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Making Charcoal from Nipah (*Nypa fruticans*) Frond Waste as an Adsorbent to Extend the Shelf Life of Fresh Bread

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ABSTRACT

Fresh bread has high potential for creating food waste that increases every year, because of its relatively short shelf life of 3-4 days after leaving the baking process. One way to extend the shelf life of bread is by using charcoal. Nipah fronds contain lignin elements that are good for charcoal. This study aims to determine the characteristics of charcoal from nipah fronds, the effectiveness of charcoal's ability to extend the shelf life of fresh bread, the effect of burning time, particle size and adsorbent mass on the storage time of fresh bread, the effect of the ratio of nipah frond adsorbent to commercial silica gel on the storage time compared to quality requirements of fresh bread of SNI 01-3840-1995 2013. Charcoal characterization includes quality tests based on SNI No. 06-3730-1995 on technical charcoal, namely water content and iodine absorption parameters and also Scanning Electron Microscopy (SEM) test. Based on the results of the study, charcoal from nipah frond waste has characteristics of water content that have met the quality standards of SNI 06-3730-1995 and in iodine absorbency only samples with pyrolysis time of 4 hours that have met the quality standards of SNI 06-3730-1995. Giving variations in charcoal burning time, mass and particle size of adsorbent powder affects the shelf life and quality requirements of fresh bread. Adsorbent packaging using teabags and silica gel paper can extend the shelf life of fresh bread up to 27 hours compared to those without adsorbent.

Keywords: charcoal, fresh bread, nipah fronds, shelf life.

1. INTRODUCTION

In Indonesia, food waste production is the highest in Southeast Asia. Citing data from the United Nations Environment Program (UNEP), Indonesia produces 20.93 million tons of food waste every year. Ministry of Environment and Forestry noted that food waste is the largest composition of waste in Indonesia, namely 28.3% in 2021 [1]. One of the processed food products that are widely consumed by the public is white bread, according to the Food Consumption Statistics Data, white bread consumption has increased from year to year. In 2014, the consumption of white bread was 3,244 packs and in 2018 it reached 19,085 packs [2]. Fresh bread has a relatively short shelf life of 3-4 days after coming out of baking. One way that can be done to extend the shelf life of bread is to use charcoal adsorbents because it can adsorb moisture which accelerates the growth of mold. Some research on the manufacture of preservatives to extend the shelf life of fresh bread has been done before, namely the extension of the shelf life of bread with the addition of ‘emprit’ ginger [3], the addition of mangrove leaf powder to the quality of the shelf life of fresh bread [4] and the characterization of the absorbent properties of dried nata de coco against sponge cake [5]. Research related to the manufacture of charcoal as an adsorbent to extend the shelf life of fresh bread has not been widely done.

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Charcoal is a porous solid containing 85-95% carbon, produced from carbon-containing materials by high temperature heating [6]. Charcoal can be used as fuel but also as an adsorbent. The absorbency of carbon is determined by the pore surface area, the wider the pore surface of charcoal has a higher absorbency that has an impact on the absorption of gas or liquid materials. Charcoal can be made from biomass materials. Biomass contains elements of cellulose, hemicellulose, lignin and carbon, so biomass can be processed into charcoal [6]. One of the plants that store carbon as carbon reserves in its biomass and has cellulose, hemicellulose and lignin content is nipah fronds. Nipah fronds have high fiber content (cellulose, hemicellulose, and lignin) and low crude protein content. Materials containing cellulose lignin elements are very good for active charcoal [7]. The chemical content of nipah fronds (% dry matter) is as follows: 41.21% cellulose, 12.73% hemicellulose, 18.93% lignin, and 4.83% crude protein. The amount of lignin content states that the more carbon content that can be formed from the material, while high cellulose content also produces combustion that tends to be constant and evenly distributed so as to produce charcoal with good quality [8]. Based on the above facts, this research will utilize nipah frond waste (*nypa fruticans*) as charcoal which will be used as an adsorbent that serves to extend the shelf life of fresh bread. The purpose of this study is to determine the method of making charcoal from nipah frond waste as an adsorbent and its characterization, the effectiveness of the ability of charcoal in extending the shelf life of fresh bread, the effect of charcoal burning time, particle size and mass on the shelf life of fresh bread and the effect of the ratio of adsorbents packed with tea bags and silica gel paper in extending the shelf life of fresh bread.

2. RESEARCH METHODS

This research was conducted in the Environmental Pollution Control Engineering Laboartorium of Cilacap State Polytechnic. In this research there are several stages that need to be done, namely as follows: preparation stage of nipah fronds, pyrolysis of nipah fronds, characterization of nipah frond charcoal to meet SNI 06-3730-1995 standards in the form of (determination of water content and iodine absorption analysis), morphological test of pore size and elemental content in nipah frond charcoal, and qualitative tests on fresh bread.

