World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Utilization of bamboo waste, ginger rhizome and sansiviera as air purifier anti-virus food storage room

Siswi Astuti [1, *], Eko Yohanes Setyawan [2], Semuel Poumer Paepenan [2] and Djoko Hari Praswanto [2]

[1] *Chemical Engineering, Faculty of Industrial Technology, National Institute of Technology Malang.*
[2] *Mechanical Engineering, Faculty of Industrial Technology, National Institute of Technology Malang.*

World Journal of Advanced Research and Reviews, 2025, 25(02), 474-485

Publication history: Received on 20 December 2024; revised on 01 February 2025; accepted on 04 February 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.2.0301

Abstract

The safety and quality of stored food are important aspects in the food industry. This study developed a natural material-based air filter from bamboo waste, red ginger rhizome, and Sansevieria to improve air quality and reduce microbial growth in food storage rooms. Bamboo-activated charcoal with 100% maturity was used due to its high absorbency, while red ginger extract was added for its antimicrobial properties derived from gingerol and shogaol compounds. The filter was tested in a semi-wet food storage cabinet, resulting in the slowdown of microbial growth such as Bacillus subtilis. The optimal combination of activated charcoal and red ginger extract was able to reduce the number of microbial colonies by 80% compared to unfiltered storage. In addition, the filter effectively absorbs pollutants, reduces moisture, and eliminates unpleasant odors, making it an eco-friendly and cost-effective solution. However, moisture accumulated on the filter after a few days of use is a challenge that requires further development to improve stability and durability. The results of this study indicate that this natural material-based air purification system has great potential for widespread application in the food storage industry.

Keywords: Air purifier; Bamboo activated charcoal; Red ginger; Food preservation

1. Introduction

The safety and quality of stored food products are fundamental elements in maintaining sustainability and trust in the food industry. This challenge is becoming more complex as the need for large-scale food storage increases and the risk of contamination can cause economic and public health losses. One innovative approach that has the potential to provide a solution to this problem is the development of a natural material-based air purification system that can improve air quality in food storage spaces. These systems are designed to effectively remove harmful microorganisms while having a positive impact on overall environmental quality [1].

The utilization of natural materials such as bamboo waste, ginger rhizome, and Sansevieria is the main foundation in the development of this system. These materials are not only abundantly available in nature but also have unique properties that are relevant in the air purification process. This makes the system a cost-effective and environmentally friendly solution. Bamboo is one of the fastest-growing and sustainably renewable natural resources. Its versatile nature has made it an important material in various industries, including construction, crafts, and renewable energy. According to Sethunga et al. (2024), bamboo waste generated during the manufacturing process can be recycled into materials with a porous structure capable of absorbing small particles and pollutant substances in the air. In the context of air purification, these bamboo pores act like natural filters that can trap dust particles, allergens, and even bacteria and viruses. Additionally, bamboo has natural antimicrobial properties, further strengthening its potential as a key component in these systems.

* Corresponding author: Siswi Astuti

The use of bamboo waste in this system also contributes to the reduction of industrial waste, thus providing additional benefits in addressing environmental concerns. By optimally utilizing bamboo waste, the system not only improves air quality in food storage spaces, but also supports sustainability principles.

Ginger rhizome, widely recognized in the culinary world and traditional medicine, has a number of benefits relevant for air purification. Active components in ginger, such as gingerol and shogaol, have been shown to have strong antimicrobial and antioxidant properties. [1] These properties allow ginger rhizomes to be used as an additional element capable of inhibiting the growth of airborne bacteria and viruses. Previous research has shown that essential oils extracted from ginger can be used to reduce microorganism contamination levels in enclosed spaces. This makes ginger a potential natural ingredient to be integrated in air purification systems, especially in applications that require a sterile environment, such as food storage rooms. In addition, ginger's aromatic properties can also provide the added benefit of reducing unpleasant odors in storage spaces.

Sansevieria, better known as tongue-in-law, has long been recognized as an ornamental plant that is not only aesthetically pleasing but also beneficial for improving indoor air quality. It is capable of absorbing various air pollutants, including volatile organic compounds (VOCs), carbon dioxide, and even small harmful particles [2]. Its resistance to various environmental conditions makes Sansivieria an ideal component for natural material-based air purification systems. In addition to its ability to absorb pollutants, Sansevieria can also increase indoor oxygen levels through photosynthesis, even at night. This is very important in maintaining a healthy and stable air environment in food storage rooms. The integration of Sansevieria in this system not only helps to reduce pollutant concentrations but also contributes to the sustainability of the ecosystem by utilizing plants that are easy to grow and do not require special care.

