Proceeding Paper

EFFECTIVENESS OF RICE STRAW AND COFFEE SKIN WASTE AS ENVIRONMENTALLY FRIENDLY BIOFOAM

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Abstract

Food products currently in circulation are not multi-purpose containers and packaging. Food packaging and containers have the main goal of keeping food safe for consumption. Styrene pellets treated with benzene are a source of danger to Styrofoam. If benzene enters the body, it can cause a number of serious diseases whose symptoms are not immediately visible. Other packaging materials that are more environmentally friendly are used as raw materials for making biofoam or biodegradable foam, namely agricultural products that are in abundant supply and the raw materials used contain starch and cellulose. Quasi-experimental research design with a quasi-experimental design. Data analysis of the One Way Anova Test and Bonffreroni Test showed the average percentage of water absorption capacity and tensile strength of biofoam at concentrations of 50%: 50%, 70%: 30%, and 30%: 70%. One Way Anova Test Results obtained ρ value of water absorption capacity 0.000 < 0.05. and the tensile strength obtained ρ value 0.004 <0.05 so that there are significant differences in various concentrations and the Bonfferoni Test Results showed that the most effective concentration for water absorption and tensile strength was at a concentration of 30%: 70%. It is hoped that further research needs to be carried out using other methods to produce biodegradable foam with better quality regarding the physical and mechanical properties of the biofoam produced.

Keywords: Biofoam, Rice Straw, Coffee Skin, Water Absorption, Tensile Strength.

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INTRODUCTION

Current food products are not merely containers and packaging used for various purposes. The main role of food containers and packaging is to package and keep the food safe for consumption. However, not all types of food containers and packaging are safe for the food they contain. Some substances may leach into the food from the container. Plastic food containers or packaging are made from several types of polymers, including polyethylene terephthalate (PET), polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), and melamine. Among these plastic packaging materials, polystyrene, particularly Styrofoam, is currently very popular among producers and consumers (Elvit Indirawati et al., 2019).

According to Mukhtar & Nurif (2015), containers or wrappers serve as stimulants or attractants. Styrofoam has the advantage of being practical and durable. Many vendors prefer Styrofoam for packaging the food they sell because it is convenient to use, leak-resistant, clean-looking, heat-resistant, and affordable. However, Styrofoam packaging has a significant drawback as it poses a health risk to humans.

The danger of Styrofoam comes from styrene beads processed with benzene. Styrofoam is hazardous because it is made using styrene beads and benzene. Benzene is a substance that, when it enters the body, can cause various dangerous diseases with symptoms that only appear after a long time. The substances contained in Styrofoam can cause damage to the human body's system, contribute to the development of cancer cells, and Styrofoam waste is a very difficult-to-decompose pollutant in nature (Alhidayati et al., 2021). Given the significant negative impact of Styrofoam usage, experts are striving to find alternative packaging materials that are more environmentally friendly. One of the materials being utilized for making biofoam or biodegradable foam is agricultural products, which are abundant in supply and include raw materials containing starch and cellulose. These materials are renewable and more affordable. Biofoam can naturally degrade (biodegradable) and is renewable. Biofoam made from natural polymers (starch and fibers) generally has low mechanical properties (Bahri et al., 2021).

According to Setyanto et al. (2022), to reduce the negative impact of Styrofoam usage as food packaging, environmentally friendly materials that do not pose health risks can be used. One material that can fulfill these criteria is a composite material made from natural fibers. The composite material used in the production of biodegradable packaging includes rice straw as a filler material and glutinous flour as a binder (matrix). Rice straw is chosen as a filler because it is lightweight, inexpensive, renewable, and biodegradable.

According to Dewi et al. (2023), biodegradable foam (biofoam) is a biopolymer that is safe and environmentally friendly, made from natural materials used in the production of biodegradable plastics. Biopolymers that can be used include starch and cellulose derived from agricultural products or agricultural waste. Biofoam has been widely recognized as one of the best choices for single-use packaging applications. Biofoam uses starch and cellulose (natural fibers) as the primary raw materials, which are known to be abundantly available. The fibers also contribute significantly to environmental sustainability due to their non-hazardous nature, which can be utilized for making biofoam.

To date, the utilization of rice straw has not reached its optimal potential. Usually, straw is used as animal feed, with the remainder left to rot or burned. This practice can lead to pollutants (CO2, NOx, SOx) that harm the environment and contribute to greenhouse gases (Hayuningtyas et al., 2014). Rice straw is the stalk and stem of rice plants after the grains have been harvested. Rice straw contains 37.71% cellulose, 21.99% hemicellulose, and 16.62% lignin. This high cellulose content can be utilized in various ways, including as a material for bioplastics. Agricultural polymers have thermoplastic properties, making them suitable for forming or molding into packaging films (Pratiwi et al., 2016). Research is needed on producing biofoam using natural materials as fillers and reinforcing layers in biofoam. This research utilizes rice straw fibers and adds polyvinyl alcohol (PVA) as a binder for the film on the fibers, using a thermopressing molding method to produce samples. This method is chosen to obtain biofoam products with better characteristics, including physical, mechanical, and biodegradable properties (Haiqal & Muldarisnur, 2023).