2.1. TOOL

Some of the tools used in supporting the manufacture of charcoal from nipah fronds as an adosrben to extend the shelf life of fresh bread in this study, as follows: standard glassware, grinder, sieve 60; 100; 200 mesh, analytical instrument, magnetic heated stirrer, pyrolyzer, oven, desiccator, press impluse sealer and instrumental tools i.e. centrifuges and Scanning Electron Microscope.

2.2. MATERIAL

The materials used in the study are as follows: nipah fronds, fresh bread, distilled water, 1% amylum solution, iodine solution, thiosulfate solution, teabag packaging and silica gel paper.

2.3. RESEARCH VARIABLE

- Fixed variable

Fixed variables are variables that are observed and measured to determine the effects of the independent variables. The fixed variable used is 1 piece of whole wheat bread

- Independent variable

Independent variables are variables that affect or cause the decrease or increase of the dependent variable. The independent variables used are as follows:

a.Pyrolysis time 3 hours and 4 hours

b.Particle size of nipah frond adsorbent powder of 60 mesh, 100 mesh and 200 mesh

c.Adsorbent period, as for the adsorbent period used, namely 2 grams and 4 grams

- Dependent variable

The dependent variable is the variable that is influenced or that becomes the result of the independent variable. The dependent variable used is the length of storage of white bread.

2.4. RESEARCH PROCEDURES

2.4.1. NIPAH FROND PREPARATION

Nipah fruit was collected from the coastal area of Cilacap Regency, Central Java. The nipah fronds were chopped using a chopper. After that, the chopped fronds were dried under direct sunlight for 7-14 days.

2.4.2. NIPAH FROND PYROLYSIS

The pyrolysis process is carried out by heating the nipah fronds that have been cut into small pieces using a pyrolysis device for 3 hours at 250°C and for 4 hours at 250°C.

2.4.3. SIEVING

Charcoal from pyrolysis is made into powder. The powder was sieved with 60 mesh, 100 mesh and 200 mesh sieves.

2.4.4. CHARCOAL CHARACTERIZATION

The charcoal that has been filtered is then analyzed quantitatively in the form of measuring water content and iodine absorption in accordance with predetermined standards, namely SNI 06-3730-1995.

2.4.5. MORPHOLOGICAL TEST OF PORE SIZE AND ELEMENT CONTENT IN NIPAH FROND CHARCOAL

Morphological tests and elemental content contained in nipah frond charcoal were carried out using a Scanning Electronic Microscope Energy Dispersive X-Ray (SEM-EDX) instrument is one type of electron microscope that is capable of producing high resolution of the surface image of a sample. Energy dispersive X-ray (EDX) is an analytical technique that uses the characteristics of X-ray radiation to analyze the chemical composition of a material.

2.4.6. QUALITATIVE TEST ON WHITE BREAD

Fresh bread has physical quality criteria, namely bread that is not hard and moldy, this is also explained in SNI 01-3840-1995 regarding the quality requirements of fresh bread which states the appearance of fresh bread based on odor, taste and color factors, identification of the appearance of sour aroma, and mold growth on white bread.

3. RESULTS AND DISCUSSION

3.1. CHARCOAL CHARACTERISTICS OF NIPAH FROND WASTE

One of the properties of activated carbon that affects the quality of charcoal is moisture content and iodine absorption. In this study, the characterization of nipah fronds observed includes moisture content and iodine absorption which is shown in Table 1 as follows.

Table 1. Characteristics of nipah frond charcoal.

Sample code	Moisture content (%)	Iodine Absorbency (mg/g)
C3_60	1.76%	571.05
C3_100	1.76%	736.02
C3_200	1.79%	723.33
C4_60	2.26%	799.47
C4_100	1.37%	812.16
C4_200	0.61%	875.61
SNI 06-3730-1995	Maks 15	Min 750

The water content in a charcoal will be able to dissolve the charcoal itself and increase the weight of the sample during the process, therefore the lower the water content the better [9] . Based on the data from the water content test results in Table 1, the water content of nipah frond charcoal can be analyzed. The following graph shows the results of the analysis of water content of nipah fronds in Figure 1.

The purpose of determining the water content of charcoal is to determine the hygroscopic nature of the charcoal. The water content in a charcoal will be able to dissolve the carbon itself and increase the weight of the sample during the process, therefore the lower the water content the better [9]. Figure 1 shows that the free water in the nipah frond charcoal is quite low, indicating that during the pyrolysis process the amount of water vapor that evaporates is realistically high considering that the nipah plant is a plant that grows in watery areas so that the water content in this plant is high.