Previous studies have shown that modern technology-based air purification systems, such as the use of UV light and photocatalytic oxidation, are able to significantly reduce the level of bacterial and viral contamination in indoor environments [2]. However, these technologies often require high costs and large energy consumption, making them less suitable for applications that require cost-effective and sustainable solutions. It is in this context that natural materials such as bamboo, ginger, and Sansevieria provide a promising alternative. In addition, recent studies have also shown the potential of clean air technologies in reducing airborne disease transmission, including SARS-CoV-2, the virus that caused the COVID-19 pandemic [3]. With the increasing awareness of the importance of maintaining air quality, especially in high-risk spaces such as food storage, the development of these natural material-based systems is becoming increasingly relevant.

The integration of bamboo waste, ginger rhizomes, and Sansevieria in an air purification system provides a multifunctional solution to food safety and air quality challenges. The system can not only improve the quality and safety of stored food products, but also support a more sustainable and environmentally friendly approach to air purification. By utilizing abundant natural ingredients and their unique properties, the system is able to make a significant positive impact in the context of the food industry and the environment as a whole.

2. Material and methods

2.1. Filter manufacturing process

This research uses Ori bamboo as one of the components of the filter. Ori bamboo was chosen because it has the advantage of being easy to obtain, easy to cultivate, fast growth rate, high durability, low price, sturdy, easy to process, dense, and high calorific value so it is very good as an activated charcoal material [4]. The second component is red ginger, which is made into extract and fiber powder. Red ginger has anti-fungal and antiviral potential because it contains gingerol, shogaol, zingerone which gives anti-oxidant, anti-carcinogenic, nonmutagenic effects [5][6][7]. In making this air filter consists of 3 stages, namely:

2.2. Preparation of activated charcoal from ori bamboo

In the manufacture of activated charcoal, ori bamboo as charcoal-making material is cut into pieces with a length of 20 cm, then dried using sunlight for 10 days. Bamboo that has been dried, put into a furnace equipped with thermocontrol and blower. This bamboo charring with a maturity level of 100% uses a temperature of 442 ºC for 2 hours [5]. after reaching 2 hours the charcoal is cooled in the furnace for 24 hours. cooling in the furnace is done so that the charcoal which is still in high temperature conditions is not contaminated with air which causes the charcoal to become ash. The cooled ori bamboo charcoal is then pulverized using a flouring machine with a size of 100 mesh. After that, the charcoal activation process is carried out using chemical methods. In the chemical charcoal activation process, charcoal weighing

1 kg was soaked using 1800 ml CaCl2 solution for 24 hours at room temperature. Then this charcoal bath is drained and then put into the furnace. The charcoal soak that was put into the furnace was reheated at 500 ºC for 2 hours and holding 30 minutes. After reaching the temperature, the furnace was turned off and the activated charcoal was cooled in the furnace for 24 hours. Furthermore, the activated charcoal that has been cooled is grinder until it becomes powder with a size of 100 mesh. Then the activated charcoal powder is put into an airtight container.

2.3. Preparation of ginger powder

Before making ginger powder, ginger as raw material is cleaned from soil. After that, ginger is peeled and cleaned again. The ginger is then thinly sliced and put into a grinder. Ginger that has been grinders, squeezed and separated between liquid and ginger pulp. After that, the separated pulp is put into a dehydrator at 70 ºC for 5 hours. The dried and cooled ginger pulp was ground into ginger powder. Then, the ginger powder is stored in a sterilized place.

2.4. Filter manufacturing

Making air filters from activated bamboo ori charcoal with powder using a formula of 100 grams of activated bamboo ori charcoal, 100 grams of ginger powder, 100 grams of distilled water and 40 grams of calcium food grade adhesive and printed using a hydraulic pressing machine. the process of making filters, namely, the first step of each material is weighed first. Then 100 grams of ori bamboo activated charcoal, 100 grams of ginger powder and 40 grams of calcium food grade adhesive are mixed until evenly distributed. After that, enter 100 grams of distilled water, then stirred until evenly distributed. In the second step, the hydraulic press equipped with a heater is turned on. Set the heating temperature of the hydraulic press at 50 ºC. put the mixture of activated charcoal bamboo ori with other materials into the mold, then pressed to a pressure of 100 bar for 10 minutes. After that, the filter is cooled using free air at room temperature for 30 minutes. The cooled filter was put into a dehydrator at 40 ºC for 5 hours. Then the filters were packaged using aluminum foil and sealed with vacuum plastic.

