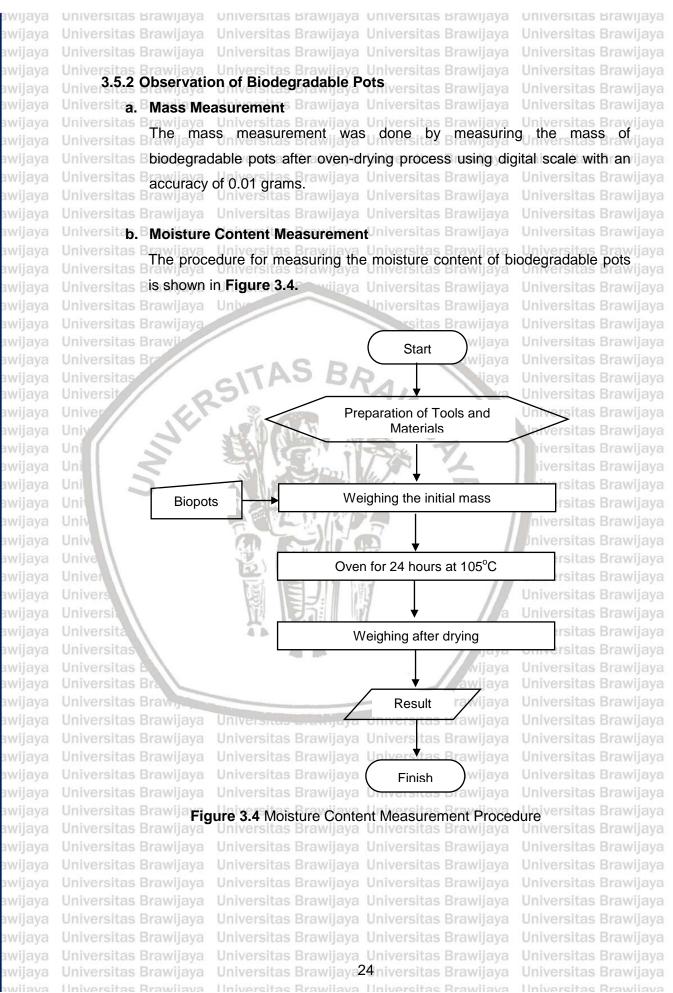
Universitas B Figure 3.2 Tensile Strength Test Tools (a) PCE-FM 500 N (b) Specimen

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitac BWater Uptake Testas Brawijaya Universitas Brawijaya awijaya awijaya The procedure for analyzing the water upatake of biodegradable pots is awijaya awijaya Universitas Bshown in Figure 3.5.s Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Start sitas Brawijava Universitas Brawijaya Univ Universitas Brawijaya Universitas Brawijaya awijaya Preparation of Tools and Universitas I awijaya 🛪 🛪 🛪 🛪 🛪 Materials Universitas awijaya Universitas Brawijaya Universitas Brawijaya awijaya diava Universitas Brawijava Universitas Brawijaya awijaya awijaya Universitas **Biopots** Cutting to size 3 x 3 cm awijaya Iniversitas Brawijaya awijaya awijaya NERS niversitas Brawijaya Weighing the dry mass awijaya awijaya Universitas Brawijaya awijaya awijaya Soaking in water for 24 hours awijaya awijaya awijaya awijaya Drying to remove the surface water awijaya awijaya awijaya Iniversitas Brawijaya Weighing the wet mass niversitas Brawijaya awijaya awijaya Universitas Brawijaya awijaya awijaya Result awijaya awijaya awijaya awijaya Finish awijaya awijaya awijaya Figure 3.5 Water Uptake Analysis Procedure awijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava25 niversitas Brawijava

Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universited. Biodegradation Test Brawijaya Universitas Brawijaya nrv ub ac. awijaya awijaya The procedure for biodegradation analysis of biodegrdable pots is shown awijaya Universitas Bin Figure 3.6 versitas Brawijaya Universitas Brawijaya Start Universitas Brawijaya Universitas Brawijaya rsitas Brawijaya Universitas Brawijava awijaya rsitas Universitas Brawijaya Preparation of Tools and awijaya Materials Jniversitas Brawijaya Universitas Brawijaya Uni ersitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya awijaya Iniversitas Brawijaya awijaya Cutting to a size 3 x 3 cm awijaya Universita **Biopots** Iniversitas Brawijaya awijaya Universitas Brawijay awijaya awijaya Jniversitas Brawijaya Weighing the initial mass awijaya awijaya awijaya Universitas Brawijaya Univ awijaya Burying in the soil for 21 days awijaya awijaya awijaya Aquadest Washing the sample after burying awijaya awijaya awijaya awijaya Iniversitas Brawijaya Oven at 105°C for 2 hours Iniversitas Brawijaya awijaya awijaya Universitas Brawijaya awijaya awijaya Weighing the final mass awijaya awijaya ijaya Jniversitas Brawijaya awijaya awijaya Jniversitas Brawijaya Comparing the biodegradability of awijaya Biopots awijaya awijaya awijaya Universitas Brawijaya Uni awijaya Brawijaya Result awijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Finish Figure 3.6 Biodegradation Analysis Procedure Universitas Brawijaya Universitas Brawijava26 niversitas Brawijava Universitas Brawijava Universitas Brawijava

Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitie BTensile Strength Test Prawijaya Universitas Brawijaya awijaya awijaya The procedure for testing the tensile strength of biodegrdable pots is awijaya Universitas Bshown in Figure 3.7.s Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Start Universitas Brawijaya Unive sitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Preparation of Tools and awijaya Universitas E 🗩 rsitas Brawijaya Materials Universitas Brawijaya awijaya Universitas Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya iversitas Powijaya Universitas Brawijaya awijaya awijaya Cutting to a size 2 x 3 cm **Biopots** awijaya awijaya awijaya awijaya NEF Clamping to the grips on PCE-FM 500 N awijaya mechine awijaya iversitas Brawijaya niversitas Brawijaya awijaya awijaya awijaya awijaya Giving an ever-increasing axial load until awijaya the point of failure awijaya awijaya awijaya niversitas Brawijaya iversitas Brawijaya awijaya Analyzing the tensile strength awijaya awijaya awijaya Result awijaya java awijaya awijaya awijaya awijaya Finish awijaya awijaya Figure 3.7 Tensile Strength Testing Procedure awijaya awijaya awijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava27 niversitas Brawijava

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya CHAPTER IV RESULTS AND DISCUSSION awijaya awijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Univer4.1.3 The Results of Making Biodegradable Pots Brawijaya The results of making biodegradable pots made from oil palm empty fruit awijaya awijaya Unive bunches and banana stems using variations of NaOH concentration can be seen lava Univerin Table 4.1.ava Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Universitas Brawijava Universitas Brawijava Universitas Brawijava UniversitaTreatment/ Formulation Universitas Brawij Results iversitas Brawijava awijaya Univers100% OPEFB Universitas R1C2iava awijaya arsitas Brawijava awijaya rsitas Brawijaya awijaya awijaya awijaya ANIJAYA awijaya versitas Brawijaya awijaya R2C2 80% OPEFB : 20% awijaya rsitas Brawijaya **Banana Stems** awijaya awijaya awijaya awijaya awijaya rsitas Brawijaya awijaya **R3C2** 60% OPEFB : 40% awijaya Banana Stems awijaya rsitas Brawijaya ersitas Brawijaya awijaya awijaya awijaya awijaya 40% OPEFB : 60% **R4C2** awijaya sitas Brawijaya **Banana Stems** awijaya awijaya awijaya ersitas Brawijava awijaya ersitas Brawijaya awijaya 100% Banana Stems awijaya Universitas Brawijaya R5C2 iversitas Brawijaya awijaya **Universitas** E ijaya sitas Brawijaya awijaya awijaya awijaya rsitas Brawijaya ersitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijava28 niversitas Brawijava

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Universitas Brawijaya ersitas The quality of 15 variations of biodegradable pots was characterized by the actual size of height, top diameter and bottom diameter. Measurement results obtained biodegradable pots height of 9 cm (±0.3), the top diameter of 8 cm (±0.4), and the bottom diameter of 5 cm (±0.3) as seen in Table 4.2. The e discrepancy between the actual size of biodegradable pots and the dimensions of the mould (5 x 8 x 9 cm) can be caused by the finishing process which aimed to improve the shape of biodegradable pots that was not tidy enough from the moulding process, as well as the addition of aluminum foil into the mould caused a reduction in the top diameter and bottom diameter of the biodegradable pots. However, the use of aluminum foil could effectively facilitate the moulding process due to the viscous pulp. Based on the **Table 4.1** it can be seen that the wall-surface of biodegradable pots with more composition of OPEFB fiber tended to be rougher compared to the biodegradable pots with more composition of banana stems fiber. It is caused by the difference in morphology of the size of the fibers between OPEFB fiber and banana stems fiber. Also according to Valasek, et al. (2021), the surface roughness of fiber was influenced by the alkaline effect. The roughness of natural fibers increased after alkaline treatment due to the disintegration of hemicellulose and lignin in lignocellulosic structure. In addition, if analyzed on the colour uniformity, biopots were brown and it tended to be whiter when the NaOH concentration in alkaline treatment was increased due to more lignin and impurities in the fiber that has been hydrolyzed, as can be seen in Appendix 10. After the process of making biopots, the physicomechanical properties will be analyzed based on the parameters of mass, moisture content, water uptake, biodegradable potential and tensile strength.

Table 4.2 The Data Quality of Biopots

| Sample | Height (cm) | Top Diameter (cm) | Bottom D | iameter (cm) |
|--|--|--|--|--|
| R1C1 R2C1 R3C1 R4C1 R5C1 R1C2 R2C2 R3C2 | ijaya 9.2 iversita ijaya 9.2 iversita ijaya 9 iversita ijaya 9 iversita ijaya 9.1 iversita ijaya 9.1 iversita ijaya 9 iversita ijaya 9 iversita | 7.8 Brawija 7.6 Brawija 7.6 Brawija 7.7 Brawija 7.8 Brawija 7.7 Brawija 7.8 Brawija 7.7 Brawija 7.8 Brawija 7.8 Brawija 7.7 Brawija 7.8 Brawija 7.8 | Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya Brawijaya | 4.7 versitas Brawijaya 4.7 versitas Brawijaya 4.7 versitas Brawijaya 4.8 versitas Brawijaya 4.9 versitas Brawijaya 4.7 versitas Brawijaya 4.7 versitas Brawijaya 4.7 versitas Brawijaya 4.7 versitas Brawijaya |
| Universitas Braw Universitas Braw Universitas Braw Universitas Braw Universitas Braw | ijaya <mark>9</mark> niversita ijaya <mark>8.9</mark> iversita ijaya Universita ijaya Universita | s Brawijaya Universitas s Brawijay7.6 Universitas s Brawijaya Universitas s Brawijaya 29 niversitas s Brawijaya Universitas | s Brawijaya s Brawijaya s Brawijaya s Brawijaya | 4.8 biliversitas Brawijaya 4.7 versitas Brawijaya Universitas Brawijaya Universitas Brawijaya |

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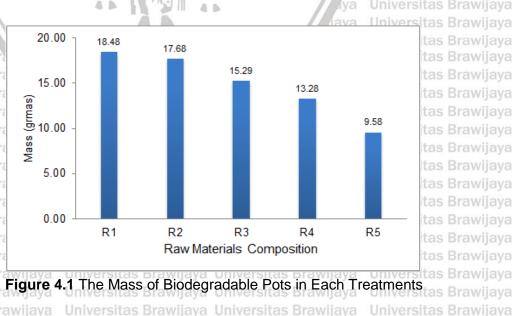
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Universitas Brawijaya wijaya Sample Top Diameter (cm) Height (cm) **Bottom Diameter (cm)** Universitas Brawijaya 88 Niversitas Brawija 7a7 Universitas Brawijaya 4 Aiversitas Brawijaya Universi R3C3rawijaya 8.8 iversitas Brawija 7.8 Universitas Brawijaya 4 7 iversitas Brawijaya Igniversitas Brawijav7a9Universitas Brawijaya Universi R4C3 rawijaya 4.8iversitas Brawijaya Universi R5C3 rawijaya 87 iversitas Brawijay 77 Universitas Brawijaya 4 giversitas Brawijaya Universitas Brawijaya Universitas Brawijaya The results of the analysis of variance (ANOVA) showed a highly significant Unive difference in the factor of raw materials composition, with a P-value of 5.225 x 10 java ⁹, while both the factor of NaOH concentrations and the interaction between the two factors were not statistically significant difference with P-value of 0.950599 for the factor of NaOH concentrations and 0.957504 for the interaction between the two factors. Based on these results, it could be assumed that the factor of raw Unive materials composition used in the making of biodegradable pots was significantly java influential toward the mass of biodegradable pots produced due to had a high diversity of variance, as seen by the highly decreasing value from R1 of 18.48 grams to R5 of 9.58 grams. But no significant influence was found for the addition of NaOH concentrations and hence there was no interaction between the two factors evidenced by the absence of the influence of NaOH factor which depends on the level of raw materials composition factor to the mass of biodegradable pots. The results of the analysis of variance (ANOVA) on the mass of biodegradable pots have been presented in the Appendix 1. While the average value of biodegradable pot's mass in each treatment can be seen in Figure 4.1.