Recent research has been conducted by several researchers using various types of starch and cellulose additives to produce biodegradable foam with optimal characteristics. Some of this research includes: cassava starch (Kaisangsri et al., 2019), sago starch (Hendrawati et al., 2017), modified sago starch (Hendrawati et al., 2019), corn starch (Yudanto and Pudjihastuti, 2020), durian seed starch (Sipahutar, 2020), jackfruit seed starch (Nurfitasari, 2018), avocado seed starch (Fauzan et al., 2018), and banana stem starch (Irawan et al., 2018). The results of these studies indicate that the properties of biofoam are highly influenced by the type of raw materials, additives, and methods used.

According to Falahuddin, Irham, et al. (2016), coffee is one of Indonesia's leading foreign exchange earners and plays an important role in developing the plantation industry. Over the past 20 years, the area and production of coffee plantations in Indonesia, particularly smallholder coffee plantations, have experienced significant growth. Coffee-producing regions in Bengkulu Province include Kepahiang, Rejang Lebong, Lebong, South Bengkulu, and North Bengkulu (Alfian, 2021). Coffee processing consists of two processes: wet processing and dry processing. Both processes can produce solid waste in the form of coffee husks, with a total proportion of 41%, consisting of 29% outer husk (pulp) and 12% parchment (Novita et al., 2018).

According to Fadilah Azzahra (2021), coffee husks are one of the most abundant wastes generated from coffee in Indonesia, yet they are only used on a small scale, such as for animal feed, fertilizer, and much of the coffee husks become waste with no useful value. Coffee husks have a fiber content of 65.2%. They are often discarded or left to accumulate on the ground, which can lead to air pollution. Coffee husks still have a high moisture content of about 70-85%, making them prone to microbial growth, which results in a foul odor (Mashami et al., 2022).

According to Syaifullah Y et al. (2023), coffee husk waste can still be processed into other products with higher commercial value. One such product is solid soap. The active compounds in coffee husks are widely utilized in various cosmetic products (Ismail et al., 2023). Coffee husk waste, with its high crude fiber content of 18.7%, has the potential to be added to the formulation of biofoam production (Sarlinda et al., 2022).

To study the characteristics of biodegradable foam from various starch and cellulose sources, as well as the references from journal guidelines, the review results can serve as a foundation or reference for conducting research on producing biodegradable foam and in the packaging of food products derived from agricultural products. Therefore, the author is interested in conducting research with a focus on the chosen title, "Effectiveness of Rice Straw and Coffee Husk Waste as Environmentally Friendly Biofoam."

Based on the background described above, the research problem can be formulated as follows: Does environmentally friendly biofoam made from natural materials, such as rice straw and coffee husks, hold potential for development.

MATERIALS AND METHODS

This study is a quasi-experimental research (quasi experiment) using a quasi-experimental design, which is a research design that applies quasi-experimental methods. The objective is to determine the water absorption capacity of biofoam made from rice straw and coffee husk waste with ratios of 50:50, 70:30, and 30:70, and to assess the tensile strength of biofoam with the same ratios. This research design measures the effect of treatments on an experimental group by comparing it with a control group (Riyanto, 2011). The sample in this study consists of rice straw and coffee husks that have been filtered using a 60-mesh sieve, with the following proportions: 50% rice straw (92 grams), 70% rice straw (129 grams), 30% rice straw (56 grams), 50% coffee husks (23 grams), 30% coffee husks (14 grams), and 70% coffee husks (32 grams). The study includes three Styrofoam controls and each experiment was repeated nine times. The water absorption test in this research refers to the ABNT NBR NM ISO 535 standard, while the tensile test follows the ASTM D-639 standard.

RESULTS AND DISCUSSION

Univariate Analysis

Table 1: Frequency Distribution of Water Absorption Ability by Composition 50% : 50%, 70% : 30% and 30% : 70%

Repetition	Composition			
	Control	50% : 50%	70% : 30%	30% : 70%
1	7,95	3,14	4,11	2,84
2	11,54	3,80	3,18	3,42
3	12,16	3,86	3,27	2,83
Total	31,65	10,80	10,56	9,10
Average	10,55	3,60	3,52	3,03

Table 1 shows that the water absorption capacity of a material indicates how much water the material can absorb. In the control test, which likely used the base material without any mixtures or modifications, the average water absorption was 10.55. With a 50%:50% composition, water absorption decreased significantly to an average of 3.60. For the 70%:30% composition, the water absorption was slightly lower, with an average of 3.52. Finally, the 30%:70% composition showed the lowest water absorption with an average of 3.03.