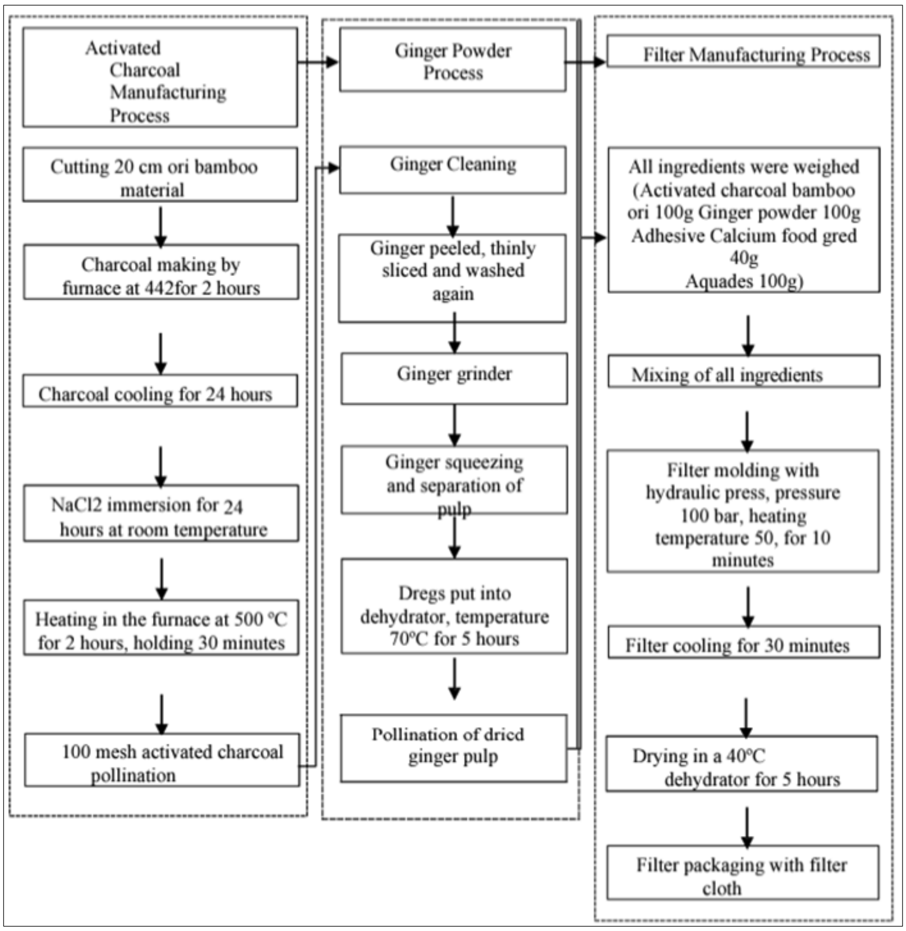


Figure 1 Flowchart of the air filter manufacturing process

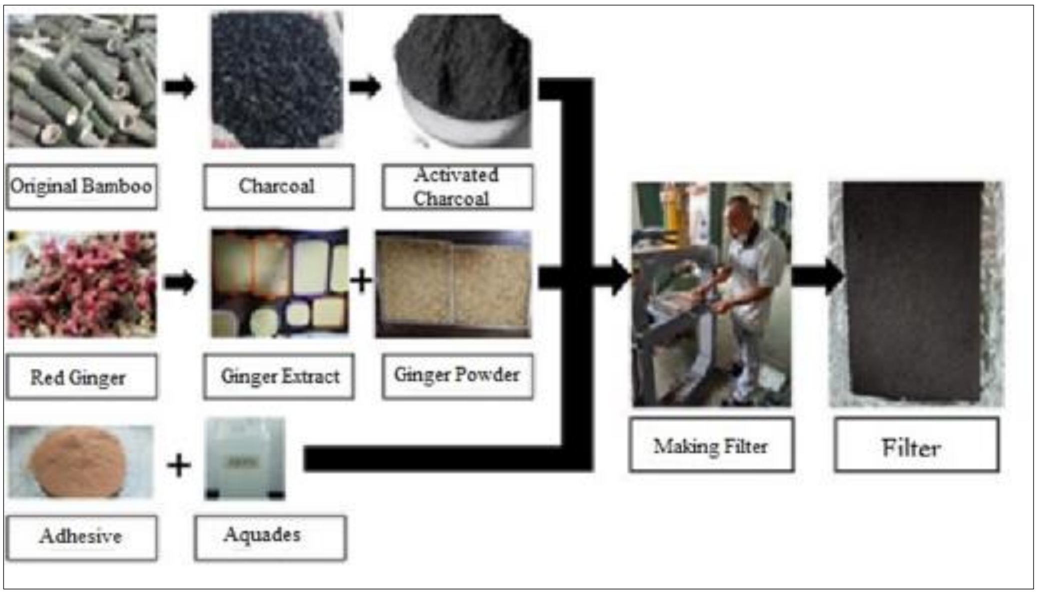


Figure 2 Filter manufacturing process and materials

The filter product is then tested by placing the filter in a test food cupboard equipped with an exhaust fan, a moisture detection device connected to a data logger to obtain data in real time as shown in Figure 3. The exhaust fan functions to direct the flow of dirty air towards the filter and in the cupboard is placed semi-finished food ingredients that have a high enough water content.

Figure 3 Food storage cabinet test equipment

3. Results and discussion

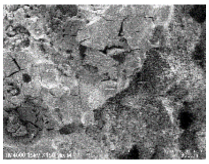
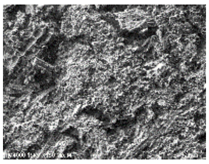
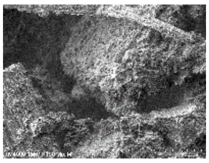
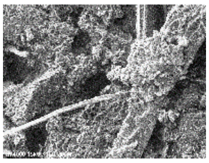
This research focuses on developing a natural air purifier using bamboo charcoal and ginger extract that aims to enhance food preservation by reducing microbial growth in the storage environment. The study was conducted over three years, with the first year concentrating on the formulation of the air purifier and its testing with food samples, specifically tofu.

Table 1 in this research report presents the characteristics of the activated charcoal and red ginger extract alloy filter before the trial. This table is important to understand how the composition and maturity of activated charcoal affect the physical and chemical properties of filters used in food storage. The analysis showed that filters with 100% maturity activated charcoal had more open pores than those with 50% and 75% maturity. These more open pores have the potential to increase the filter's absorbency of microbes and pollutants, which is essential for maintaining the freshness of foodstuffs.