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versitias In Figure 4.1 above, it can be seen that the average value of biodegradable pots mass in each treatment of raw materials composition factor showed different results, ranged from 9.58 grams to 18.48 grams. The lowest biodegradable pot's mass is 9.58 grams was obtained from the treatment of R5 (100% Banana stems), and the highest mass of 18.48 grams was obtained from available. the treatment of R1 (100% OPEFB). In the treatment of raw materials composition factor, the mass of biodegradable pots tended to decrease. It can be seen that the treatment of R1 (100% OPEFB) had the highest value then continuously decreased to the treatment of R5 (100% Banana Stems). This trend might occur due to the differences in morphology of the fiber size between oil palm empty fruit bunches fiber and banana stems fiber, and also due to the physical properties of the fiber, namely its density. According to Rahmasita, et al. (2017), the density of OPEFB fiber reached to 1.55 g/cm³, whereas according to [2017] Nopriantina and Astuti (2013), the density of banana stems fiber only 1.35 g/cm³. Unive The effect of differences in fiber size morphology on the biodegadable pots can lava be seen in Figure 4.2.

R2 R3 **R1**

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awijaya awijaya morphology of OPEFB fiber which leaned to be coarser and larger than banana

R4

R5 Figure 4.2 Fiber Size Morphological Appearances of Biopots

Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universital Based on Figure 4.2 above, in can be seen the fiber size morphology between OPEFB fiber and banana stems fiber was very different. The

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stems fiber will have an effect on the mass of the biodegradable pots when used in larger quantities, as seen in the treatment of R1 (100% OPEFB), the OPEFB fiber still looked very clear and had a large size compared to the treatments of R3 (60% OPEFB: 40% Banana Stems) and R5 (100% Banana Stems). Unlike the case in the treatment of K5, the fiber was almost invisible because of the small and smooth size of the fiber. According to Rahmasita, *et al.* (2017), the morphology of the oil palm empty fruit bunches fiber had a rough surface with large dimensions of 343 – 365 µm, while the large dimesions of banana stems fiber only reached to 5.8 µm (Nopriantina and Astuti, 2013). In this case, with large dimensions and higher density, the use of OPEFB fiber as raw materials can subsidize the mass of the biodegradable pot produced, which caused the higher the percentage of OPEFB used, the mass of the biodegradable pot will increase.

Unive 4.2.1. The Effect of Raw Materials Composition on Mass of Biopotssitas Brawijava

The results of the analysis of variance (ANOVA) test which showed a significant difference then continued with the DMRT (Duncan's Multiple Range) to figured out the difference between each level of raw materials composition in giving effect to the mass of biodegradable pots. Based on the results obtained, the DMRT test that was performed on the R factor (Raw Materials Composition) have been presented in the **Appendix 6**. The results of the DMRT test on the factor of raw material composition can be seen in **Table 4.3**.

| aya | Table 4.3 The Value of Biopots Mass Due to Raw Materials Composition Factor | | | | | |
|------------|---|--------------------------|---|---|--|--|
| aya | Universitas Treatm | | Average Value (grams) ersitas Brawijaya | | | |
| aya | Universitas B R1 | | 18.477c | Universitas Brawijaya | | |
| aya | Universitas Bra R2 |) | 17.681c | universitas Brawijaya | | |
| aya | Universitas Braw, R3 | | 15.288b | Universitas Brawijaya | | |
| aya | Universitas BrawijayaR4 | Universitestation | universitas E13.282b | Universitas Brawijaya | | |
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| aya | Note: the average | alue followed by the san | ne letter does not signifi | cantly different based | | |
| aya | Universitas on the DMRT | test analyzed in SPPS p | ackagesitas Brawijaya | universitas Brawijaya | | |
| aya | Universitas Brawijaya | | | | | |
| aya aya | Universitas Brawijava Universitas Based on Ta | able 4.2 above and the | e DMRT test in the Ap | pendix 6, it can be | | |
| aya | Unive seen that the leve | Is of raw materials cor | nposition factor had a | difference in giving Java | | |
| aya aya | effect to the mas | ss of the biodegradal | ole pots, indicated by | / different notation | | |
| aya | Unive results. Treatmen | t of R1 (100% OPEFB) |) had the highest average | age value, however jaya | | |
| aya | Unive not significantly d | ifferent from the treat | ment of R2 (80% OP | EFB: 20% Banana | | |
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stems) in giving effect to the mass of biopots. Likewise, the treatment of R3 (60% OPEFB: 40% Banana stems) was no significantly different from the treatment of R4 (40% OPEFB: 60% Banana stems) in giving effect to the mass of biopots. While in the treatment of R5 (100% Banana Stems) had the lowest average value of biodegradable pot's mass and significantly different from all treatment combinations. It seemed that the crosslinked biodegradable pots with the higher composition of banana stems fiber caused the decrease in the mass of biodegradable pots, while in the case of un-crosslinked biodegradable pots of OPEFB fiber-based to the un-crosslinked biodegradable pots of banana stems Unive fiber-based had a high statistical significance in the mass of biodegradable pots, lava it was due to the difference in the morphology and the density of the fiber. The relationship between raw materials composition and the mass of biodegradable

Unive pots is presented in Figure 4.3. 3RA Universitas Brawijaya 20.00 18.00 16.00 14.00 Mass (grams) 12.00 10.00 -9.2848x + 18.946 8.00 R² = 0.9886 6.00 4.00 2.00 0.00 0% 20% 40% 60% 80% 100% 120% Percentage of Reduced OPEFB in Raw Materials

Figure 4.3 The Trend of Mass on Raw Materials Composition stars Brawlava

Brawijaya Universitas Brawijaya The regression graph in Figure 4.3 explained of the tendancy of the reduction of the percentage of OPEFB used in raw materials in each treatment to decrease the mass of biodegradable pot produced. The higher the percentage of Unive banana stems used in raw materials, the lighter the mass of biodegradable pots java obtained. These results were by research conducted by Randa and Alimin e (2019), which stated that adding banana stems fiber could reduce the mass and lava density of a GRC (Glass-Fiber Reinforced Cement) composite material. Banana stems fiber is morphologically small, smooth, and light in size, thus the use of Unive banana fibers in large quantities will make the mass of the biodegradable pot lava Universitas Brawijava Universitas Brawijava 33 niversitas Brawijava Universitas Brawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya lighter. Analysis of the mass of the biodegradable pots was carried out to awijaya determine the durability level of biodegradable pots. The mass of biodegradable awijaya awijaya pots indicated the level of durability of biodegradable pots as nursery container media, which according to Evans, et al. (2010), the lighter the mass, the biodegradable pots tended to tear or break during greenhouse production, awijaya packaging, shipping, and retailing especially when wet condition. Therefore, in this research, the best result was obtained on the treatment combination of R1C1 awijaya awijaya (100% OPEFB; 3% NaOH) because had the heaviest mass. awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Moisture Contentsitas Parvijava Universitas Brawijava Universitas Brawijava awijaya awijaya Universitas In the moisture content test, the results of the analysis of variance awijaya (ANOVA) test showed no significant difference in both of the factors of raw awijaya Universation and the interaction of NaOH, as well as the interaction awijaya awijaya between the two factors was no statistically significant difference. With each Pawijaya Universalue of 0.8270 for raw materials composition factor, 0.11345 for NaOH awijaya awijaya concentrations factor, and 0.99645 for the interaction between the two factors. In awijaya other words, there was no significant effect on the moisture content of biopots awijaya awijaya that was given by either the factor of raw materials composition or NaOH awijaya concentrations factor, because the value of biopots moisture content had very awijaya low diversity of variance at each level of the factor. As seen for raw materials awijaya awijaya composition factor in R1 of 59.34 grams to R5 of 58.94 grams and for NaOH awijaya concentrations factor in C2 of 64.99 grams to C3 of 64.42 grams. Thus there was awijaya awijaya Unive no interaction between the two factors that affected the value of the biopots awijaya moisture content, evidenced by the absence of the influence of the raw materials awijaya composition factor which depends on the level of NaOH concentrations factor, awijaya awijaya also vice versa. The results analysis of variance (ANOVA) on the Moisture awijaya content of biodegradable pots can be seen in the Appendix 2. While the average awijaya awijaya ve value of the Moisture content of the biodegradable pot in each treatment can be awijaya ersitas Brawijaya Universitas Brawijaya seen in Figure 4.4. awijaya awijaya awijaya awijaya Universitas Brawijava34 niversitas Brawijava awijaya Universitas Brawijava Universitas Brawijava

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50.00 40.00 30.00

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Content

Moisture

59.34^{62.04}

R1

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58.29

64.99 64.42

R2

C1 (3% NaOH)

57.84

64.57 ^{65.89}

54.88

61.27 59.36

R4



65.73

58.97

R5

C3 (7% NaOH)

50 42



Universi Figure 4.4 The Moisture Content of Biodegradable Pots in Each Treatments availage

R3

C2 (5% NaOH)

Raw Materials Composition

Universitas Based on Figure 4.4 above, it is known that the percentage of moisture lava content of biodegradable pots in each treatment showed different results, ranged from 50.42% to 65.89%. The lowest moisture content of 50.42% was obtained from the treatment combination of R5C1 (100% Banana stems; 3% NaOH), whereas the highest moisture content was 65.89% obtained from the treatment combination of R3C3 (60% OPEFB: 40% Banana stems; 7% NaOH). The graph above showed in treatment of raw materials composition had a percentage of moisture content that tended to fluctuate at each treatment. However, in the treatment of NaOH concentration, even though the ANOVA test showed no significant difference, the percentage of moisture content tended to increase with optimum point in the treatment of NaOH 7%. As seen that the treatment of C1 java (3% NaOH) in each combination had the lowest percentage of moisture content and continued to increase until the treatment of C3 (7% NaOH), but in the treatment of C2 (5% NaOH) with a combination treatment of R2 (80% OPEFB: 20% Banana Stems) had a higher value of moisture content than the treatment of C3 (7% NaOH) on the same combination. According to Pudjiono, et al. (2012), an java increase of NaOH levels in alkaline treatment could break the fiber bond more completely, thus could increase the porosity of biodegradable pots, and caused the moisture content stored in the biodegradable pots to be increased. Meanwhile, according to Wahyudi (2014) in Jaya, et al. (2019), the composition Unive of the raw materials mixture for making biodegradable pots had no effect on the lava moisture content. Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava35 niversitas Brawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

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Universitas Brawijaya versitias BNevertheless, in this research, it was found the opposite result for the NaOH concentration factor. This unusual outcome could be due to an uneven increased porosity of the biodegradable pot caused by irregular dispersion of the fibers in the biodegradable pot matrix during the moulding process. The nive appearance of fiber dispersion in the biodegradable pots can be seen in Figure lava Univeraitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya niversitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya

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Irregular Dispersion Regular Dispersion Figure 4.5 Fiber Dispersion Appearances of Biopots

Based on the Figure 4.5 above, the regular fiber dispersion was indicated by completely bonded fibers. While the irregular fiber dispersion shows the breaking point, lead to discontinuity of the fibers bonds in the biodegradable pots. This irregular dispersion of fibers would cause decreasing the ablity of biopots to retain water, therefore the unevenness of the increase in porosity had an impact on an insignificant increase in moisture content, moreover, the moisture content decreased in R2 (5% NaOH) of 64.99% to R3 (7% NaOH) of 64.42%. Meanwhile, the results of this research was also in accordance with the results of research by Effendi (2012), in the making of green polybags from OPEFB and oil palm midribs, that either the material composition of green polybags or the NaOH concentration used, also the interaction between the two factors, did not significantly affect the moisture content of green polybags produced. The most plausible explanation for this difference in results may be available due to the optimum concentration of NaOH used in the alkaline treatment, especially for crosslinked biocomposites. Because according to Valasek, et al. (2021), each type of nature fiber tends to have a different optimum of NaOH concentration. In addition the different amount of cellulose can be obtained from Unive different NaOH concentration, it will also cause different changes in fiber ava dimensions after alkaline treatment, including fiber expansion, enlargement of the Universitas Brawijava Universitas Brawijava 36 niversitas Brawijava Universitas Brawijava

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lumen diameter, and thinning of the cell wall as owing by dissolved lignin conten in fibers (Fitriasari et al., 2019). Thus, allows for differences in physical properties, not only the composites but also individual fibers. Moreover, excessive use of NaOH caused the degradation of cellulose (Paskawati et al., e 2010). It may result in the deterioration of the physical properties of ava biocomposites. Therefore the level of NaOH concentration used needs to be considered to get significant results on the moisture content value in crosslinked ^e biocomposites more than one type of fiber. Iversitas Brawijaya Universitas Brawijaya Based on the results of the ANOVA test obtained, showed no significant e difference, then no DMRT (Duncan's Multiple Range) test was needed to figure out the difference between each treatment in giving effect to the moisture content of biodegradable pots. The value of moisture content obtained in this research Unive was also better than Jaya's research on making Biodegradable pots from OPEFB and fiber with a moisture content of 70.93% (wet basis) and also in accordance Unive with SNI (Standart Nasional Indonesia) 03-2105-2006 for composite, which the lava moisture content was less than 14% (dry basis) or 93% (wet basis). s Brawijaya

The percentage of moisture content in the biodegradable pots also indicated the level of durability of biodegradable pots as nursery container media, according to Jaya, *et al.* (2019), high moisture content had caused damage to biodegradable pots due to the growth of unfavorable microorganisms. Therefore, it is expected that as a container media for seedling, biodegradable pots have a low moisture content to avoid spoilage and damage during storage and easier to apply in the nursery process, because this is related to the flexibility of using biodegradable pots both indoor and outdoor. Accordingly, in this research, the best result of moisture content was obtained in combination treatment of R5C1 (100% Banana stems; 3% NaOH).

