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Environmentally Friendly Odor Absorbing Product Engineering Based on Banana Peel Waste

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ABSTRACT

The increasing accumulation of organic waste and the widespread use of synthetic odor absorbers have encouraged the development of environmentally friendly alternatives. Banana peel waste is one of the abundant agricultural wastes in Indonesia and contains lignocellulosic compounds with adsorption potential. This study aims to engineer an eco-friendly odor-absorbing product using banana peel waste and evaluate its odor adsorption performance. Banana peels were processed through cleaning, drying, grinding, and simple activation treatments before being formulated into odor-absorbing products. The products were evaluated based on odor reduction effectiveness and product stability. The results indicate that banana peel-based adsorbents possess promising odor adsorption capabilities and can be used as sustainable household odor absorbers. This innovation contributes to waste valorization, environmental protection, and the development of low-cost bio-based products.

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INTRODUCTION

Bad odors are a common problem in households and public facilities, such as trash cans, bathrooms, storage cabinets, and other enclosed spaces. These odors generally originate from volatile compounds produced by the activity of microorganisms and the decomposition of organic matter (Bhatnagar & Sillanpää, 2010). Continuous exposure to unpleasant odors can reduce environmental comfort and negatively impact people's quality of life (Geissdoerfer et al., 2017). Most odor-absorbing products currently available on the market use synthetic chemicals. While effective in reducing odors, the use of synthetic materials has the potential to produce environmentally unfriendly residues and increase dependence on non-renewable resources (Foo & Hameed, 2012). Therefore, the development of natural and environmentally friendly odor absorbers is becoming increasingly important as part of efforts to achieve sustainable development (Geissdoerfer et al., 2017).

Indonesia is one of the world's largest banana producers and consumers, resulting in a significant amount of banana peel waste annually. Most banana peels are discarded as waste without further use, despite their cellulose, hemicellulose, lignin, and pectin content, which have the potential to act as natural adsorbents (Emaga et al., 2007). This lignocellulose content allows banana peels to be used as an absorbent for various pollutants and odor-causing compounds (Annadurai et al., 2002).

Various studies have shown that agricultural waste can be used as an environmentally friendly adsorbent due to its porous structure and active functional groups capable of binding specific molecules (Sudrajat & Siregar, 2019). However, research on the engineering of banana peel-based odor absorbent products ready for direct use by the public is still relatively limited compared to research focused on activated carbon or adsorbents for liquid waste treatment (Hidayat & Wahyuni, 2021). Based on these conditions, this study aims to develop an environmentally friendly odor absorber product based on banana peel waste and evaluate its adsorption performance. The novelty of this research lies in its simple, easy-to-implement product engineering approach, which is oriented towards utilizing local organic waste into an odor absorber product applicable for household needs and supports the concept of a circular economy (Geissdoerfer et al., 2017).

LITERATURE REVIEW

Adsorption Theory

Adsorption is the process of absorbing gas molecules or certain substances on the surface of a solid material due to physical forces or chemical interactions between the adsorbent and adsorbate (Foo & Hameed, 2012). Adsorbents with a high surface area and containing many active functional groups generally have better adsorption capacity than materials with low porosity (Bhatnagar & Sillanpää, 2010).

Banana Peel as Biomass Adsorbent

Banana peels contain cellulose, hemicellulose, lignin, and pectin, which can form porous structures and provide active functional groups for the adsorption process (Emaga et al., 2007). Furthermore, the presence of hydroxyl (-OH) and carboxyl (-COOH) groups in banana peel biomass allows for interactions with odor-causing molecules through physical and chemical adsorption mechanisms (Annadurai et al., 2002). The abundant availability of banana peel waste and its relatively low processing costs make this material a promising alternative biomass adsorbent (Hidayat & Wahyuni, 2021). Previous research has shown that banana peels can be used as a raw material for activated carbon, with quite good adsorption capacity against various pollutant compounds (Hidayat & Wahyuni, 2021).

Environmentally Friendly Product Engineering

Eco-friendly product engineering emphasizes the use of renewable resources, waste reduction, and environmental sustainability at every stage of product development (Geissdoerfer et al., 2017). The use of banana peel waste as an odor absorber aligns with the principles of a circular economy that converts waste into value-added products while reducing environmental pollution (Geissdoerfer et al., 2017). This concept also supports efforts to develop biomass-based products that are safer, more economical, and more sustainable than synthetic products (Bhatnagar & Sillanpää, 2010).