In addition, the table also includes information on the different mineral content of each filter composition. This shows that variations in raw material composition can affect the effectiveness of the filter in absorbing contaminants. By using activated charcoal from ori bamboo and red ginger extract, this study aims to create a filter that is not only effective in absorbing microbes, but also environmentally friendly and affordable for the community. From the test results, it can be concluded that the filter with a combination of 100% maturity-activated charcoal and red ginger extract gave the best results in inhibiting microbial growth. Although some types of microbes such as Bacillus subtilis can still be detected, the number is much less compared to samples that do not use filters. This suggests that the use of these filters can slow down the rate of microbial growth, thus improving the safety and quality of food storage.

The materials and methods should be typed in Cambria with font size 10 and justify alignment. The author can select the Normal style setting from the Styles of this template. The simplest way is to replace (copy-paste) the content with your own material. The method and analysis which is performed in your research work should be written in this section. A simple strategy to follow is to use keywords from your title in the first few sentences.

Table 1 Characteristics of Filter Alloy Activated charcoal and red ginger extract before trial

No	Filter Composition	Compound Mass (%)										SEM-EDX Image
		C	O	Ca	Na	Cl	K	S	Al	F	Si	
1	50% 200 g Activated charcoal	32.66	59.67	5.67		19.59		0.54	16.72	0.57		
2	50% 150 g Activated charcoal	55.08	35.31	3.68	0.90	3.70	0.52	0.81				
3	50% 100 g Activated charcoal	48.74	29.35	3.64	1.52	3.21	1.03	1.58				
4	50% 50 g Activated charcoal	46.52	44.79	2.56	1.76	1.59	1.53	1.27				