4.4. Water Uptake The results of the analysis of variance (ANOVA) test showed a highly significant difference in the factor of NaOH concentration with a P-value of 0.001713, while the factor of the raw materials composition and the interaction between the two factors showed a significant difference with a P-value of 0.015304 for the factor of raw materials composition and a P-value of 0.024443 for the interaction between the two factors. Based on these results, it can be seen that both at the factor of raw materials composition and NaOH concentrations

Universitas Brawijaya awijaya awijaya affected differently to the percentage of water uptake of biodegradable pots awiiava produced due to had a high diversity of variance, as seen by the highly increasing unive value from R1 of 3.41% to R4 of 4.82%, and highly decreasing value from C1 of 4.22% to C3 of 2.27%. It indicates there was an interaction between the two e factors evidenced by the influence of the raw materials composition factor which depends on the level of NaOH concentrations factor, also vice versa. The results of the analysis of variance (ANOVA) test on water uptake of biodegradable pots awijaya awijaya have been presented in the Appendix 3. Meanwhile, the average percentage of awijaya

water uptake in each treatment can be seen in Figure 4.6.

Universitas Brawijaya Universitas Powijaya Universitas Brawijaya 6.00 4.82 5.00 4.22 3.76 3.72 3.80 3.65 3.57 3.50 8 4.00 ^{3.41} 3.18 3.79 3.64 3.29 Water Uptake 2.72 3.00 2.00 1.00 0.00 R5 R1 R2 R3 R4 Raw Materials Composition C1 (3% NaOH) C2 (5% NaOH) C3 (7% NaOH)

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In Figure 4.6 above, it can be seen that the percentage of water uptake of biodegradable pots in each treatment showed different results, ranged from 2.72% to 4.82%. The lowest percentage of biodegradable pots water uptake of 2.72% was obtained from the treatment combination of R5C3 (100% Banana stems; 7% NaOH), and the highest percentage was 4.82% obtained from the treatment combination of R4C1 (40% OPEFB: 60% Banana stems; 3% NaOH). ve As seen in the graph above on the treatment of NaOH concentrations, the java percentage of water uptake tended to fluctuate, then decreased on the treatment combination of R3, R4, and R5 in each treatment. Meanwhile, from the treatment of raw materials composition, the percentage of water uptake also tended to fluctuate, but increased on the treatment of R4, and decreased in value on the e treatment of R5. According to Akhir, et al. (2018), it is known that the percentage lava of water uptake was influenced by fiber density. The more fiber density of the surface of biopots, the tendency of water to penetrate was inhibited. In this case, Universitas Brawijava Universitas Brawijava 38 niversitas Brawijava Universitas Brawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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Universitas Brawijaya awijaya it can be proven by increased the thickness of the biocomposite during the swelling phenomena which cause an increase in free volume due to the availability of empty space in the biocomposite to bind water molecules. The more the thickness of the sample expanded, the higher the volume of water Univerabsorbed by the sample. The percentage of water uptake in organic growing java media according to Sarka, et al. (2011) ranged from 3.86% - 9.44%. Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya 4.4.1. The Effect of Raw Materials Composition on Water Uptake Biopots The data results from the analysis of variance (ANOVA) test that indicated Unive a significant difference then followed by the DMRT (Duncan's Multiple Range) test to figured out the difference between each level of factors in giving effect to the water uptake of the biodegradable pots. Based on the results obtained, the DMRT test that performed on the R factor (Raw Materials Composition), C factor (Concentration of NaOH), and the interaction between the two factors (R*C) have awijaya Unive been presented in the Appendix 7. The results of the DMRT test on the each lava level of raw materials composition factor are presented in Table 4.4.

 Table 4.4 The Value of Biopots Water Uptake Due to Raw Materials Composition

 Factor

| ya | Unit Factor | hiversitas Brawijaya | | | |
|----------|--|---------------------------------------|--|--|--|
| ya | Univ Treatments | Average Value (%) tas Brawijaya | | | |
| ya | Univ R1 | 3.460aniversitas Brawijaya | | | |
| ya | Unive R2 | 3.536aniversitas Brawijaya | | | |
| ya | Univer | 2 ETZ2 | | | |
| ya | Universi R4 | 4.097bniversitas Brawijaya | | | |
| ya ya | Universita R5 | 3.411aniversitas Brawijaya | | | |
| va | Note: the average value followed by the same letter do | bes not significantly different based | | | |
| ya | Universitias on the DMRT test analyzed in SPPS packages | wijaya Universitas Brawijaya | | | |
| ya | Universitas Bra | awijaya Universitas Brawijaya | | | |
| ya | Universitas Braw, | Brawijaya Universitas Brawijaya | | | |
| ya | Universitas Based on Table 4.4 it can be seen that the treatment of raw materials jaya | | | | |
| ya | composition had a difference in giving effect to the | e percentage of water uptake of | | | |
| ya ya | biodegradable pots, indicated by different notation results. The treatment of R5 | | | | |
| ya | Unive (100% Banana stems) had the lowest average value of water uptake, but not | | | | |
| ya ya | significantly different from the treatments of R | 1, R2, and R3. While in the | | | |
| ya | Unive treatment of R4 (40% OPEFB: 60% Banana | Stems) produced the highest ava | | | |
| ya | average value of biodegradable pot's water upta | ke and significantly different for | | | |
| ya | Universitas Brawijaya Universitas Brawijaya Universit | | | | |
| ya | all treatment combinations. These results show | | | | |
| ya | pores and free space in the case of crosslinke | • 1981 1981 | | | |
| ya | Universitas Brawijaya Universitas Brawijaya Universit | | | | |
| ya | Universitas Brawijaya Universitas Brawijaya Universitas | | | | |
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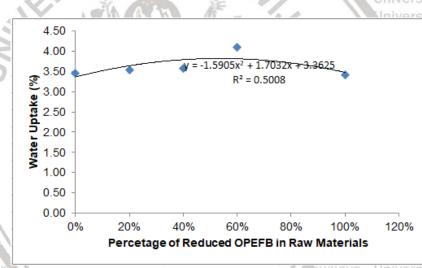
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fibers were added to the raw materials. The tendency for treatment of K4 to have the highes percentage of water uptake could be caused by the formation of more pores in the biopots. The pores formed in the materials would cause the materials to have permeability properties (Rahamsita, *et al.*, 2017). It causes water could to pass through and be absorbed by the biopots. Moreover, the results show the water uptaking process increased in the crosslinked biodegradable pots if compared to un-crosslinked biodegradable pots. These results were also in agreement with the previous research on crosslinked biopots by Schettini, *et al.* (2013), crosslinked biopots able to increase the binding availability sites for water molecules by inducing the increasing of free volume. In addition, it also can be seen that the water uptaking process in the un-crosslinked biodegradable pots of banana stems fiber-based was lower than the un-crosslinked biodegradable pots of OPEFB fiber-based. The Trend of the percentage of water uptake biodegradable pots on raw materials composition can be seen in **Figure 4.7**.



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Figure 4.7 The Trend of Water Uptake on Raw Materials Composition From the graph in Figure 4.7, it is known that there was a trend of influence of the reduction of OPEFB used in raw materials composition in each treatment on the percentage of water uptake of biodegradable pots produced. It showed in crosslinked biodegradable pots, the higher the percentage of banana stems used resulted in increased the percentage of water uptake of biodegradable pots, but then decreased in un-crosslinked biodegradable pots of banana stems fiberbased of R5 (100% Banana stems). In the crosslinked biopots, adding too much banana stems fiber can create more pores, thus cause the high porosity of the

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material and results in high water uptake of the material. This may be happened because banana stems fiber was hydrophilic, then it is facilitated the process of water absorption in the composite (Randa and Alimin, 2019). Meanwhile, according to Rahmasita, *et al.* (2017), the structure of Oil Palm Empty Fruit Bunches (OPEFB) fiber has a fairly large size dimension about 343 – 365 μ m, and it is bigger than the size dimension of banana stems fiber which has a small dimension of 5.8 μ m (Nopriantina and Astuti, 2013). This case allows for different pore characteristics of the fiber. Pore characteristics describe the total, size, distribution, and continuity of pores which play very important role in determining the movement of water (Masria, *et al.*, 2018). In addition according to research by Bhagat, *et al.* (2013), the rate of water uptake on composite increase along with increase in fiber dimensions. Hence. it may cause the water absorption of uncrosslinked biodegradable pots of OPEFB fiber-based is higher than uncrosslinked biodegradable pots of banana stems fiber-based.

4.4.2. The Effect of NaOH Concentrations on Water Uptake Biopots

The results of DMRT (Duncan's Multiple Range) test for the each level of NaOH concentrations factor can be seen in **Table 4.5**.

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Unive Table 4.5 The Value of Biopots Water Uptake Due to NaOH Concentrations Java Unive Factor

| · J … J … | | | | | |
|-----------|---|--|--|--|--|
| ijaya | Univer Treatments | Averange Value (%) tas Brawijaya | | | |
| ijaya | Univers | Universitas Brawijaya | | | |
| ijaya | Universi C1 C2 | 3.977b niversitas Brawijaya 3.396a | | | |
| ijaya | Universita C3 | 3.474a niversitas Brawijaya | | | |
| ijaya | | ne letter does not significantly different based | | | |
| ijaya | Universitas on the DMRT test analyzed in SPPS | packages wijaya Universitas Brawijaya | | | |
| ijaya | Universitas Bra | awijaya Universitas Brawijaya | | | |
| ijaya | Universitas Braw, | Brawijaya Universitas Brawijaya | | | |
| ijaya | Universitas Based on Table 4.5 above, it can | be seen that the treatment on the factor | | | |
| ijaya | Universitas Brawijaya Universitas Brawijaya | rence in giving effect to the percentage of | | | |
| ijaya | of NaOH concentration used had a diffe | rence in giving enect to the percentage of | | | |
| ijaya | Unive water uptake of biodegradable pots, indicated by different notation results. The jaya | | | | |
| ijaya | highest average value of water uptake was obtained in the treatment of C1 (3% | | | | |
| ijaya | Universitas brawijaya Universitas brawijaya Universitas brawijaya Universitas brawijaya | | | | |
| ijaya | Unive NaOH). As for the lowest average value of water uptake obtained in the treatment jaya | | | | |
| ijaya | of C2 (5% NaOH), but the results v | were not significantly different with the | | | |
| ijaya | Universitas Brawijava Universitas Brawijava | Universitas Brawijaya Universitas Brawijaya | | | |
| ijaya | Unive treatment of C5 (7 % NaOri). The value | of water uptake of biodegradable pots in jaya | | | |
| ijaya | | with the increase of NaOH concentration Java | | | |
| ijaya | as a delignificator agent These resu | Ilts is in agreement with research by | | | |
| ijaya | Universitas Brawijaya Universitas Brawijaya | Universitas Brawijaya Universitas Brawijaya | | | |
| ijaya | | Universitas Brawijaya Universitas Brawijaya | | | |
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Ramadevi, *et al.* (2012) on water absorption of abaca fiber, indicated the ability of fiber to absorb water was reduced by alkaline treatment and decreased with an increase in alkaline concentration due to removal lignin content in the fiber. Hence, These results indicates the hydrolysis phenomena of higher lignin content in OPEFB fiber and Banana stems fiber from alkaline treatment of 3% NaOH concentration to 5% NaOH concentration. The NaOH treatment aims to ionize the hydroxyl groups on fiber lead to alkalization of cellulose. Thus, the fiber had a high water resistant (Zebua, 2015). However, in this research, there was an indication of decreased cellulose content in alkaline treatment of 7% NaOH as indicated by increased the concentration of water uptake on biodegradable pots. The Trend of the percentage of water uptake biodegradable pots on NaOH concentrations can be

awijaya Unive seen in Figure 4.8. awijaya awijaya awijaya awijaya awijaya awijava awijaya awijaya awijaya awijaya awijaya awijaya awijaya awijaya awijava awijaya awijaya awijaya awijaya awijaya awijaya awijaya awijaya awijaya

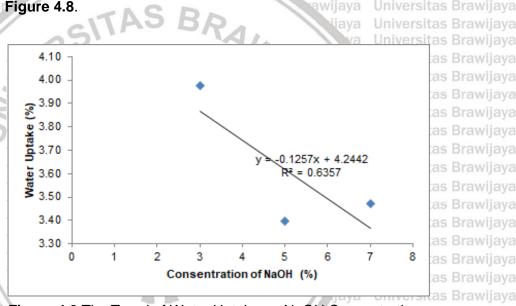


Figure 4.8 The Trend of Water Uptake on NaOH Concentrations as Brawijaya

The regression graph in **Figure 4.8** above, explained the trend influence of the concentration of NaOH used in each treatment on the percentage of water uptake of biodegradable pots produced. The percentage of water uptake decreased along with the increase in the concentration of NaOH used. This is shown in the percentage of water uptake obtained in the treatment of C1 (3% NaOH) which decreased when the concentration of NaOH was added to the treatment of C2 (5% NaOH). However, at an increased concentration to the treatment of C3 (7% NaOH), the percentage of water uptake precisely increased. On alkaline treatment, cellulose fiber would react with alkaline and form alkaline

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cellulose indicated a broken lignocellulosic structure, with hydrolyzed the lignin content and resulted in the cellulose content increased. According to Zebua (2015), cellulose fibers that react with alkaline caused the permeability of the fiber to decrease, it made the water difficult to penetrate the surface of composite. Therefore, it concluded that the reduced level of permeability of the biodegradable pots directly affects the hygroscopicity of the biodegradable pots. And cause reduces the ability of the biodegradable pots to absorb water. This research showed that the delignification efficiency increased in line with the increase in the concentration of NaOH used. While the decrease in cellulose content that occurred in the alkaline treatment of 7% NaOH showed a tendency for the optimum NaOH concentration at 5% concentration for the crosslinked biodegradable pot of OPEFB fiber and Banana Stems fiber-based.