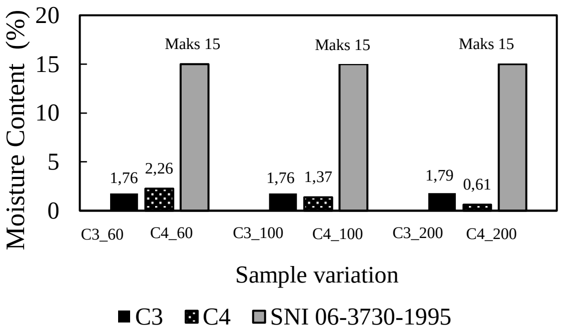

Figure 1. Variation of mesh size of nipah frond charcoal and the length of time for burning nipah fronds on the percentage of water content.

The best water content test results in this study are on charcoal measuring 200 mesh with a burning time of 4 hours, the test value of water content of 0.61%. The water content of charcoal from nipah fronds pyrolyzed for 4 hours has met the requirements of SNI 06-3730-1995 regarding the quality requirements of technical activated charcoal with the SNI standard value for maximum water content of 15%. Based on the results of the determination of water content, it shows that the smaller the powder size, the lower the water content contained in the charcoal. The low water content found in frond charcoal indicates that the free water content and bound water contained in nipah fronds have evaporated during the carbonization process [10].

The results of the charcoal characterization test from nipah fronds based on the iodine absorption test can be seen in Figure 2. Diagram of the percentage of iodine absorption of nipah frond charcoal.

The absorption capacity of iodine is determined with the aim of knowing the adsorption ability of the resulting adsorbent [11]. Based on the results of the iodine absorption test of charcoal from nipah fronds, the best in this study is on charcoal powder size of 200 mesh with a burning time of 4 hours amounting to 875.61 mg/g.

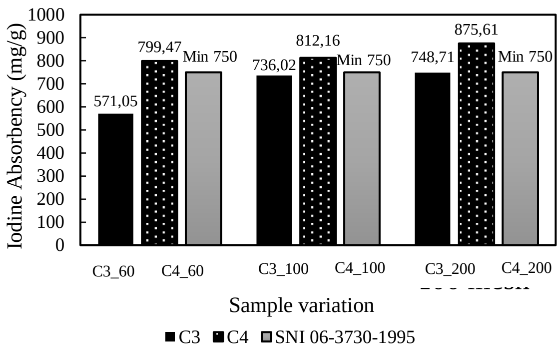

Figure 2. Variation of mesh size of nipah frond charcoal and burning time of nipah frond charcoal on the percentage of iodine absorption.

The iodine absorption of charcoal from nipah fronds with a burning time of 4 hours has met the quality requirements of technical activated charcoal, namely SNI 06-3730-1995 with a minimum value of iodine absorption of 750 mg/g. Long burning time for 4 hours with increasingly fine powder size has an effect to increase iodine absorption. Judging from the comparison of the length of burning time and the size of 200 mesh charcoal powder has higher test results compared to charcoal powder measuring 60 mesh and 100 mesh, this is because the pores and a wider surface area will affect the adsorption power of the charcoal itself. The greater the iodine number value, the greater the adsorption power of the adsorbent and the highest iodine absorption value indicates that many pore structures are formed [11].

3.2. MORPHOLOGICAL TEST RESULTS OF PORE SIZE AND ELEMENTAL CONTENT OF NIPAH FROND CHARCOAL

The results of the pore size morphology test show the visualization of the charcoal surface and particle size. In this test using 1,000x magnification. In the average test results, the morphology of charcoal particles shows an irregular and non-uniform shape, while the size of charcoal particles in the best results on average reaches a size on a scale of 1.80 μm in sample (e). The results of the pore size morphology test using SEM (Scanning Electron Microscopy) showed that nipah frond charcoal has a porous morphology. The following SEM analysis results are shown in Figure 3.

SEM can observe the structure and shape of a finer scale surface equipped with EDX (Energy Dispersive X-Ray) can detect the elements contained in the sample [12]. The following SEM-EDX analysis data is shown in the Table 2.