Table 2: Frequency Distribution of Tensile Strength Capacity with Composition 50% : 50%, 70% : 30%, and 30% : 70%

Repetition	Composition			
	Control	50% : 50%	70% : 30%	30% : 70%
1	0,45	1,39	1,91	3,43
2	0,77	2,11	2,70	3,01
3	0,98	3,28	2,90	3,20
Total	2,20	6,78	7,52	9,64
Average	0,73	2,26	2,51	3,21

Table 4.2 shows that the tensile strength of a material measures the maximum stress it can withstand before breaking. In the control test, likely using the base material without any modifications, the average tensile strength was 0.73. With a 50%:50% composition, the tensile strength significantly increased to an average of 2.26. For the 70%:30% composition, the tensile strength averaged 2.51. Finally, the 30%:70% composition showed the highest tensile strength, with an average of 3.21.

Bivariate Analysis

This One Way ANOVA test is used to examine a design with more than one variable. The statistical analysis in this study was conducted with a 95% confidence level or α 0.05 using the one-way ANOVA method. First, a homogeneity test was performed, resulting in a significance value for water absorption of 0.000 < 0.05 and a significance value for tensile strength of 0.004 < 0.05. This test was used to determine whether there were differences in water absorption and tensile strength across various concentration variations.

Table 3: One Way Anova Test Results of Water Absorption Capacity With Comparison Variations of 50:50, 70:30, and 30:70 in the Control.

Concentration Variable	Mean	SD	95% CI	ρ value
50 : 50	3.5200	0. 51293	2.2458 – 4.7942	0.000
70 : 30	3.600	0.39950	2.6076 – 4.5924	
30 : 70	3.0300	0.33779	2.1909 – 3.8691	
Kontrol	10.5500	2.27291	4.9038 – 16.1962	

Table 4: One Way Anova Tensile Strength Test Results With Comparison Variations of 50:50, 70:30, and 30:70 in the Control

Concentration Variable	Mean	SD	95% CI	ρ value
50 : 50	2.2600	0.95389	- 0.1096 - 4,6296	0.004
70 : 30	2.5033	0.52348	1.2029 – 3.8037	
30 : 70	3.2133	0.21032	2.6909 – 3.7538	
Kontrol	0.7333	0.26690	0.0703 – 1.3963	

Based on the table above, the one way anova test ρ value of 0.004 <0.05 can be interpreted that statistically so it can be concluded that there is a difference in tensile strength of various concentration variations with a ratio of 50: 50, 70: 30, and 30: 70 to the control. Furthermore, to determine the difference in the average of various concentration variations and control, a Bonferroni test was carried out. The results of the Bonferroni Test can be seen in table 4.5.

Table 5: Bonferroni Test Results for Water Absorption with a ratio of 50%: 50%, 70%: 30% and 30%: 70% with Control

I (Treatment)	J (Treatment)	Mean Diference (I-J)	ρ value
Ratio 50 : 50	Ratio 70 : 30	-0.08000	1.000
	Ratio 30 : 70	0.49000	1.000
	Control	-7.03000	0.001
Ratio 70 : 30	Ratio 30 : 70	0.57000	1.000
	Control	-6.95000	0.001
Ratio 30 : 70	Control	-7.52000	0.000

It is known that the average difference in water absorption capacity between the control and treatment at a concentration ratio of 30:70 with the control ρ value of 0.000 < 0.005, so there is a significant difference with the mean difference.

Table 6: Bonferroni Tensile Strength Test Results With Comparisons of 50% : 50%, 70% : 30%, and 30% : 70% With Control

I (Treatment)	J (Treatment)	Mean Diference (I-J)	ρ value
Ratio 50 : 50	Ratio 70 : 30	- 0.24333	1.000
	Ratio 30 :70	- 0.95333	0.448
	Control	1.52667	0.067
Ratio 70 : 30	Ratio 30 : 70	- 0.71000	0.994
	Control	1.77000	0.031
Ratio 30 : 70	Control	2.48000	0.004

It is known that the average difference in tensile strength of biofoam with control and treatment at a concentration ratio of 30:70 with the control ρ value of 0.004 <0.005, so there is a significant difference with the mean difference.

Based on research conducted from May 11, 2024, to May 28, 2024, the univariate results in Table 4.1 show that the water absorption capacity of biofoam made from rice straw and coffee husks significantly decreased compared to the control. The control had a total water absorption of 31.65 with an average of 10.55. In the variation with a 50% rice straw and 50% coffee husk ratio, water absorption decreased to a total of 10.80 with an average of 3.60. The 70% rice straw and 30% coffee husk variation had a total water absorption of 10.56 with an average of 3.52. The lowest water absorption was observed in the 30% rice straw and 70% coffee husk composition, with a total absorption of 9.10 and an average of 3.03. This indicates that increasing the proportion of coffee husks in the mixture reduces the water absorption capacity of the biofoam.