4.4.3.The Effect of Interaction between Raw Materials Composition and NaOH Concentration

The results of DMRT (Duncan's Multiple Range) test for the interaction between raw material composition factor and NaOH Concentration factor (R*C) can be seen in **Table 4.6**.

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 Table 4.6 The Value of Biopots Water Uptake Due to The Interaction between available Raw Materials Composition and NaOH Concentrations

| awijaya | Unive Raw Materials C | omposition and NaOr | | Universitas Brawijaya |
|---------|------------------------|-------------------------|--|---------------------------------------|
| awijaya | Unive | Treatments | Averag | e Value (%) as Brawijaya |
| awijaya | Univers | R1C1 | | .407a iversitas Brawijaya |
| awijaya | Universit | R2C1 | 3 | 786b iversitas Brawijaya |
| awijaya | Universita | R3C1 | 3 | 653a iversitas Brawijaya |
| awijaya | Universitas | R4C1 🚺 🧥 | jay | 820d iversitas Brawijaya |
| awijaya | Universitas B | R5C1 | | 219 civersitas Brawijaya |
| awijaya | Universitas Bra | R1C2 | awijay | a, Universitas Brawijaya |
| awijaya | Universitas Braw, | R2C2 | Brawijava | a Universitas Brawijaya 184a |
| awijaya | Universitas Brawijaya | | | |
| awijaya | Universitas Brawijaya | Universitas Brawija | ya Universitas Brawijaya | .570a iversitas Brawijaya |
| awijaya | Universitas Brawijaya | UnNersitas Brawija | ya Universitas Brawijaya | 756biversitas Brawijaya |
| awijaya | Universitas Brawijaya | | | 291a iversitas Brawijaya |
| awijaya | Universitas Brawijaya | | | 798b iversitas Brawijaya |
| awijaya | Universitas Brawijaya | | | .638a iversitas Brawijaya |
| awijaya | Universitas Brawijaya | | | 496a iversitas Brawijaya |
| awijaya | Universitas Brawijaya | | | 715 Provincia and American Strawijaya |
| awijaya | Universitas Brawijaya | Universitas Brawija | ya Universitas Brawijay <mark>2</mark> | 724a Brawijaya |
| awijaya | Note: the average | value followed by the s | ame letter does not signifi | cantly different based laya |
| awijaya | Universitas Bradie DMR | T test analyzed in SPP | S packages | a Universitas Brawijaya |
| awijaya | Universitas Brawijaya | Universitas Brawija | ya Universitas Brawijaya | |
| awijaya | Universitas Brawijaya | | ya Universitas Brawijaya | |
| awijaya | Universitas Brawijaya | | ya Universitas Brawijaya | |
| awijaya | Universitas Brawijaya | | ya 43 niversitas Brawijaya | |
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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Based on Table 4.6, it can be seen that the interaction between the factor awijaya of raw materials composition and the factor of NaOH concentration used in the ve process of making biodegradable pots had a difference in giving effect on the percentage of water uptake of biodegradable pots produced, indicated by different notation results. The lowest average value of water uptake was obtained in the treatment combination of R5C3 (100% Banana stems; 7% NaOH) and was not significantly different with the treatment combination of R1C1, R3C1, R1C2, awijaya awijaya R2C2, R3C2, R5C2, R2C2, R3C3, proved by the notation "a". While the highest awijaya average of water uptake was obtained in the treatment combination of R4C1 awijaya e (40% OPEFB: 60% Banana stems; 3% NaOH) and significantly different with all lava awijaya awijaya the treatment combinations. Following the hypothesis, the mass ratio of OPEFB fiber to banana stems fiber used in the composition of the raw materials, as well awijaya as the amount of NaOH concentration used in making biodegradable pots can awijaya awijaya affect the value of water uptake. The results in Table 4.6, show an increasing in awijaya Unive certain porosity at the treatment of crosslinked samples when the concentration awijaya awijaya of banana stems fiber in raw materials increases, as seen in the treatment awijaya combination of R3C1 to R4C1, R2C2 to R4C2, and R2C3 to R4C3. In this case, awijaya awijaya indicates the crosslinked biodegradable pots with higher levels of banana stem awijaya fiber could absorb more water, compared to un-crosslinked biodegradable pots. awijaya either OPEFB fiber-based or banana stems-based. However, it was found a awijaya awijaya phenomenon of decreasing water uptake value in crosslinked biopots when the awijaya banana stems concentration was increased from treatment combination of R2C1 awijaya to R3C1 and R2C3 to R4C3 This is probably due to the irregular fiber dispersion awijaya that was shown in Figure 4.5, it leads to the presence of voids and discontinuity awijaya points on the biopots, thus higher un-wettable sample. vijava Universitas Brawijaya On the other hand, the value of water uptake will decrease along with an awijaya increase of NaOH concentration which indicates the increase of cellulose content awijaya in biopots, both in the crosslinked and uncrosslinked biopots of OPEFB fiberawijaya based or banana stems fiber-based. Whereas, there was a tendency of a awijaya e decrease in cellulose content due to optimum alkaline treatment at C2 (5% awijaya awijaya NaOH), which was shown in the increase of water uptake in treatment awijaya combination of R1C2 to R1C3 and R2C2 to R2C3. The trend of water uptake Univervalue on the interaction between raw material composition factor and NaOH lava concentration factor can be seen in Figure 4.9. Universitas Brawijava Universitas Brawijava 44 niversitas Brawijava Universitas Brawijava Universitas Brawijava Universitas Brawijava

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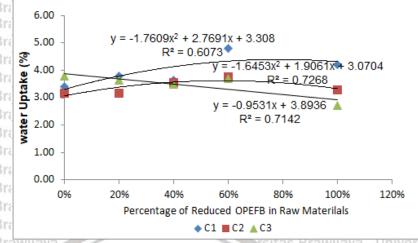


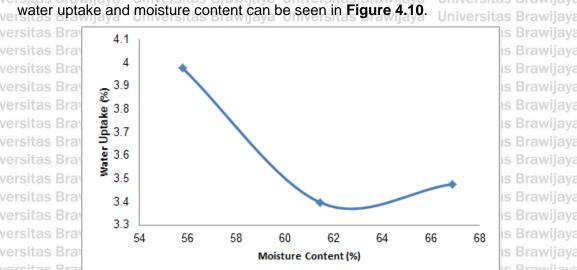
Figure 4.9 The Trend of Water Uptake on The Interaction of Raw Materials Composition and NaOH Concentrations

The regression graph in Figure 4.9 above, explained the trend of water uptake value due to the interaction between the raw material composition factor and NaOH concentration factor used. The variations in the composition of raw material and concentration of NaOH used as an alkaline treatment gives variations in the percentage of water uptake of biodegradable pots. Schettini, et al. (2013), said that biocomposites consisted of several raw materials that would form crosslinked polymers caused differences in the volume of free space between biocomposites. Meanwhile, alkaline treatment could reduce the hydrophilic properties of the natural fiber. In alkaline treatment, hydrophilic hydroxyl groups reduce by reacting with NaOH which leads to prohibiting absorbed water of composite (Reddy, et al., 2018). Hence, the interaction between raw materials factor and NaOH concentrations factor tends to influence the water uptake value of biodegradable pots. In addition, the use of an adhesive also facilitated the closure of the capillary cavity that connects the empty space of an also facilitated the closure of the capillary cavity that connects the empty space of the cavity the cavity the cavity that connects the cavity the polymers, thereby reducing the water absorption ability of the material (Maharany Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitians In addition, based on the results of water uptake, there was an indication that value of water uptake was inversely proportional to the value of moisture content. It proved by the treatment combination of R5C1 with a moisture content of 50.42% had a water uptake of 4.22%, while the R5C3 with a moisture content Universitas Brawijava 45 niversitas Brawijava

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of 65.73% had a water uptake of 2.72%. The trend of the relationship between



Universit Figure 4.10 The Relationship Between Water Uptake and Moisture Content awijaya Universitas

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This phenomenon in Figure 4.10 has to do with the osmosis process, follow by Jaio, et al. (2015), since the osmosis process was driven by an osmotic pressure difference across solvent and solute, which is when the solvent had a higher concentration rather than the solute, lead to water molecules migrate into the solute until reaching the equilibrium state. Therefore, the higher osmotic pressure differences across water and biopots, the more water molecules tend to migrate into biopots, thus caused a higher percentage of water uptake. The percentage of water uptake of biodegradable pots indicated resilience biodegradable pots to water through the ability to absorb water. This is related to the level of durability of biodegradable pots as nursery media when applied in the field. The lower the percentage of biodegradable pot's water uptake, then the quality of the biodegradable pots would be even better. Therefore, In this research, the best result was obtained from biopots with high water-resistant in Unive the treatment combination of R5C3 (100% Banana stems; 7% NaOH). Universitas Brawijaya Universitas Biodegradation Tests Brawijaya Universitas Brawijaya Universitas Brawijaya In the biodegradation test, the results of the analysis of variance (ANOVA) showed there was a significant difference in the factor of NaOH concentrations, with a P-value of 0.01556, while the factor of raw materials composition and the interaction between two factors showed highly significant difference with P-value Unive respectively was 2.149 x 10⁻¹⁰ for the factor of raw materials composition and lava Universitas Brawijaya Universitas Brawijaya⁴⁶niversitas Brawijaya Ilniversitas Rrawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

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Universitas Brawijaya awijaya awijaya 0.006551 for the interaction between two factors. In other words, both factors of awijaya raw materials composition and the concentration of NaOH used in the making of biodegradable pots influence the biodegradability of biodegradable pots due to had a high diversity of variance, as seen by the highly increasing value from R1 ve of 76.39% to R4 of 51.14%, and highly increasing value from C1 of 76.39% to C3 of 68.85%. Hence, it indicates there was an interaction between the two factors evidenced by the influence of the raw materials composition factor which awijaya depends on the level of NaOH concentrations factor, also vice versa. The Results awijaya of the Analysis of variance (ANOVA) on the biodegradability of biodegradable awijaya University pots can be seen in the Appendix 4. While the average value of the awijaya awijaya biodegradability of the biodegradable pots in each treatment is presented in Figure 4.11 awijaya

> ersitas Brawijava 100.00 80.00 76.39 8 68 85 66.66 62.52 58.16 55.54 Degredation Potential 60.05 58.77 60.00 55 53.82 50.66 51.14 5.70 40.00 20.00 0.00 R1 R2 R3 R4 R5 Raw Materials Composition C1 (3% NaOH) C2 (5% NaOH) C3 (7% NaOH)

Figure 4.11 The Biodegradation Potential of Biodegradable Pots in Each

Treatements

Based on Figure 4.11, it can be seen that the Biodegradation Potential of Biodegradable Pots in each treatment showed different results, ranged from available 40.54% to 76.39%. The lowest value of biodegradation potential of 40.54% was University obtained from the treatment combination of R5C2 (100% Banana stems; 5% NaOH), and the highest value of 76.39% was obtained from the treatment combination of R1C1 (100% OPEFB; 3% NaOH). As seen in the graph above, in the treatment of NaOH concentration, the biodegradation potential of biodegradable pots tended to undergo a reduction. While from the treatment of University materials composition, the biodegradation potential of biodegradable pots Universitas Brawijaya Universitas Brawijaya Oniversitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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Universitas Brawijaya awijaya awijaya also tended to decrease. Phenomena of the reduced potential of the awijaya biodegradable pot sample to be degraded during the burial period in the soil are related to the cellulose content in each treatment combination of the biodegradable pots. The hypothesis says the higher the cellulose content in the sample, the longer the biodegradable pots would take to degrade. According to Nambuthiri, et al. (2013), biodegradable pots as a good alternative media for seedlings at least capable of being degraded up to 60% in good natural awijaya awijaya conditions, including soil conditions and temperature. In this regard, the treatment awijaya combination between R1 (100% OPEFB) and R2 (80% OPEFB: 20% Banana awijaya Unive stems) with each level of the NaOH concentrations factor (C1, C2, and C3) have lave awijaya awijaya reached that number. Mass loss in biodegradable pot samples during the

biodegradation test within 21 days can be seen in Figure 4.12.

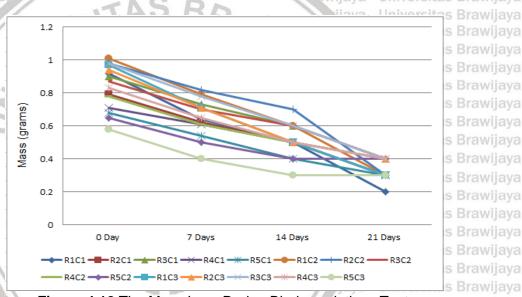


Figure 4.12 The Mass Loss During Biodegradations Testarsitas Brawijaya awijaya Universitas Brawijaya

Figure 4.12 showed the mass loss kinetics of biodegradable pot sample during the biodegradation testing period. As seen all treatment combinations experienced mass loss during the period of burial in the soil. This matter indicated an interaction between microorganisms and the sample of biodegradable pots that were buried during 21 days. Each treatment combination of biodegradable pots tends to have a different rate of degradation. This possibility indicates the ability of microorganisms in the soil to react with each sample, the difference occurs due to the different conditions of the biodegradable pots. The process 48

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Universitas Brawijaya awijaya of the biodegradation mechanism occurs when microorganisms in the soil released enzymes and then adhesion of enzymes to surface and cleavage of polymer which caused the material will be damaged over time, this enzymatic process also produced final products in the form of water, carbon dioxide, and nive other metabolic products (Tomadoni, et al., 2020).as Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya 4.5.1. The Effect of Raw Materials Compotion on Biodegradable Potential of Brawijaya Universitas Brawijaya Universitas Brawijaya **Biodegradable Pots** s Brawijaya Universitas Brawijaya Universitas Brawijaya Universitian The data results from the analysis of variance (ANOVA) test which available indicated a significant difference then continued with the DMRT (Duncan's Multiple Range) test to figured out the difference between each treatment in giving effect to the biodegradation potential of the biodegradable pots. Based on awijaya the results obtained, the DMRT test that performed on the R factor (Raw Materials Composition), C factor (Concentration of NaOH), and the interaction awijaya awijaya between the two factors (R*C) have been present in the Appendix 8. The results awijaya of the DMRT test on the each level of raw materials concentration factor are awijaya awijaya presented in Table 4.7.