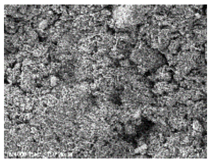
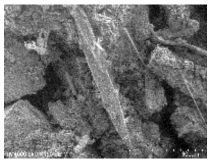
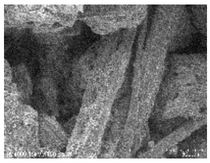
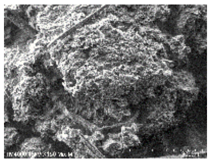
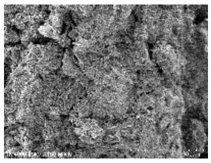
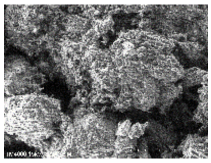
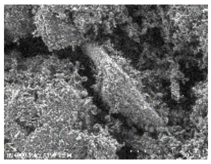
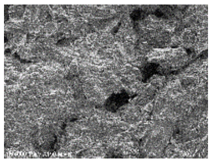
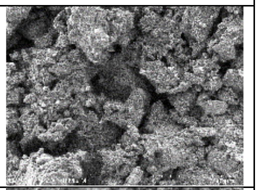
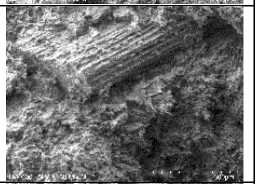
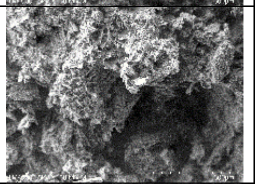
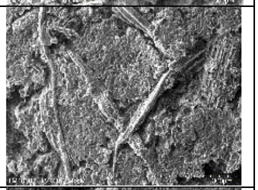
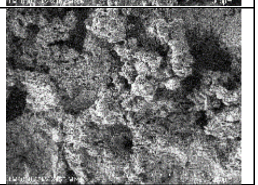
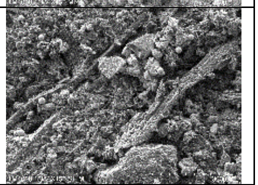
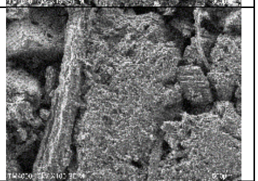
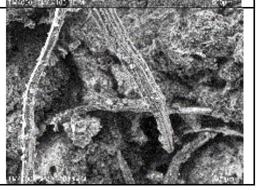
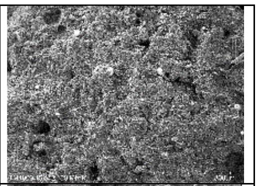
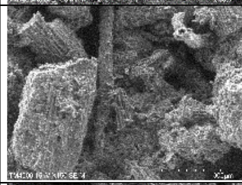
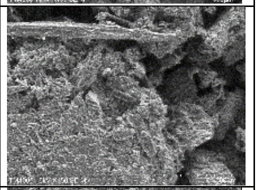
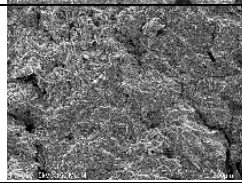
5	75% 200 g Activated charcoal	65.50	25.09	2.58	1.83	2.31	0.52	1.61			0.57	
6	75% 150 g Activated charcoal	41.41	21.54	13.82	1.53	8.85		2.32			2.56	
7	75% 100 g Activated charcoal	46.82	48.45	5.43	1.17	4.11	1.34	1.90		0.55		
8	75% 50 g Activated charcoal	47.42	42.70	2.65	1.35	2.45	1.61	1.14			068	
9	100% 150 g Activated charcoal	47.42	40.79	7.49	1.86	8.40	1.10	2.01		0.59		
10	100% 100 g Activated charcoal	56.04	33.99	3.48	1.22	3.16	0.94	1.16				
11	100% 50 g Activated charcoal	46.98	44.09	2.53	1.46	1.70	1.60	1.63				
12	200 g Ginger	42.81	51.15	0.46	1.74		2.34	1.49				

Table 2 provides an overview of the characteristics of filters made from activated charcoal and red ginger extract after a series of trials. The results of these trials are critical to understanding the effectiveness of the filters in maintaining food quality, especially in the context of microbial control and odor removal. One of the key findings of the trial was the increase in moisture in the filters. The filters used demonstrated the ability to absorb moisture from the air, which plays an important role in reducing microbial growth inside food storage cabinets. Despite this, microbiological analysis showed that some microbes could still be detected, with Bacillus subtilis being the most common. Although Bacillus subtilis can grow under certain conditions, this type of microbe is considered harmless to human health.