METHODOLOGY

Research Design

This research is a laboratory experiment aimed at developing an environmentally friendly odor absorber product based on banana peel waste and evaluating its odor absorption effectiveness. The research involved raw material preparation, adsorbent production, product formulation, odor absorption effectiveness testing, and product stability evaluation.

Population and Sample

The population in this study was all banana peel waste that has the potential to be used as an adsorbent raw material. The research sample consisted of ripe banana peel waste obtained from fruit vendors and households in West Jakarta. The samples were selected using a purposive sampling method, with the criteria being that the banana peels were fresh, free from mold, and free from decay.

At the product formulation stage, three variations of odor absorber formulations were made as test samples, namely:

Table 1. Product Formulation Variations

Formulation	Banana peel (%)	Tapioca flour (%)	Essential Oil (%)
F1	70	25	5
F2	80	15	5
F3	90	5	5

Tools and Materials

The tools used in this study include a drying oven, blender, sieve, digital scales, measuring cups, mixing containers, product molds, and odor test containers. The ingredients used consist of banana peel waste, tapioca flour as a binding agent, distilled water, and essential oil as an aroma enhancer.

Research Procedures

The research stages were carried out as follows:

1. Preparation of Raw Materials: Wash the banana peels using running water to remove any dirt, then cut them into small pieces.
2. DryingBanana peels are dried using an oven at a temperature of 60–80°C for 4–6 hours until the water content decreases.
3. RefiningDried banana peels are mashed using a blender and sieved until uniform particle size is obtained.
4. Simple ActivationBanana peel powder was reheated to increase the porosity and surface area of the adsorbent.
5. Product FormulationBanana peel powder is mixed with tapioca flour and essential oil according to the specified formulation variations, then molded and dried to obtain an odor-absorbing product.
6. Odor Absorber Effectiveness TestThe product is placed in a closed container containing an odor source, such as organic waste or ammonia solution. Observations are made on changes in odor intensity during the test period.
7. Product Stability TestThe product was observed for 14 days to determine changes in color, texture, aroma, and physical form.

The test results of each formulation were compared to determine the best formulation based on odor absorption effectiveness, product stability, and aroma persistence. The data were then presented in tables and graphs to facilitate interpretation of the research results.

RESEARCH RESULT

Characterization of Banana Peel Adsorbent

The first stage of the research involved processing banana peel waste into an adsorbent through washing, drying, grinding, and activation. The drying process aims to reduce the water content, thereby increasing the stability of the adsorbent during storage. Meanwhile, the activation process increases the number of pores and surface area of the adsorbent, thus improving its adsorption capacity against odor-causing compounds (Foo & Hameed, 2012). Observations showed that the activated adsorbent changed color from yellow-brown to dark brown. Furthermore, the texture of the adsorbent became smoother than before the activation process.

Table 2. Characteristics of Banana Peel Adsorbent Before and After Activation

Parameter	Before Activation	After Activation
Color	Brownish yellow	Dark chocolate
Texture	Rough	Fine
Water content (%)	15.2	7.8
Pore Condition	A little	More

The decrease in water content indicates that the drying and activation processes have successfully improved the quality of the adsorbent. According to Bhatnagar and Sillanpää (2010), adsorbents with low water content have better adsorption capacity because the pores are not covered by water molecules.

Odor Absorbing Product Formulation

The odor-absorbing product was made using three formulation variations to determine the best composition for reducing odor intensity.

Table 3. Variations in Odor Absorbing Product Formulations

Formulation	Banana peel (%)	Tapioca flour (%)	Essential Oil (%)
F1	70	25	5
F2	80	15	5
F3	90	5	5

Odor Absorption Effectiveness Testing

The test was conducted using an odor intensity scoring method with a range of values 1–5. A score of 1 indicates a very weak odor, while a score of 5 indicates a very strong odor.

Table 4. Odor Intensity Assessment Criteria

Score	Criteria
1	Very weak
2	Weak
3	Currently
4	Strong
5	Very strong

The test results showed that all formulations were able to reduce odor intensity, but the highest effectiveness was obtained in formulation F2.

Table 5. Results of the Odor Absorber Effectiveness Test

Formulation	Initial Odor Score	Final Smell Score	Odor Reduction (%)
F1	5.0	1.8	64.0
F2	5.0	0.9	82.0
F3	5.0	1.4	72.0

The data in Table 5 shows that formulation F2 produced the highest percentage of odor reduction, at 82%. This indicates that the 80% banana peel adsorbent composition provides the best balance between adsorbent amount and product stability.