Table 4.7 The Value of Biopots Biodegradable Potential Due to Raw Materials Composition Factor Universitas Brawijava

| nive | Treatments | Average Value (%) as Brawijaya |
|---------------|------------|--------------------------------|
| niver | RI | 71.035civersitas Brawijaya |
| nivers | R2 5 | 62.242biversitas Brawijaya |
| niversit | R3 | 57.915b |
| niversita | R4 | 51 868a |
| niversitas | R5 🧠 🌇 | 48.338a Brawijaya |
| IIIVEISILAS D | | Allava universitas plavijava |

Note: the average value followed by the same letter does not significantly different based Universitas on the DMRT test analyzed in SPPS packages

Based on Table 4.7 above, it can be seen that the treatment of raw Unive material composition factor had a difference in giving effect to the biodegradation lava potential of biodegradable pots, indicated by the different notation results. The treatment of R1 (100% OPEFB) had the highest average value of biodegradation potential, and significantly different for all treatment combinations. Likewise in treatment of R2 (80% OPEFB: 20% Banana stems) was not significantly different Unive from the treatment of R3 (60% OPEFB: 40% banana stems). While in the treatment of R5 (100% Banana stems) produced the lowest average value of Universitas Brawijaya Universitas Brawijaya49 niversitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awilaya Universitas Bradatian actential of biodearridable poer but not significantly different from jaya

biodegradation potential of biodegradable pots, but not significantly different from the treatment of R4 (40% OPEFB: 60% banana stems). These phenomena explain that the addition of banana stem fiber to the crosslinked biodegradable pot would increase the cellulose content in the biodegradable pots, lead to the ability of the biodegradable pots to be degraded in nature decreased. Meanwhile, in un-crosslinked biodegradable pots, the highest biodegradable potential was owned by un-crosslinked biodegradable pots of OPEFB fiber-based since by means of contained less cellulose compared to un-crosslinked biodegradable pots of banana stems fiber-based, as can be seen in **Table 2.2**. The Trend of the percentage of biodegradation potential on raw materials composition is presented

in Figure 4.13.

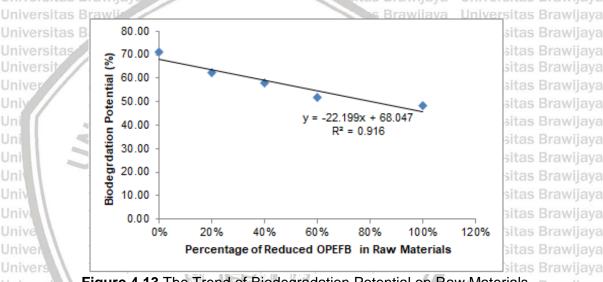


Figure 4.13 The Trend of Biodegradation Potential on Raw Materials Composition

The regression graph in **Figure 4.13** explained the trend of influence of the reduction of OPEFB used in raw materials composition in each treatment on the decreasing percentage of biodegradation potential of the biodegradable pot produced. The types of fiber greatly affect the ability of a biocomposite to degrade in nature, which the higher the percentage of banana stems in the raw materials used, the biodegradation potential of the biodegradable pots would be decreased. According to Schettini, *et al.* (2013), the high content of microcrystalline cellulose in fiber resulted in a low rate of biopolymer biodegradability, due to the chain hydrophilic macromolecules were not easily susceptible to attack by microorganisms. Cellulose fiber-based biocomposite had a chemical composition that was more structured, thus could inhibit and retarded 50

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microbial attack. On the other hand, the morphology of the oil palm empty fruit bunches fiber which was porous and contains silica (Rahmasita, et al., 2017), made the fiber easier to reacted by microorganisms in the soil during burying. Because following by Chinnathambi and Fuyuhiko (2020), silica was sensitive to enzymatic activities due to having a biodegradable organic group framework. On the other hand, the pores in the OPEFB fiber facilitated the enzymatic process in breaking down the molecular structure of the biopots caused the biodegradation process to take more quickly. These are sufficient enough to explain the trend of the regression graph in decrease the biodegradability of biopots due to the compostion of the raw materials. The cellulose content in the raw materials indicated to continue to increase from un-crosslinked biopots of OPEFB fiberbased to the crosslinked biopots, up to un-crosslinked biopots of Banana stems fiber-based. Nevertheless, the higher the proportion of banana stems added to the crosslinked biopots, the more difficult biopots to be degraded due to the high Unive cellulose content. While in the un-crossllinked biopots of OPEFB fiber-based had lava the highest biodegradation potential because it was influenced by less cellulose content, also had silica content in the fiber, thus cause easily to attact by microorganisms during the burying test.

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4.5.2.The Effect of NaOH Concentrations on Biodegrdable Potential of Biodegrdable Pots

The results of DMRT (Duncan's Multiple Range) test for the each level of NaOH concentrations can be seen in **Table 4.8**.

 Table 4.8
 The Value of Biopots Biodegradable Potential Due to NaOH

 Concentration Factor
 Concentration Factor

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Treatments Average Value (%) tas Brawijaya Uni\C1 60.404b versitas Brawijaya awijaya Universitas Brawijaya Universitas Brawija55.259a Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Note: the average value followed by the same letter does not significantly different based awijaya on the DMRT test analyzed in SPPS packages Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Based on Table 4.8 above, it can be seen that the treatment on the factor of NaOH concentrations had a difference in giving effect to the biodegradation University of biodegradable pots, indicated by the different notation results. The highest value of biodegradation potential of biodegradable pots was obtained in Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya

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the treatment of C1 (3% NaOH) but not significantly different from the treatment of C3 (7% NaOH). While the lowest value of the biodegradation potential of ^{we} biodegradable pots was obtained in the treatment of C2 (5% NaOH) and was significantly different from the two other treatments. The NaOH concentration in alkaline treatment plays a role in increasing the purity of the cellulose contained in the material by dissolving the lignin content. In this case, it can be seen that the C1 (3% NaOH) treatment released less lignin content than the C2 (5% NaOH) and C3 (7% NaOH) treatments. However, it was noted that there was an unusual degradation phenomenon as a result of the too high concentration of NaOH, namely in the treatment of C3 (7% NaOH), which was indicated by an increase in the biodegradation potential of the biodegradable pot when compared to the biodegradation potential in the treatment of C2 (5% NaOH). The Trend of Unive the percentage of biodegradation potential on NaOH concentrations is presented java in Figure 4.14 Universitas Brawijaya

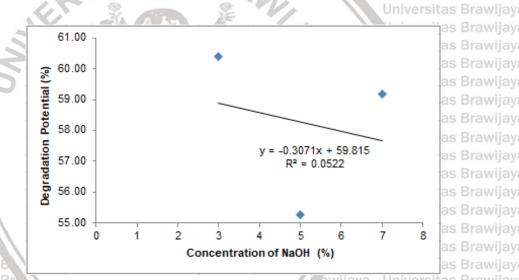


Figure 4.14 The Trend of Biodegradation Potential on NaOH Concentrations

Iniversitias The regression graph in Figure 4.14 above, explained the trend influence concentration of NaOH used in each treatment to decreased the of Universide biodegradation potential of the biodegradable pot produced. Gunam, et al. (2011), said that the higher the concentration of NaOH used as a delignification agent allowed hydrolysis of lignin in large quantities, thus caused the cellulose content to increases. In this research, there was a tendency of decreased the ability of biodegradable pots to degrade during the burial period, it showed an Unive increased cellulose content in OPEFB fiber and banana stems as raw materials. Universitas Brawijaya Universitas Brawijaya 52 niversitas Brawijaya Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava Universitas Rrawijava

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Somehow, there was also an unsual results that were in agreement with the analysis of the water uptake, that NaOH concentration tended to be optimum at 5% due to a phenomenon of a decrease cellulose content of biopots at 7% NaOH, that was indicated by increased the biodegradation potential. Cellulose is a simple polymer, but it formed insoluble, and crystalline microfibrils. The organization of individual microfibrils in crystalline cellulose is packed tightly enough to prevent penetration by enzymes (Lakhundi, *et al.*, 2015). This may cause high resistance to enzymatic hydrolysis. Hence, the higher the cellulose content in the biocomposite, the more difficult biocomposite would be to degrade in nature due to poor enzymatic attack. Thus, the mechanism of cellulose hydrolysis could be achieved by the synergistic activity of two components, the first is swelling disrupt cellulose and the second having endoglucanase activity in order to get a faster cellulose degradation process (Dimarogona, *et al.*, 2021).

Unive 4.5.3. The Effect of Interaction between Raw Materials Composition and jaya NaOH Concentration

The results of DMRT (Duncan's Multiple Range) test for the interaction between raw material composition factor and NaOH Concentration factor (R*C) can be seen in **Table 4.9**.

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 Table 4.9 The Value of Biopots Biodegradable Potential Due to The Interaction

 between Raw Materials Composition and NaOH Concentrations

| /a | Univers | Treatments | Average | Value (%) as Brawijaya |
|----|-------------------------|--------------------------|-------------------------------|-------------------------|
| /a | Universit | R1C1 | 76.3 | 90g Brawijaya |
| /a | Universita | R2C1 | 62.5 | Universitas Brawijava |
| /a | Universitas | R3C1 | 58.1 | Universitas Brawijava |
| /a | Universitas B | R4C1 | | Universitas Brawijava |
| /a | Universitas Bra | | awijaya | 37bversitas Brawijaya |
| /a | Universitas Brawn | R5C1 | Brawija53.8 | 18bversitas Brawijaya |
| /a | Universitas Brawijaya | Un R1C2 | oniversitas Brawija 67.8 | 63fiversitas Brawijaya |
| /a | Universitas Brawijaya | UniR2C2 as Brawijaya | Universitas Brawija 66.6 | 58eversitas Brawijaya |
| /a | Universitas Brawijaya | UniR3C2 as Brawijaya | Universitas Brawija 55.5 | 38bversitas Brawijaya |
| /a | Universitas Brawijaya | UniR4C2 as Brawijaya | Universitas Brawija 45.6 | 97aversitas Brawijaya |
| /a | Universitas Brawijaya | UniR5C2 as Brawijaya | Universitas Brawija 40.5 | 39aversitas Brawijaya |
| /a | Universitas Brawijaya | UniR1C3 as Brawijaya | Universitas Brawija 68.8 | 851 fversitas Brawijaya |
| /a | Universitas Brawijaya | UniR2C3 as Brawijaya | Universitas Brawija 57.5 | 51 dversitas Brawijaya |
| /a | Universitas Brawijaya | UniR3C3 as Brawijaya | Universitas Brawija 60.0 | 50 dversitas Brawijaya |
| /a | Universitas Brawijaya | | Universitas Brawija 58.7 | |
| /a | Universitas Brawijaya | | Universitas Brawijavã.6 | |
| /a | Unive Note: the average | | me letter does not significar | |
| /a | Universitas Brawijava | T toot engly and in CDDC | packages | Universitas Brawijaya |
| /a | Universitas Brawijaya | T lest analyzed in SPPS | Universitas Brawijava | Universitas Brawijaya |
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Universitas Brawijaya awijaya awijaya Based on Table 4.9, it can be seen that the interaction between the factor awijaya of the composition of raw materials and the factor of NaOH concentration used in awijaya awijaya the process of making the biodegradable pots had a difference in giving the effect on the biodegradable potential of biodegradable pots, indicated by the different awijaya ve notation results. The lowest average value of biodegradation potential was average awijaya obtained in the treatment combination of R5C2 (100% Banana stems; 5% NaOH) and not significantly different with treatment combinations of R4C2 and R5C3, as awijaya awijaya shown in Table 4.9. While the highest average value of biodegradation potential awijaya was obtained in the treatment combination of R1C1 (100% OPEFB; 3% NaOH) awijaya Unive and significantly different with all treatment combinations. These results indicate lava awijaya awijaya that the un-crosslinked biodegradable pots of banana stems fiber-based were awijaya more difficult to degrade in nature when compared to the crosslinked awijaya biodegradable pots and to the un-crosslinked biodegradable pots of OPEFB fiberawijaya awijaya based. Moreover, it does be even more difficult to be degraded when the awijaya concentration of NaOH during alkaline treatment was increased because of the awijaya awijaya having more cellulose content in the raw materials. However it also was found a awijaya phenomenon of increasing the biodegradation potential when the concentration awijaya awijaya of banana stems was increased from treatment ombination of R4C1 to R5C1 and awijaya from R2C3 to R3C3. This outcome could be due to the irregular dispersion of awijaya

fiber inside the biopots that responsible for the voids rising and lead to facilitate the microorganisms to reach the bonding of the fibers on biopots, thus more easily cleavage of the polymer. Moreover, there was a tendency of a decrease in cellulose content because of excessive NaOH concentration at 7% NaOH, which and a second s was shown in the increase of biodegradation potential in the treatment combination of R1C3, R3C3, R4C3, and R5C3 respectively from 5% NaOH Concentration. Meanwhile, the trend of biodegradation potential value on the interaction between raw material composition factor and NaOH concentration

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Unive factor can be seen in Figure 4.15. Vijaya Universitas Brawijaya
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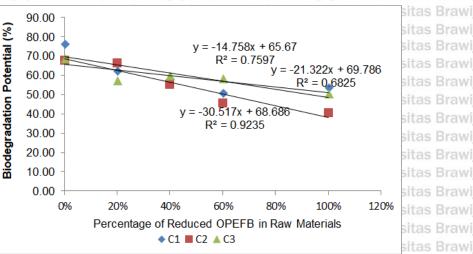


Figure 4.15 The Trend of Biodegradation Potential on The Interaction of Raw Materials composition and NaOH Concentrations Iniversitas Brawijaya

The regression graph in Figure 4.15 above, explained the trend of biodegradation potential value due to the interaction between the raw material composition factor and NaOH concentrations factor used. The combination of treatments used in research provided different variations in the degradation rate.