In addition, the filters also proved to be effective in eliminating foul odors that often appear inside storage cabinets. This shows that the filter not only functions as a moisture absorber, but also has deodorizing and anti-microbial properties. The presence of red ginger extract in the filter blend provided additional benefits, although the shogaol compound found in red ginger was not effective in killing Bacillus subtilis. However, the red ginger extract helped to improve the overall anti-microbial properties of the filter. Overall, the trial results show that the use of activated charcoal and red ginger extract alloy filters can slow down microbial growth and maintain food quality. Although there was bacterial growth, the detected types did not cause significant damage to the foodstuffs. Thus, this filter can be considered a safe and effective solution to maintain the freshness and quality of foodstuffs over a period of time.

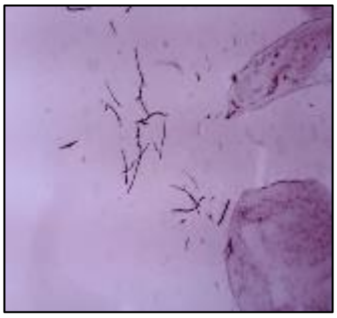
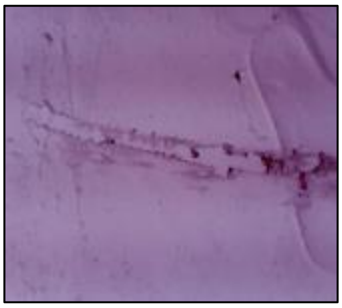
Table 2 Filter characteristics of activated charcoal and red ginger extract alloy after trial

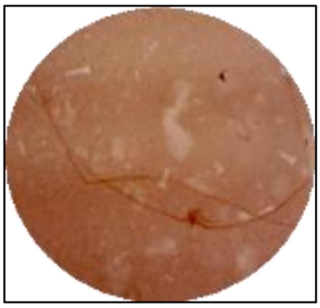
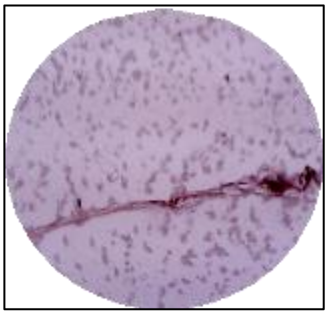
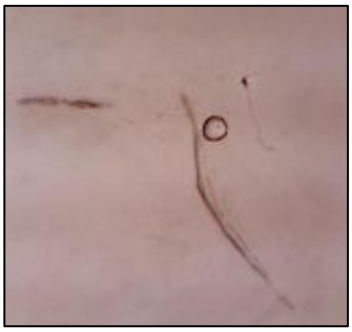
No	Filter Composition	Compound Mass (%)										SEM-EDX image
		C	O	Ca	Na	Cl	K	S	P	Si	Fe	
1	50% 200 g Activated charcoal	59.41	34.85	9.10	1.24	7.18		1.57		0.69	0.13	
2	50% 150 g Activated charcoal	42.41	21.65	3.67	0.47	3.50	0.50	0.70			0.13	
3	50% 100 g Activated charcoal	39.78	27.60	3.12	0.88	2.93	0.86	0.70				
4	50% 50 g Activated charcoal	48.74	42.81	2.03	2.10	1.70	1.34	1.28				
5	75% 200 g Activated charcoal	64.76	25.91	2.96	1.76	2.50	0.70	1.68			0.66	
6	75% 150 g Activated charcoal	41.44	31.12	5.37	0.93	4.77	0.69	1.15		1.63	2.74	
7	75% 100 g Activated charcoal	41.76	45.35	7.38	1.45	4.95	0.97	3.29		0.37		
8	75% 50 g Activated charcoal	24.73	21.72	2.15	0.54	2.33	1.53	0.87				