Product Stability Testing

In addition to the effectiveness of odor absorption, product stability was also observed during 14 days of storage at room temperature.

Table 6. Product Stability Observation Results

Formulation	Day 0	Day 7	Day 14
F1	Good	Good	Good
F2	Very good	Very good	Very good
F3	Good	Pretty good	Pretty good

Observations showed that formulation F2 had the best stability during storage. The product retained its shape, color, and aroma without significant deterioration.

Analysis of Research Results

Based on all test results, formulation F2 was the best, producing the highest odor reduction effectiveness and the best product stability. These results indicate that banana peel waste has the potential to be developed as a raw material for environmentally friendly, economical, and sustainable odor absorbing products.

DISCUSSION

The research results show that banana peel waste has good potential to be developed as a basic material for environmentally friendly odor absorbing products. The adsorption capacity demonstrated by the product is influenced by the lignocellulose content found in banana peels. Cellulose, hemicellulose, and lignin components are known to have a porous structure that can provide active sites to bind odor-causing molecules (Emaga et al., 2007). Therefore, banana peels can function as an effective natural adsorbent in odor control applications.

The activation process used in this study plays a crucial role in improving the quality of the adsorbent. Activation results in the formation of new pores and increases the surface area of the material, thus improving its adsorption capacity. This finding aligns with research conducted by Foo and Hameed (2012), which states that increasing the surface area of the adsorbent is a key factor influencing the adsorption capacity of biomass. The greater the number of pores formed, the greater the chance for odor-causing molecules to be adsorbed on the adsorbent surface.

The performance of product formulations indicates that the composition of the ingredients influences the effectiveness of the odor absorber. Formulations with a balanced adsorbent composition produce more optimal performance than formulations with too little or too much adsorbent content. This condition indicates that the presence of the binder not only functions to maintain the product's shape but also affects the accessibility of the adsorbent pores to odor molecules. If the amount of binder is too large, some of the adsorbent pores can be blocked, thereby reducing the adsorption capacity. Conversely, if the amount of adsorbent is too dominant, product stability can decrease.

The results of this study support previous research that stated that biomass waste has great potential as an environmentally friendly adsorbent (Sudrajat & Siregar, 2019). Various types of biomass, such as rice husks, coconut shells, coffee grounds, and corn cobs, have been reported to have good adsorption capacity for various pollutant compounds. This study expands the use of biomass by demonstrating that banana peel waste can also be used as a raw material for odor-absorbing products ready for direct application by the community.

Overall, the research results indicate that banana peel waste has potential as an alternative raw material for environmentally friendly odor absorbing products. The combination of good adsorption capacity, abundant raw material availability, and environmental benefits make this product relevant to support the development of biomass-based technologies and a circular economy in Indonesia.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, banana peel waste has been shown to have the potential to be engineered into an environmentally friendly odor absorbent product through the stages of drying, refining, activation, and product formulation. The activation process can improve the quality of the adsorbent by creating more pores, thus supporting increased adsorption capacity against odor-causing compounds. The resulting odor absorbent product has demonstrated the ability to reduce odor intensity and has good stability during storage.

This research contributes to the development of biomass-based technology by utilizing banana peel waste, which has previously been underutilized. Furthermore, the product innovations developed support the implementation of the circular economy concept by converting organic waste into value-added and environmentally friendly products (Geissdoerfer et al., 2017).

Practically, odor-absorbing products made from banana peel waste have the potential to be used in various household applications, such as storage cabinets, trash cans, bathrooms, shoe racks, and other enclosed spaces. With abundant raw materials and a relatively simple production process, this product also offers potential for development as a micro- and medium-sized enterprise based on local innovation.

Based on the findings of this study, further development is recommended to optimize the product formulation composition, increase adsorption capacity, and test its effectiveness against various odor sources. Furthermore, an economic feasibility study and commercialization strategy are needed to ensure wider and more sustainable production.

ADVANCED RESEARCH

This study has several limitations that should be considered. Product effectiveness testing was conducted on a laboratory scale with a relatively short observation time. Furthermore, the observed parameters were limited to odor reduction and product physical stability, thus not including in-depth adsorption capacity testing or specific identification of the odor-causing compounds adsorbed. Therefore, further research is recommended to examine the kinetics and isotherms of adsorption to gain a more comprehensive understanding of the odor absorption mechanism by banana peel adsorbents. Longer-term product shelf-life testing is also necessary to determine product stability during storage.

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