But it can be concluded that the percentage of the biodegradation potential of the biodegradable pots had decreased along with the increased concentration of banana stems fiber which added in raw materials because of the higher cellulose content in banana stems fiber rather than in OPEFB fiber, thus could enrich the cellulose content in raw materials, as shown in Table 2.3. Also, the addition of NaOH concentration in alkaline treatment has resulted in high cellulose content in the raw materials. Hence, the interaction between raw materials factor and NaOH concentrations factor tends to influence the percentage of biodegradation potential of biodegradable pots. As a result, compared to the crosslinked biopots and the un-crosslinked biopots of banana stems fiber-based, the un-crosslinked biopots of OPEFB fiber-based in all treatment combinations with the e concentration of NaOH used were able to be degraded faster in nature due to contained less cellulose. The biodegradation process of biocomposite occurs when microorganisms firstly mineralized the polymetric matrix then following transform the fibers (Schettini, et al., 2013). Therefore, the higher the cellulose content in the fibers, it would be slow down the process of biodegradation on the Univerbiodegradable potsniversitas Brawijaya Universitas Brawijaya

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The biodegradability test was also related to the lifespan of the biodegradable pot as an alternative nursery media that could be adapted to the cycle plant production. According to Nambuthiri, *et al.* (2013), mostly biodegradable pots would decompose in a few months depending on the conditions of the environment. In addition, extending the lifespan of biodegradable pots could be done by adding natural or synthetic adhesives, resins, waxes, or binder which then determines the level of biodegradability and compostability of the containers as nursery media. Regarding these results, in this research, the best result was obtained, which was the most easily to be degraded in nature in the treatment combination of R1C1 (100% OPEFB; 3% NaOH). Meanwhile, in the **Figure 4.16** below is showed the difference between biodegrable pots sample after and before the degradation test.



Figure 4.16 The Sample of Biodegradation Test (a) Sample before Biodegradation Test (b) Sample after Biodegradation Test

4.6. Tensile Strength Test

The results of the analysis of variance (ANOVA) test showed a highly significant difference in the factor of NaOH concentrations, with a P-value of 3.75 x 10^{-7} , while the factor of raw materials composition and the interaction between two factors also showed highly significant difference with P-value respectively was 1.68×10^{-23} for the factor of raw materials composition and 9.98×10^{-14} for the interaction between two factors. In other words, both factors of raw materials composition and the concentration of NaOH used in the making of biodegradable pots influence the tensile strength of biodegradable pots due to had a high diversity of variance, as seen by the highly increasing value from R1 of 8798 Pa

to R5 of 23418 Pa, and highly increasing value from C1 of 17320 Pa to C3 of 23418 Pa. Hence, it indicates there was an interaction between the two factors evidenced by the influence of the raw materials composition factor which depends on the level of NaOH concentrations factor, also vice versa. The results of the analysis of variance (ANOVA) on tensile strength of biodegradable pots have been presented in the **Appendix 5**. While the average value of tensile strength of biodegradable pots in each treatment can be seen in **Figure 4.17**.

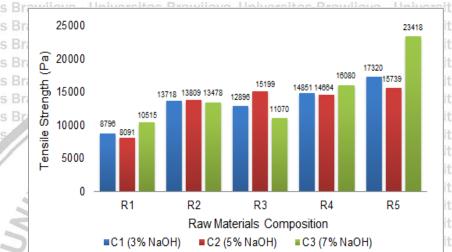


Figure 4.17 The Tensile Strength of Biodegradable Pots in Each Treatments

Based on Figure 4.17, it can be seen that the average value of biodegradable pots tensile strength in each treatment showed different results, Universide and the strength of the lowest value of tensile strength of the str biodegradable pots of 8091 Pa was obtained from a treatment combination of R1C2 (100% OPEFB; 3% NaOH) and the highest value of 23418 Pa was available obtained from the treatment combination of R5C3 (100% Banana stems; 7% NaOH). In the treatment of raw materials compositions and NaOH concentrations, the tensile strength of the biodegradable pot tended to increase with optimum point in the treatment of C3 (7% NaOH) and the treatment of K5 (100% Banana Stems). In the study of Schettini, et al. (2013), the making process of biodegradable pots from tomato and hemp fibers, the tensile strength e resulted ranged from 460000 - 1200000 Pa, and the value of the tensile strength was influence by the fiber dispersion during the making process. To date, research and studies on the mechanical properties of biodegradable pots from Unive OPEFB fibers were still limited. If compared to the result by Schettini, et al. Universitas Brawijaya Universitas Brawijaya Diversitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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(2013), the tensile strength of the biodegradable pots produced in this research tended to be smaller. It probably due to discontinuity of fibers on biodegradable pots, as a result by irregular fiber dispersion during the moulding process of biodegradable pots. Following by Schettini, *et al.* (2013), if the voids were produced due to irregular dispersion of fiber in the composite, it would significantly weaken the load transfer capability, thus the tensile strength would decrease. Furthermore, the biodegradable pots have a stiffness composite structures by utilizing natural fibers, thus the mechanichal permorfance of the composites of natural fibers-based was poorer if compared to the composites of synthetic fibers-based.

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The data results from the analysis of variance (ANOVA) test which indicated a significant difference then continued with the DMRT (Duncan's Multiple Range) test to figured out the difference between each treatment in giving effect to the biodegradation potential of the biodegradable pots. Based on the results obtained, the DMRT test that performed on the R factor (Raw Materials Composition), C factor (Concentration of NaOH), and the interaction between the two factors (R*C) have been present in the **Appendix 9**. The results of the DMRT test on the each level of raw materials concentration factor are presented in **Table 4.10**

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| | Universitas Brawijaya Universitas Brawijaya | R1 R2 R3 R3 R3 R4 R5 Note: the average value followed by the san on the DMRT test analyzed in SPPS p Based on Table 4.10 above, it ca raw material composition factor had a strength of biodegradable pots, indicate | Treatments Average R1 91 R2 13 R3 R3 R4 15 R5 18 Note: the average value followed by the same letter does not signification on the DMRT test analyzed in SPPS packages Based on Table 4.10 above, it can be seen that each le raw material composition factor had a difference in giving effective strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the different not strength of biodegradable pots, indicated by the strength of biodegradable pots, indicated by |

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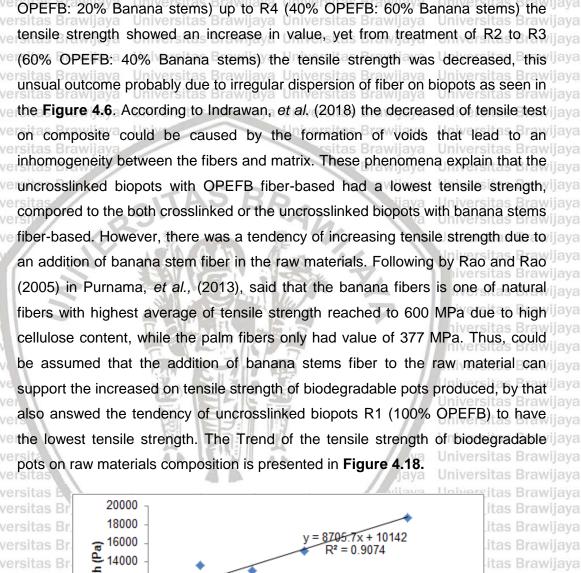
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and significantly different for all treatment combinations. Meanwhile, in the

treatment of R1 (100% OPEFB) had the lowest average value of tensile strength,

^{ve} treatment of R5 (100% Banana stems) showed the highest average value of tensile strength of biodegradable pots, also significantly different from all

treatment combinatrion. Moreover, in the uncrosslinked biopots from R2 (80%

ngth 12000 Strer 10000 8000 Tensile 6000 4000 2000 0 40% 80% 0% 20% 60% 100% 120% Percentage of Reduced OPEFB in Raw Materials



Figure 4.18 The Trend of Tensile Strength on Raw Materials Composition

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya awijaya The regression graph in Figure 4.18 explained the trend of influence of the awijaya reduction of OPEFB used in raw materials composition in each treatment on the increasing tensile strength of the biodegradable pot produced. The types of fiber greatly affect to the mechanical properties, especially the tensile strength of awijaya biodegradable pots, which the higher the percentage of banana stems in the raw materials used, the tensile strength of the biodegradable pots would be increased awijaya awijaya due to more cellulose content in raw materials. This result is in a greement with awijaya Karimah, et al. (2021), reported that the presence of cellulose of natural fiber awijaya affected to the tensile strength of biocomposites when used as a mixture or raw lava awijaya awijaya materilas. Cellulose correlated positively with tensile strength and Young's modulus, which means the higher the cellulose content in the raw materials used, awijaya Unive the higher the tensile strength of biocomposite will be. Following this hypothesis, java awijaya awijaya it can be known that the cellulose content in the raw materials indicated to awijaya Unive continue to increase from un-crosslinked biopots of OPEFB fiber-based (R1) to java awijaya awijaya the crosslinked biopots (R2, R3, and R4) up to un-crosslinked biopots of Banana awijaya stems fiber-based (R5). Thus, the higher the proportion of banana stems added awijaya awijaya to the crosslinked biopots could support a stronger tensile strength of biopots due awijaya more cellulose content, supported by Nair, et al. (2016), the addition of banana awijaya fiber in composites material composition could strengthen composited and awijaya awijaya showed higher tensile. Whereas, in the un-crossllinked biopots of OPEFB fiberawijaya based had the lowest tensile strength because it was influenced by less cellulose awijaya awijaya ve content and had more lignin content compared to banana stems fiber as can be seen in Table 2.2, which lignin content had negative impact and correlation to the awijaya mechanical properties of natural fiber, especially the tensile strength. Moreover, awijaya the un-crossllinked biopots of banana stems fiber-based had the highest tensile awijaya strength influenced by the highest the cellulose content in the fibers as can be Universiten in Table 2.3 Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Unive 4.6.2. The Effect of NaOH Concentrations on Tensile Strength of Biopots rawijava awijaya Universities The results of DMRT (Duncan's Multiple Range) test for the each level of awijaya awijaya NaOH concentrations can be seen in Table 4.11 as Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijava60 niversitas Brawijava Universitas Brawijava Universitas Rrawijava Universitas Rrawijava

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awijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Table 4.11 The Value of Biopots Tensile Strength Due to NaOH Concentration er<mark>Facto</mark> Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya versitas Brawijava Treatments Average Value (Pa) Universitas Brawijaya C1 13515a Un C2 Brawijava Universitas Brawi 13500a C3 14900b Note: the average value followed by the same letter does not significantly difference Universitian based on the DMRT test analyzed in SPPS packages awijava Based on **Table 4.10** above, it can be seen that the treatment on NaOH Inive concentration factor had a difference in giving effect to the tensile strength of biodegradable pots, indicated by different notation results. The highest value of tensile strength was obtained in the treatment of C3 (7% NaOH), and significantly different for all treatment combinations. And the lowest value of tensile strength was obtained in the treatment of C2 (3% NaOH), but not significantly different from the treatment of C1 (5% NaOH). Tensile strength analysis showed that the increase in NaOH concentration would increase the tensile strength of the biodegradable pots due to the high cellulose content obtained by hydrolyzed the lignin content in fibers. Based on Bahtiar, et al. (2016), lignin is a component that covers cellulose and hemicellulose in the fibers and could provide stiffness to the fibers. Thus far, the hydrolysis of lignin in fiber among alkaline treatment was able light to increase the mechanical properties of the fibers due to reduced stiffness in fibers.