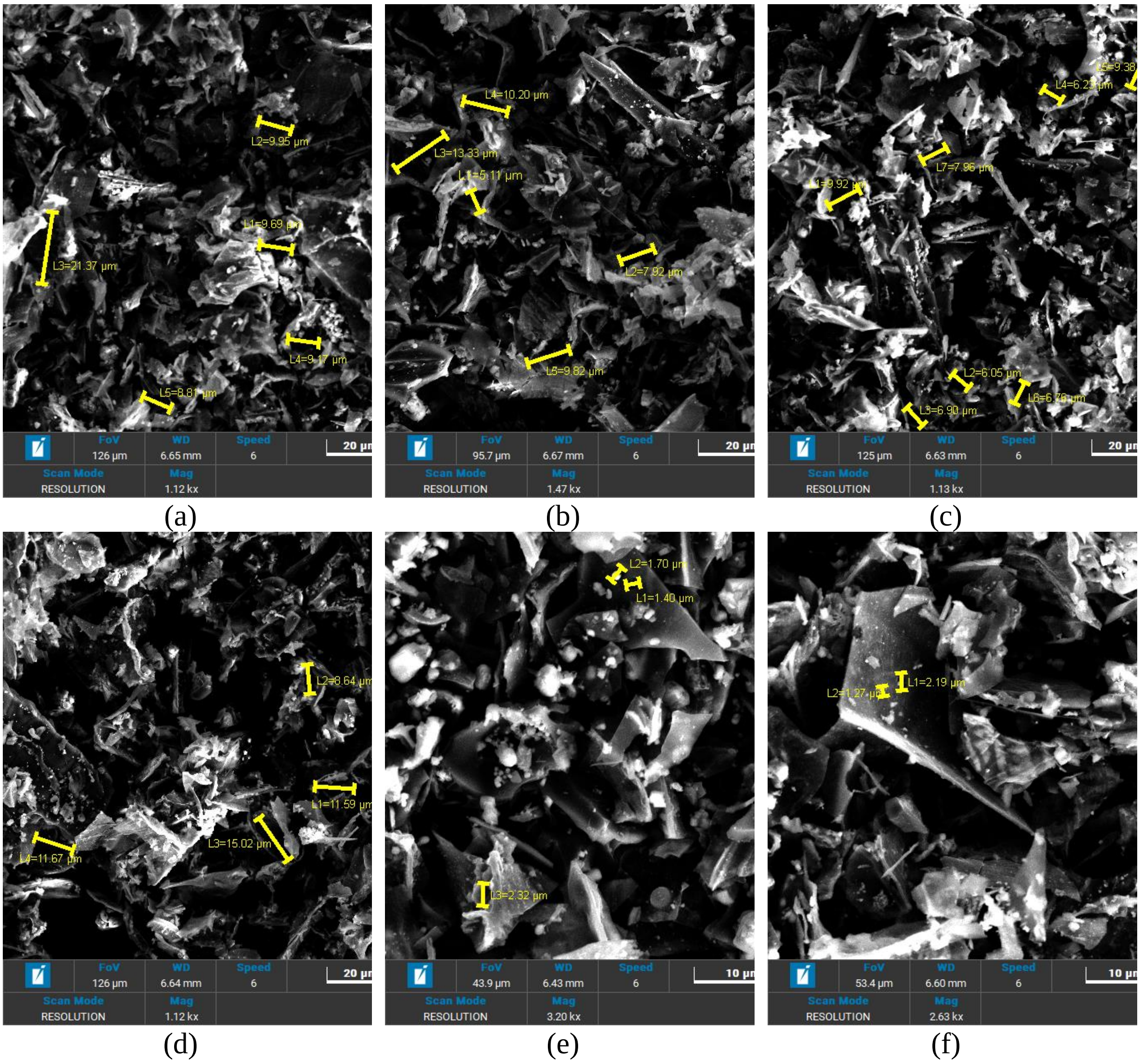

Figure 3. Morphological Test Results of Pore Size and Elemental Content of Nipah Frond Charcoal (a; C3_60), (b; C3_100), (c; C3_200), (d; C4_60), (e; C4_100), (f; C4_200).

The results of testing the identification of elements contained in charcoal contained in sample C4_100 long pyrolysis time of 4 hours with a particle size of 100 mesh. The elements contained include the main constituent element of charcoal material, namely carbon by 72.29% mass and minor elements consisting of sodium, Na by 5.28% mass, magnesium, Mg by 0.58% mass; aluminum, Al by 0.09% mass; chloride, Cl by 0.47% mass; and potassium, K by 1.055% mass.

Carbon materials with pyrolysis times of 3 hours and 4 hours at 250°C still show the content of other elements which are impurities found in nipah frond charcoal.