The results suggest that rice straw and coffee husks are suitable materials for biofoam production due to their low water absorption rates, which meet the Indonesian National Standard (SNI) for biofoam, set at 26.12%. Previous research by Agus et al. (2023) indicated that lower water absorption percentages can slow the degradation of biodegradable plastics by water, allowing them to last longer. The water absorption percentages in this study performed better than previous research, with the best result being the 3.03% absorption rate in the 30% rice straw and 70% coffee husk composition.

Table 2 shows that the tensile strength of biofoam made from rice straw and coffee husks significantly increased compared to the control, which had a total tensile strength of 2.20 with an average of 0.73. In the 50% rice straw and 50% coffee husk variation, tensile strength increased to a total of 6.78 with an average of 2.26. The 70% rice straw and 30% coffee husk variation resulted in a total tensile strength of 7.52 with an average of 2.51. The highest tensile strength was achieved with the 30% rice straw and 70% coffee husk composition, with a total of 9.64 and an average of 3.21. Therefore, the 30% rice straw and 70% coffee husk composition proved to be the most effective.

Currently, there is no Indonesian National Standard (SNI) related to reference values for biofoam products. However, compared to other food packaging products like bioplastics, the SNI 7188,7:2016 standard specifies a tensile strength requirement of 29.16 MPa, which is significantly higher than the tensile strength achieved by the biofoam samples in this study (Daulay, Lubis, H.L, 2023). The best result from this study was a tensile strength of 3.21 MPa in the 30% rice straw and 70% coffee husk composition.

The One Way ANOVA test results in Tables 3 and 4 indicate significant differences in water absorption and tensile strength. Therefore, changes in the ratio of rice straw to coffee husks affect the water absorption and tensile strength of the resulting material. The Bonferroni test results show a trend of increasing water absorption and tensile strength with varying concentrations, with the 30:70 rice straw and coffee husk combination proving as effective as the control. In water absorption testing, the 30:70 combination demonstrated significant efficiency in absorbing water, while in tensile strength testing, this combination showed strong resistance to pulling forces. It can be concluded that using this combination of rice straw and coffee husks is an effective, efficient, and environmentally friendly alternative.

This research used four concentration variations, which were compared in each treatment and control (+) to assess the effectiveness of water absorption and tensile strength. The study aligns with research conducted by Lucky (2023) titled "Formulation and Fabrication of Biofoam from Rice Straw Waste as a Replacement for Styrofoam Food Packaging Using Thermopress Techniques," which found that biofoam with a 40 mesh size had low water absorption resistance with a weight increase of 36%. Heat resistance testing showed a weight increase of 1.681%. Biofoam with a 60 mesh size showed a 23% weight increase after water absorption testing and a 1% weight increase in heat resistance testing. The biofoam with an 80 mesh size showed a 15% weight increase after water absorption testing and a 1% weight increase in heat resistance testing. The best results for mesh 40, 60, and 80 were found in the 80 mesh, due to its smoother surface characteristics, lower water absorption, and lower weight gain due to heat, although it was more challenging to mold compared to the 40 mesh biofoam. The biofoam produced from rice straw waste with natural adhesives was biodegradable at all particle sizes (mesh 40, 60, and 80), with the final conclusion that rice straw waste can be utilized to create value-added products, such as biofoam, as an alternative material for food packaging to replace Styrofoam.

Research conducted by Akmala & Supriyo (2020) titled "Optimization of Cellulose Concentration in the Production of Biodegradable Foam from Cellulose and Cassava Flour" found that varying the operational conditions in the production process of biofoam with alpha cellulose filler did not significantly affect water absorption or biodegradability but did impact the visual appearance of the biofoam. The optimum conditions for the biofoam produced were an operating temperature of 70°C and an operating time of 90 minutes. Morphological analysis using the SEM EDX method showed the surface of the samples consisted of interconnected spheres with some cavities. This indicates that the tapioca starch and alpha cellulose were well-distributed, but uneven baking resulted in incomplete gelatinization, causing the starch not to form a good paste and weak interphase bonds between the alpha cellulose filler and the matrix of tapioca starch and PVAc.

CONCLUSION

Based on the research objectives, the following conclusions can be drawn:

1. The average water absorption capacity of biofoam made from rice straw and coffee husks with a 30%:70% ratio resulted in 3.03%.
2. The average tensile strength of biofoam made from rice straw and coffee husks with a 30%:70% ratio resulted in 3.21 MPa.
3. There is a difference in water absorption capacity and tensile strength with the 30%:70% ratio.

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