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However, the results in tensile test of biopots were slightly different from the results of the water uptake and biodegradation test, which showed the optimum delignification point at 5% NaOH concentration. In the tensile strength test, the concentration of 5% NaOH and 3% NaOH showed not significantly different in giving effect on tensile strength, also the tendency of tensile strength continued to increase up to 7% of NaOH concentration indicated the highest cellulose content obtained, both in the un-crosslinked biodegradable pots and crosslinked biodegradable pots treatment. The difference at the optimum point of NaOH concentration may be influenced by the irregular fiber dispersion that leads to produce the voids on biopots. The presence of these voids could affect the fiber density of biopots. According to Herma P, *et al.* (2019), the fiber density of the composite will weaken when voids were more formed inside the composite. Furthermore, as reported by Darni, *et al.* (2018), fiber density is one of the physical properties of polymer that influence the mechanical properties. The mechanical properties. The higher the fiber density of the materials will increase the mechanical properties. Due to this hypothesis, it can be assumed that the mechanical properties of the biopots are not necessarily affected by the high content of cellulose in the fibers. The phenomenon of irregular fiber dispersion on the biopots probably indicates a poor uniformity of the fiber density of the biopots and it is responsible for the poor ability of biopots to transfer the load during tensile test. The Trend of the tensile strength of biodegradable pots on NaOH concentrations can be seen in **Figure 4.19**

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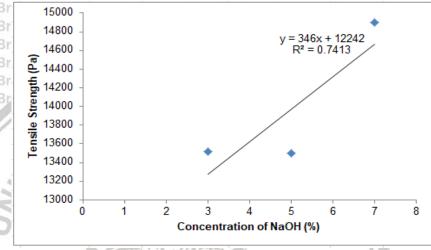


Figure 4.19 The Trend of Tensile Strength on NaOH Concentrations Brawijaya

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The regression graph in Figure 4.19 explained the trend influence of Unive concentration of NaOH used in each treatment to increased the value of tensile strength of the biodegradable pots, which was the higher concentration of NaOH used, the tensile strength of the biodegradable pots would also increase. This is related to the number of cellulose content obtained after the alkaline treatment process. According to Rachman (2010), said that the increase in cellulose content caused increased hardness of the material, which was directly related to increases in the tensile and compressive strength of the composites. This Unive corresponds to research conducted by Schettini, et al. (2013), that the available biocomposite composed of natural fibers which were mostly cellulose structures increased in tensile strength. Therefore, the tensile strength of biodgradable pots, both the un-crosslinked biodegradable pots with OPEFB fiber-based and uncrosslinked biodegradable pots with banana stems fiber-based, as well as the Unive crosslinked biodegradable pots (R2, R3, and R4) tended to increased along with java an increase of NaOH concentration due to more lignin content that were be Universitas Brawijaya Universitas Brawijaya Universitas Brawijava62 niversitas Brawijava Universitas Brawijava Universitas Brawijava

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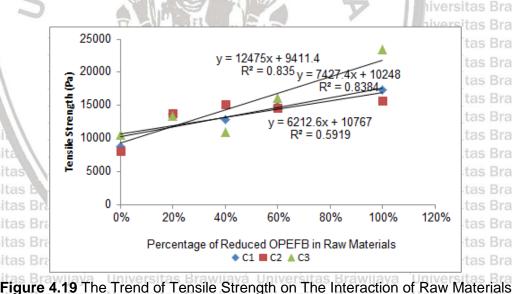
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Universitas Brawijaya treatment combination of R3C5 (100% Banana stems; 7% NaOH) and significantly different with all treatment combinations. These results indicate that the un-crosslinked biodegradable pots of banana stems fiber-based had astronger of tensile strength compared to the crosslinked biodegradable pots and to the un-crosslinked biodegradable pots of OPEFB fiber-based. Futhermore, the tensile strength even higher when the concentration of NaOH during alkaline treatment was increased due to more cellulose content was obatained in the raw materials. However it also was found a phenomenon of decreasing the tensile strength when the concentration of banana stems was increased from treatment ombination of R2C1 to R3C1, R3C2 to R4C2 and from R2C3 to R3C3. This un unusual outcome could be due to the irregular dispersion of fiber inside the biopots that lead to voids rising, thus caused inefficient load transfer between University fibers and matrix of biodegradable pots. Moreover, there was also unusual outcome by decreasing value of tensile strength when the NaOH concentration University increased in treatment combination of R1C1 to R1C2, and from R3C2 to R3C3. Meanwhile, the trend of tensile strength on the interaction between raw material composition factor and NaOH concentration factor can be seen in Figure 4.15.



The regression graph in **Figure 4.19** above, explained the trend of tesile strength value due to the interaction between the raw material composition factor and NaOH concentrations factor used. The combination of treatments used in research provided different variations of tensile strength. But it can be assumed 64

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that the value of biopots tensile strength of the had increased along with the increased concentration of banana stems fiber which added in raw materials because of the higher cellulose content in banana thus support the higher presence of cellulose content in raw materials. As well as, the addition of NaOH e concentration in alkaline treatment and an increase in concentration has resulted java in high tensile strength due to rich of cellulose content in the raw materials. Hence, the interaction between raw materials factor and NaOH concentrations factor affect the tensile strength of biodegradable pots. If compared to the crosslinked biopots and the un-crosslinked biopots of OPEFB-based, the uncrosslinked biopots of banana stems fiber-based in all treatment combinations ava with the concentration of NaOH used had a stronger tensile strength. ersitas Brawijaya Following the results of tensile strength, the fiber density of biodegradable e pots, both crosslinked and un-crosslinked, needs to be considered. The Irregular dispersion of the fibers inside the polymeric matrix that provided voids in the biocomposites, both in the matrix or between the fiber and matrix would cause uneven load distribution on biodegradable pots due to discontinuity of fibers bonding. Moreover, the tensile strength is affected by the efficiency of load transfer from the matrix to the fiber (Schettini, et al., 2013) Thus, increasing the Java fibers density of biodegradable pots are needed to build a good bonding between the fiber and the constituent matrix, to get a good tensile strength. The tensile strength of biodegradable pots also indicated the level of durability of biodegradable pots as nursery container media. Tensile strength account for handling capacity of biodegradable pots, which refers to the tensile forces are exerted on the container walls during plant growth and manually transporting the container (Juanga, et al., 2021). Hence, in this regard, the best result based on the highest value of tensile strength was obtained in the treatment combination of R5C3 (100% Banana Stems; 7% NaOH). Universitas Brawijaya versitas Brawijaya Universitas Brawijaya Universitas Brawijaya 4.7. The Best Treatment Formulation niversitas Brawijaya Universitas Brawijaya versitas According to Juanga, et al. (2021), the development of bio-containers has java been continuously focused on utilizing the appropriate biodegradable waste materials, improving the strength of the container and also increasing its biodegradability. Thus, the best treatment formulation in this study was obtained from treatment combinataion of R2C2 (80% OPEFB: 20% banana stems; 5% Unive NaOH) due to higher OPEFB in raw materilas could support the faster Universitas Brawijaya65 niversitas Brawijaya Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava Ilniversitas Rrawijava

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biodegradability of biopots by the avalaibility of silica content. Following by Tomadoni, et al. (2020) the main thing to consider is that it is fundamental to offer fast biodegradation of planting biopots within the soil to avoid their accumulation and root circling while increasing biopots water use efficiency when rising plants. ve Thus far, adding banana stems fiber in the raw materials could support the better strength of biopots, both in the tensile strength and water resistance. Because reported by Nechita (2019), the main drawbacks of the biodegradable pots are its strength, especially wet strength. However, adding too much banana stems fiber is necessary to avoid due to more pores that caused the low water resistance of Unive biopots and related to the durability of biopots that plays an important role during lava the plant's nursery process before the plants are ready to be transferred to the cultivation land. Thus, biodegradable container or biopots become a sustainable Unive containers that could easily adjust to both horticulture and floriculture production. Also, based on physicomechanical testing that was carried out to the biodegradable pots indicated an irregular dispersion of the fiber during the moulding process, thus cause the presence of discontinuity of fibers affected the fiber density of biodegradable pots, resulting in a weakening of the biodegradable pots matrix which directly related to the quality of biodegradable pots. Hence, the fibers density of biodegradable pots needed some improvement in future research. The poor fibers density might be by means of the size dimensions of the OPEFB fibers still quite rough during the pulping process, that lead to inhomogeneity fibers size when mixed with banana stems fiber. The Unive physicomechanical results of the quality of biodegradable pots are presented in lava 1 AL A 15 the Table 4.13.

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| а | Universitas BrParamete | ers | Results | Universitas Brawijaya |
| а | Univer Mass Brawijaya | Universities | The mass of biodegradable pots was | influenced by raw laya |
| а | Universitas Brawijaya | Universitas | materials composition. The value r | anged from 9.58-ijaya |
| а | Universitas Brawijaya | Universitas | 18.48 grams, a significant difference | |
| а | Universitas Brawijaya | Universitas | of the fiber size and the density bet | |
| а | Universitas Brawijaya | Universitas | banana stems greatly affected biodegradable pots. | the mass the |
| а | Universitas Brawijaya | Universitas | Brawijaya Universitas Brawijaya | Universitas Brawijaya |
| а | Unive Moisture Content | Universitas | The factors of raw materials compo | osition and NaOH laya |
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| а | Universitas Brawijaya | Universitas | irregular dispersion of fibers slightly af | UTHVEISINGS DIAWHAVA |
| а | Universitas Brawijaya | Universitas | qualityof biodegradable pots. Howe content obtained in this study was | |
| а | Universitas Brawijaya | Universitas | previous study and was in accordance | |
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Universitas Brawijaya awijaya awijaya Universitas B Parameters Results Unive Water Uptake Va The factors of raw materials composition and NaOH Universitias concentrations, also the interaction affected on water available Universitas uptake. The value ranged from 2.72%-4.82%, an java increase of banana stems in raw materials was able to take increase the permeability of biodegradable pots due to the formation of more pores in biodegradable pots, therefore crosslinked biodegradable pots absorb water awijaya more easly rather than uncrosslinked biodegradable pots. While an increase in NaOH concentration affected lava the reduction number of hydroxyl groups that were ionized and form alkaline cellulose in the fiber, thus will awijaya increase the water resistance of the biodegradable pots. awijaya awijaya Biodegradation Potential The factors of raw materials composition and NaOH awijaya concentrations, also the interaction affected on available biodegradation potential. The value ranged from available 76.39%- 40.54%, the addition of banana stems fiber in the raw materials composition and the increase in the **Universitas Brawi** awijaya concentration of NaOH had an impact on increasing the awijaya cellulose content in biodegradable pots. Thus, able to awijaya inhibit the enzymatic activities of microorganism, and awijaya thereby reducing the potential for biodegradable pots to lava be degraded in nature. awijaya awijaya The factors of raw materials composition and NaOH **Tensile Strength** awijaya concentrations, also the interaction affected on tensile strength. The value ranged from 8091 Pa-23418 Pa, the awijaya increase in NaOH concentration as well as the proportion of babana stems fibers used in raw materials awijaya lead to more cellulose obtained, which was able to awijaya increase the hardness of the biodegradable pots, thus the tensile strength increased. However, the irregular awijaya dispersion of fibers phenomenon found in the awijaya biodegradable pots was able to weaken the bonding between the matrix and fibers, thereby reducing the java awijaya effiency of load transfer which results in a weakening of awijaya the biodegradable pots tensile strength. awijaya awijaya awijaya awijaya awijaya

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Universitas Brawijaya Universitas Brawi CHAPTER V CONCLUSION AND RECOMMENDATION ersitas Brawijaya Universitas Conclusionsniversitas Brawijaya Universitas Brawijaya Universitas Brawijaya Based on the results of research and discussion, it can be concluded that: 1. OPEFB have the potential to be utilized, especially in the making of biodegradable pots as an alternative nursery container. Also adding banana stems in the raw materials, as well as increasing the concentration Universitial of NaOH, can strengthen the physicomechanical properties of the java biodegradable pots, due to the increasing cellulose content in the fibers. 2. The raw materials composition factor affects the mass of biodegradable Universitial pots, the interaction between two factors influences the value of water uptake, biodegradation potential, and tensile strength, yet it does not show any effect on the moisture content of biodegradable pots. Universitas Brawijava Universit The quality results show biodegradable pots have the height of 9 cm (± 0.3) , the top diameter of 8 cm (±0.4), and the bottom diameter of 5 cm (±0.3). The physicomechanical results show biodegradable pots have a mass 4. range from 9.58-18.48 grams, moisture content of 50.42%-65.89%, water uptake of 2.72%-4.82%, biodegradation potential of 40.54%-76.39%, and tensile strength of 8091 Pa-23418 Pa.

5. Treatment combination of R2C2 (80% OPEFB: 20% banana stems; 5% NaOH) is the best treatment formulation due to having faster biodegradability also can support the durability of biodegradable pots through high tensile strength and water resistance. However, the fiber density of biodegradable pots needs some improvement caused by the irregular fiber dispersion.

5.2. Recommendations
1. In future research, it is recommended to do a Scanning Electron Micrograph (SEM) on the sample to determine the image of the bonding between fibers and matrix in biodegradable pots produced.
2. It is recommended to use a smaller size of OPEFB fiber to increase the fiber density of biopots, also facilitate the moulding proses.
3. To get a whiter and cleaner color of cellulose fiber a bleaching process is required using a Hydrogen Peroxide solution (H₂O₂).

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4. Research on the effect of the types of the banana plants used on the banana stems fiber as raw material for making biodegradable pots deemed

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Universitas necessary to do so itas Brawijaya Universitas Brawijaya

Universities value of biodegradable pots through the hedonic test.