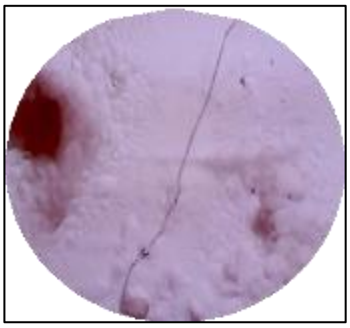
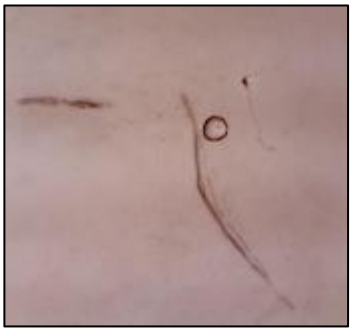
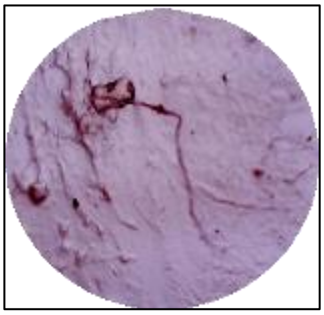
9	100% 150 g Activated charcoal	40.80	50.58	10.82	0.96	4.50	0.68	4.28		1.28	2.52	
10	100% 100 g Activated charcoal	28.25	21.82	3.75	0.45	2.39	0.73	0.88				
11	100% 50 g Activated charcoal	49.67	40.85	2.27	1.91	1.97	1.62	1.71				
12	200 g Ginger	30.94	35.63	0.43	1.95		2.46	1.57	0.58		0.42	

To see the results of the microbes that grew on the research material after day 5 can be seen in table 3.

Table 3 Results of Analysis of Microbes Growing on Test Material day 5

No.	Filter Composition	Types of Microbes	Day	Total Microbes	Image
1.	No filter	Bacillus Cereus	2	47	
2	50% 200 g Activated charcoal	Bacillus Subtillis	3	16	

3	50% 150 g Activated charcoal	Bacillus Subtillis	4	6	
4	50% 100 g Activated charcoal	Bacillus Subtillis	4	9	
5	50% 50 g Activated charcoal	Bacillus Subtillis	4	6	
6	75% 200 g Activated charcoal	Bacillus Subtillis	3	11	
7	75% 150 g Activated charcoal	Bacillus Subtillis	5	16	

8	75% 100 g Activated charcoal	Bacillus Subtillis	5	20	
9	75% 50 g Activated charcoal	Bacillus Subtillis	4	8	
10	100% 200 g Activated charcoal				
11	100% 150 g Activated charcoal	-	3	0	
12	100% 100 g Activated charcoal	Bacillus Subtillis	5	9	
13	100% 50 g Activated charcoal	Bacillus Subtillis	5	15	

14	200 g Ginger	Bacillus Subtillis	3	4	

Table 3 presents the results of microbial growth analysis on test materials (semi-wet food) stored in food cabinets with and without bamboo activated charcoal and red ginger extract-based filters. The data show clear differences in the time and number of microbial colonies growing based on the composition of the filters used. Without the use of filters, microbes began to grow on the second day, with the number of colonies reaching 47. The dominant microbe found was Bacillus cereus, a microorganism that can harm health and accelerate the process of food spoilage.

In cabinets using pure activated charcoal-based filters, microbial growth was slowed down. Microbes such as Bacillus subtilis began to appear on the third to fifth day, with a lower number of colonies than the unfiltered test material. This suggests that activated charcoal has the ability to absorb pollutants and reduce air humidity, creating a less favorable environment for microbial growth. However, the use of activated charcoal alone did not completely eliminate microbial growth, and the filters tended to become moist after being used for several days.

Filters combining bamboo activated charcoal with red ginger extract showed better results. The optimal combination with a 2:2 ratio of activated charcoal and ginger extract was able to delay microbial growth until the fifth day, with colony counts remaining low. The antimicrobial effects of gingerol and shogaol contained in ginger extract provided additional protection against microbial growth, while activated charcoal at 100% maturity provided high absorbency to absorb pollutants and excess moisture.

This study shows that the use of natural material-based air filters can significantly improve the hygiene of food storage rooms. Combining the adsorptive properties of bamboo activated charcoal with the antimicrobial effects of red ginger extract results in an effective, environmentally friendly and economical air filtration system. However, the moisture in the filter after a few days of use indicates the need for further development to improve the structural stability and durability of the filter for long-term use.

4. Conclusion

This study shows that utilizing bamboo waste, red ginger rhizome, and Sansivieria as the main ingredients for a natural material-based air purification system is an effective, economical, and environmentally friendly approach to improve air quality and slow microbial growth in food storage rooms.