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5. The study in particular focus on the customer acceptance of biodegradable Universitas pots is recommended to do so, to knowing the appeal and the aesthetic java 6. The application test of biodegradable pots in the nursery process is needed Universitias to knowing the effectiveness of using biopots compared to polybags. Brawlaya Iniversitas Brawijaya

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| | awijaya awijaya awijaya awijaya awijaya | Unive NaOH Concentra Unive Interaction Unive Within Unive Total | ations 29834.756 40063.034 | 52 8 530 | 14917.4 7.9351 5007.88 2.6638 1879.92 | 7 0.0153 2 0.00171 8 0.02444 | 2.68963 3.31583 2.26616 |
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| awijaya | Appendix 4. The Da | ta and Anova | Test for The | Biodegradatio | n Potential | o <mark>r</mark> s Brawijaya |
| awijaya | Universitas Brawijaya Uni | iversitas Braw | ijaya Univer | rsitas Brawijay | a Universi | tas Brawijaya |
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| | Universitas Brawijaya 4 Universitas 4 R4C1 | 57.746 | 51.220 | 44.444 | 153.41 | |
| awijaya | Universitas Brawijaya 5 Universitas Brawijaya | 55.882 | 58.904 | 46.667 | 161.45 | tas Brawijaya tas Brawijaya |
| awijaya awijaya | Universitas 6 rawijava R1C2 | 70.297 | 67.480 | 65.812 | 203.58 | as Brawijaya |
| awijaya | Universitas 73 rawijay R2C2 | 69.388 | 68.085 | 62.500 | 199.97 | las biawijaya |
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| awijaya | Universites | 1 1 3 1 | RD | lion | Universit | |
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| awijaya | Univer 12 R2C3 | 100 | 62.264 | 52.941 | 172.65 | as Brawijaya |
| awijaya | Univ 13 R3C3 | 59.184 | 55.056 | 65.909 | 180.14 | as Brawijaya |
| awijaya | Uni 14 R4C3 | 51.807 | 61.538 | 62.963 | 176.30 | as Brawijaya |
| wijaya | Uni 15 R5C3 | 48.276 | 54.545 | 49.153 | 151.97 | 4as Brawijaya |
| awijaya | | 876.144 | 894.383 | 8 852.053 | 2622.57 | g is Brawijaya |
| wijaya | Uni | | A | ×. | niversi | tas Brawijaya |
| wijaya | Univ ANOVA | | | | niversi | tas Brawijaya |
| awijaya | Univer Source of Variation | SS SS | Df M | S F | P-value | ta F crit vijaya |
| wijaya | Unive Raws Materials | | | | 2.15E-si | tas Brawijaya |
| awijaya | Univer Composition | 2866.22 | 4 716. | 556 31.7768 | U10/ersi | 2.68963 aya |
| awijaya | Univer NaOH | | | | | tas Brawijaya |
| awijaya | Univer Concentrations | 216.598 | 2 108. | | | 3.31583 jaya |
| awijaya | Univerdinteraction | 616.914 | 8 77.1 | | | 2.26616 Jaya |
| awijaya | UniversWithin | 676.49 | 30 22.5 | | | tas Brawijaya |
| awijaya | Universities | 4376.23 | 44 | wijay | | tas Brawijaya |
| awijaya awijaya | Universitas Bra Universitas Brawn | | | Brawijay | | tas Brawij aya tas Brawijaya |
| awijaya | | ype III Sum | Df I | Mean Square | | Circ |
| awijaya | | of Squares | | noan equato | · | - |
| awijaya | erinter | | | | | aya |
| awijaya | Univer Corrected Model | 3699.714 ^a | 14 | 264.265 | 11.720 | .000 aya |
| wijaya | Univer Intercept | 152842.680 | 1 | 152842.680 | 6778.278 | .000 aya |
| wijaya | Univer R | 2866.225 | 4 | 716.556 | 31.778 | .000 iya |
| wijaya | Univer C | | | | | .016 ^{aya} |
| wijaya | Univer R*C | 216.586 | 2 | 108.293 | 4.803 | .016 ^{aya} |
| wijaya | Univer | 616.903 | 8 | 77.113 | 3.420 | .007 aya |
| wijaya | Univer | 676.467 | 30 | 22.549 | | aya |
| wijaya | Univer Total | 157218.861 | 45 | | | aya |
| awijaya | Univer Corrected Total | 4376.180 | 44 | | | aya |
| awijaya | Univer a. R Squared = .845 (Ad | justed R Squared | = .773) | | | |
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| wijaya | Appendix 5. 7 | The Data and And | va Test | for The Tens | ile Strength of | Biopots | wijaya |
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| wijaya | Uni ANOVA | | 1. 1 | TTA | | iversitas Bra | |
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| wijaya | Units Source of Variation | SS | df | MS | F P-valu | e ^{ersita} F crit | wijava |
| wijaya | Raws Materials | | u | IVIS | 1.68079 | | |
| wijaya | Univ Composition | 444935864.2 | 4 1.1 | 1E+08 289. | 6267 | 23 2.689627 | |
| wijaya | Unive NaOH | ST ST | | | 3.746 | 111/01/01/01/01/01/01 | wijaya |
| wijaya | Concentrations | 19377465.87 | 2 96 | 688733 2 | 5.227 | 07 3.315829 | 501 |
| | | | | | 9.98294 | 4E- | wijaya |
| wijaya | UniversInteraction | 118744808 | | .79 | | 14 2.266163 | |
| wijaya | UniversWithin | 11521791.99 | 30 38 | 4059.7 | | niversitas Bra | |
| wijaya | Universita | 4 11 | | l. | / /// · | niversitas Bra | |
| wijaya | Universitional | 594579930.1 | 44 | | | niversitas Bra | |
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| wijaya | Univer Corrected | I | | | | | vijaya |
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| wijaya | Univer Intercept | 0100100001 | 1 | 8785159997 | 7.613 22874.4 | | vijaya |
| wijaya | Univer R | 444935854.964 | | 111233963 | 3.741 289. | 627 000 | vijaya |
| wijaya | Univer C | 19377465.817 | | 9688732 | | 227 .000 | vijaya |
| wijaya | Univer R * C | 118744810.572 | | 1484310 | | 648 .000 | vijaya |
| wijaya | Univer Error | 11521792.022 | | 384059 | | | vijaya |
| wijaya | Univer | 9379739920.98 | 2 | 20100 | | | vijaya |
| wijaya | Univer Total | { | 45 | | | | vijaya |
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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Appendix 6. The DMRT Test for The Mass of Biopots Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Unive Factor R (Raw Materials Composition) Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya

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| awijaya | Univer | Factor R | Ν | | Subset | l |
| awijaya | Univer | | | 1 | 2 | 3 (|
| awijaya | Univer | R5 | 9 | 9.5767 | | 1 |
| awijaya | Univer | R4 | 9 | | 13.2822 | l. l |
| | Univel Duncan ^{a,} | b R3 | 9 | | 15.2878 | 1 |
| awijaya | Univer | R2 | 9 | | | 17.6811 |
| | Univer | R1 | 9 | | | 18.4767 |
| awijaya | University | Sig. | | 1.000 | .062 | .448 |
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- The error term is Mean Square(Error) = 4.812.
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Factor C (NaOH Concentrations)

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| | | | 1 | ę |
| | C2 | 15 | 14.2840 | |
| Duncan ^{a,b} | C1 | 15 | 14.9140 | |
| Duncan | C3 | 15 | 15.3847 | |
| | Sig. | | .204 | |
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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya awijaya awijaya Appendix 7. The DMRT Test for The Moisture Content of Biopots Diversitas Brawijaya awijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Factor R (Raw Materials Composition) Universitas R awijava Universitas Brawijaya **Moisture Content** awijaya Factor R Subset Ν Univer 1 58.3744 ^{iversitas} Brawijaya R5 9 58.5029 iversitas Brawijaya awijaya R4 9 59.5807 iversitas Brawijaya awijaya **R1** 9 Duncan^{a,b} awijaya 62.4168 iversitas Brawijaya 9 R2 awijaya R3 9 62.9179 iversitas Brawijaya Siq. .423 iversitas Brawijaya awijaya awijaya Univ awijaya Univer Means for groups in homogeneous subsets are displayed. Univer Based on observed means. awijaya a Univer The error term is Mean Square(Error) = 110.973. awijaya a awijaya Univer a. Uses Harmonic Mean Sample Size = 9.000. а awijaya Univer b. Alpha = .05. awijaya Iniversitas Brawijaya awijaya Factor C (NaOH Concentrations) awijaya awijaya **Moisture Content** awijaya Subset Factor C Ν awijaya 1 awijaya C1 15 55.7593 awijaya C2 15 61.4480 Duncan^{a,b} awijaya C3 15 63.8683 awijaya Sig. .054 awijaya Univer 11:3 s Brawijaya awijaya Means for groups in homogeneous subsets are displayed. awijava Based on observed means. awijaya The error term is Mean Square(Error) = 110.973. awijaya Univer a. Uses Harmonic Mean Sample Size = 15.000. Univerb. Alpha = .05. awijaya awijaya awijaya awijaya awijaya awijaya Universitas Brawijava84 niversitas Brawijava awijaya

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Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Appendix 8. The DMRT Test for The Water Uptake of Biopots Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Unive Factor R (Raw Materials Composition) Universitas Brawijaya

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| awijaya | Univer | Factor R | Ν | Subs | set | Irawijaya |
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| awijaya | Univer | R5 | 9 | 3.4111 | | rawijaya |
| awijaya | Univer | R1 | 9 | 3.4608 | | rawijaya |
| awijaya | Unive Duncan ^{a,b} | R2 | 9 | 3.5360 | | rawijaya |
| awijaya | Univer | R3 | 9 | 3.5730 | | rawijava |
| awijaya | Univer | R4 | 9 | | 4.097 | rawijava |
| awijaya | Universitas praw | Sig. | | .478 | 1.00 | |
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Based on observed means.

The error term is Mean Square(Error) = .188.

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Factor C (NaOH Concentrations)

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| | Wat | er Uptak | e | |
| | Factor C | N | Subs | set |
| i - | | | 1 | 2 |
| iv | C2 | 15 | 3.3958 | |
| iv Dumanab | C3 | 15 | 3.4740 | |
| Duncan ^{a,b} | C1 | 15 | | 3.9769 |
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| awijaya | Unive | | R5C3 | 2.724 | | | | iversitas Brawijaya |
| awijaya | Univer | | R1C2 | 3.178 | | | | iversitas Brawijaya |
| awijaya | Univer | | R2C2 | 3.184 | | | | iversitas Brawijaya |
| awijaya | Univer | | R5C2 | 3.291 | | | | liversitas Brawijaya |
| | | | R1C1 | 4.407 | | | | |
| awijaya | Univer | | R3C3 | 3.496 | | | | iversitas Brawijaya |
| awijaya | Univer | | R3C2 | 3.570 | | | | iversitas Brawijaya |
| awijaya | | Duncan ^{a,b} | R2C3 | 3.638 | | | | iversitas Brawijaya |
| awijaya | Univer | | R3C1 | 3.653 | | | | iversitas Brawijaya |
| awijaya | Univer | | R4C3 | | 3.715 | | | iversitas Brawijaya |
| awijaya | Univer | | R4C2 | | 3.756 | | | iversitas Brawijaya |
| awijaya | Univer | | R2C1 | | 3.786 | | | iversitas Brawijaya |
| awijaya | Univer | | R1C3 | | 3.798 | | | iversitas Brawijaya |
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| | | Factor | R N | | Subset | 0 |
| | | | | 1 | 2 | 3 |
| awijaya | Univer | R5 | 9 | 48.3383 | _ | U |
| awijaya | Univer | R4 | 9 | 51.8678 | | U |
| awijaya | Univer | D2 | 9 | 01.0070 | 57.9144 | U |
| awijaya | Univer Duncar | R2 | 9 | | 62.2424 | U |
| awijaya | Univer | R1 | 9 | | | 71.0347 🕖 |
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Univer Means for groups in homogeneous subsets are displayed.

Univer Based on observed means.

Univer The error term is Mean Square(Error) = 22.549.

Univer a. Uses Harmonic Mean Sample Size = 9.000.

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Factor C (NaOH Concentrations)

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| | Factor C | Ν | Subset | | |
| | | | 1 | 2 | |
| | C2 | 15 | 55.2591 | | |
| Duncan ^{a,b} | C3 | 15 | | 59.1757 | |
| | C1 | 15 | | 60.4039 | |
| | Sig. | | 1.000 | .484 | |

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a. Uses Harmonic Mean Sample Size = 15.000. b. Alpha = .05.

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| ivei | R5C2 | 40.539 | | | | | | | aya |
| ive | R4C2 | 45.697 | | | | | | | |
| | R5C3 | 50.658 | | | | | | | aya |
| ivei | R4C1 | | 51.137 | | | | | | aya |
| iver | R5C1 | | 53.818 | | | | | | aya |
| ive | R3C2 | | 55.538 | | | | | | aya |
| ivei | R2C3 | | | 57.551 | | | | | aya |
| ive Duncan ^{a,b} | R3C1 | | | 58.156 | | | | | aya |
| ivei | R4C3 | | | 58.770 | | | | | aya |
| iver | R3C3 | | | 60.050 | | | | | aya |
| ive | R2C1 | | | | 62.519 | | | | aya |
| ivei | R2C2 | | | | | 66.658 | | | aya |
| ivei | R1C2 | | | | | | 67.863 | | aya |
| | R1C3 | | | | | | 68.851 | | |
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The error term is Mean Square(Error) = 384059.734.

^{Vel} a. Uses Harmonic Mean Sample Size = 9.000.

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Factor C (NaOH Concentrations)

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| | Te | nsile Stro | ength | |
| | Factor C | Ν | Sub | oset |
| | | | 1 | 2 |
| | C2 | 15 | 13500.4885 | |
| Duncan | _{a,b} C1 | 15 | 13516.1797 | |
| Duncan | C3 | 15 | | 14900.2974 |
| e | Sig. | | .945 | 1.000 |

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Appendix 11. The Documentations and Universitas Brawijaya Universita The Making Process of Biopots a Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya Universitas Brawijaya

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The Process of Chopping the OPEFB and Banana Stems



OPEFB and Banana Stem Fibers



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