Bamboo activated charcoal with 100% maturity showed high pollutant absorption, mainly due to its more open pores. The addition of red ginger extract provided the added benefit of antimicrobial properties derived from gingerol and shogaol compounds, which helped slow the growth of bacteria such as Bacillus subtilis. While these bacteria were still detected, the number of colonies found was much lower than in unfiltered storage rooms or with activated charcoal-based filters alone. The system was also effective in removing odors and maintaining the quality of foodstuffs, showing great potential for widespread application in the food storage industry. However, the moisture in the filters after a few days of use poses new challenges that need to be addressed through further development, such as improving the stability and durability of the filters.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Sethunga M, Gunathilake KDPP, Ranaweera KKDS, Munaweera I. Antimicrobial and antioxidative electrospun cellulose acetate-essential oils nanofibrous membranes for active food packaging to extend the shelf life of perishable fruits. In Innovative Food Science & Emerging Technologies. 2024; (97) : p. 103802). Elsevier BV. https://doi.org/10.1016/j.ifset.2024.103802

[2] Chan DWT, Law KC, Kwan CHS, Chiu WY. Application of an Air Purification System to Control Air-borne Bacterial Contamination in a University Clinic. In HKIE Transactions. 2005; (12) : Issue 1, p. 17). The Hong Kong Institution of Engineers. https://doi.org/10.1080/1023697x.2005.10667988

[3] Oscar TP. A multiple therapy hypothesis for treatment of COVID-19 patients. In Medical Hypotheses. 2020 (145) ; p. 110353. Elsevier BV. https://doi.org/10.1016/j.mehy.2020.110353

[4] Arsyad E, Hamdi S. Processing Technology and Utilization of Activated Carbon for Industry. Journal of Forest industry Research. 2010 Dec (2) ; 43-5

[5] Bernie M [Internet]. Hundreds of Children Affected by Air Pollution from Factory in Sukoharjo; © 2008 https://tirto.id-brn/ale

[6] Desrosier WN translated by Muljohardjo. Food Preservation Technology. Jakarta: UI Press; 2008.

[7] Ikewuchi CC, Ayalogu EO, Onyeike EN, Ikewuchi JD. Study on the alkanoid, Allicin, Glycocide and Saponin Composition of the Leaves of Sanseviera Liberica Gerome and Labroy by Gas Chromatography. The Pacific Journal of Science and Technology. 2011; (122) : 367-373

[8] Suwito W. Bacteria that often contaminate milk: Detection, Pathogenesis, Epidemiology, and Control. Journal of Agricultural Research and Development. 2010. Vol. 29(3): 96-100

[9] Untari T, Widyarini S, Wibowo MH. Aktivitas Antiviral Minyak Atsiri Jahe Merah terhadap Virus Flu Burung. Jurnal Veteriner. 2012 ; vol. 15(3): 309-312

[10] Ulfah NN, Mutakin M. Review: Antiviral Activity of Five Rhizome Plant Extracts Against H5N1 Influenza Virus Inhibition by Invitro Method. Journal of Pharmacology. 2017; Vol.15(3) : 153-161

[11] Medical Advisory Secretariat. Air Cleaning Technologies: an evidence-based analysis. Ontario Health Technology Assessment series 2005;5(17).

[12] David A, Christopherson, William C, Yao, Mingming. High–Efficiency Particulate Air Filters in the Era of Covid-19: Function and Efficacy. Otolaryngology – Head and Neck Surgery. 2020; Vol.163 (6) :1153-1155.

[13] Hendra D. Preparation of activated charcoal from Palm Kernel Shell and Mixed Sawdust. ejournal.forda-mof.org. 2006; Vol. 24 No.2: E-ISSD 2442-8957; PISSN 0216-4329.

[14] Horikawa DT, Kitakaze Y, Sekida T, Hayashi j, Katoh M. Characteristics and Humidity Control Capasity of Activated Carbon From Bamboo. Bioresource Technology 101. 2010; 3964-3969 Journal home page ; www.elsevier.com/locate/biortech

[15] Polii FF. Effect of Temperature and Duration of Activation on the Quality of Activated Charcoal from Coconut Wood. Journal of Plantation Industry. 2007 Dec; Vol.12 No.2: 21-28

[16] Rastini EK, Jimmy, Asmoro WP. Preparation of Activated Carbon Powder from Bamboo Waste as Metal Catalyst Buffer in Fischer-Tropsch Biofuel Synthesis. ICAJ Journal. 2018; Vol.2 No.1, ISSN: 2549-2314.

[17] Lee HS, Lim SS, Lim GJ, Lee JS, Kim EJ, Hong KJ. Antiviral Effect of Ingenol and Gingerol during HIV-1 Replication in MT 4 Human T Lymphocytes. Antiviral Res. 2008; (12) : 34-37.