3.3. QUALITATIVE TEST ON FRESH BREAD

In this study, adsorbents applied to white bread were used to determine the ability to absorb oxygen in extending the shelf life of white bread. Changes that occur visually become a parameter to determine the length of storage of white bread. The application of adsorbent on white bread is shown in Figure 4. Adsorbent packaging uses teabag packaging and silica gel paper. Storage was carried out at room temperature (27±3°) for 3-4 days until the fresh bread was damaged. The application of adsorbent is shown in Figure 4 as follows.

Table 2. Elemental Content Results of Nipah Frond Charcoal

Sample	% C	% O	% Na	% Mg	% Si	% S	% Cl	% K
C3_60	66.58	9.99	5.93	0.74	1.27	2.14	9.68	3.67
C3_100	66.57	7.67	6.61	0.69	1.04	2.40	12.20	3.82
C3_200	71.22	9.26	4.47	0.49	1.02	1.68	8.50	3.37
C4_60	67.51	11.22	5.33	0.49	2.38	1.86	8.21	2.99
C4_100	72.29	8.71	5.28	0.58	1.00	1.57	7.67	2.91
C4_200	69.93	6.51	6.55	0.65	0.90	1.58	10.93	2.95

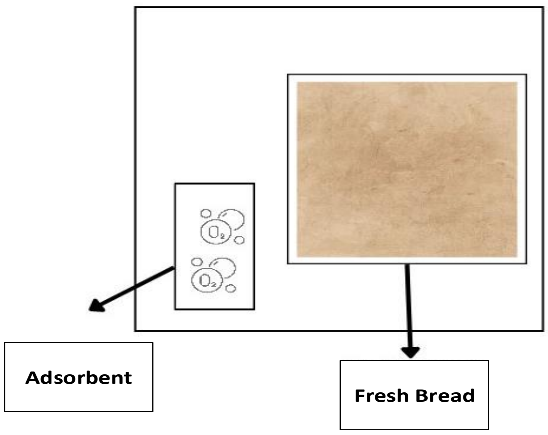

Figure 4. Application of adsorbent on fresh bread.

Figure 5. Visual appearance of control bread after storage.

In the storage of white bread with the addition of adsorbents as moisture absorbers (water vapor) is expected to extend the shelf life of white bread. The type of packaging used for the adsorbent also helps the adsorbent in the absorption of moisture (water vapor) to be more optimal. The type of packaging used for the adsorbent produces different results. Some parameters that can be observed during storage, namely the color produced from white bread, the aroma of bread that arises during the storage process, changes in the texture of white bread, and the presence or absence of mold that grows well on the surface of white bread.

Based on the data from the visual identification of the bread, it shows that the bread used as a control has started to grow black mold on the crumb (surface) on the 3rd day of storage followed by a sour aroma on the whole bread and a slightly hard texture on the crust (side) of the bread. Table 1 Visual identification results of bread with Teabag packaging adsorbents and 2 Visual identification results of bread with silica gel paper packaging adsorbents show the results of visual identification of mold and Figure 5 shows the visual appearance of control bread that has grown mold.

Based on the results of visual identification of the bread, it shows that the white bread used as a control has started to grow black mold on the crumb (surface) on the 3rd day of storage followed by a sour aroma on the whole bread and a slightly hard texture on the crust (side) of the white bread. The following Figure 5 shows the visual appearance of the control bread that has grown mold.

The results of visual identification of bread with teabag packaging adsorbent showed that the adsorbent sample with a burning time of 4 hours and a particle size of 60 mesh (C4_60) with an adsorbent mass of 2 grams had a slow quality change compared to other samples. Sample C4_60 with a mass of 2 grams of adsorbent experienced black mold growth on the surface of the bread on the 4th day precisely at 09.00 WIB, followed by a sour aroma on the surface of the bread and a slightly hardened texture of the bread, this indicates that the sample has the best moisture absorption ability. The following Figure 6 shows the results of the visual appearance of bread with C4_60 adsorbent mass of 2 grams after storage for 4 days as follows.

Then for the results of visual identification of bread with silica gel paper packaging adsorbents, it shows that adsorbent samples with a burning time of 4 hours and a particle size of 200 mesh (C4_200) adsorbent mass of 4 grams experience slow quality changes with other types of samples. Mold grew on sample C4_200 with a mass of 4 grams of adsorbent on the 4th day precisely at 12.00 WIB, the mold was black on the surface of the bread, followed by the sour aroma produced on the surface of the bread and the texture of the bread which slightly began to harden. This shows that in the variation of adsorbent packaging with silica gel paper, sample C4_100 adsorbent mass of 4 grams has the best absorption ability compared to other types of samples. The following Figure 7 shows the visual appearance of bread with a 4 gram mass C4_200 adsorbent sample after storage.

However, teabag packaging material that has large pores cannot hold adsorbents with fine particle sizes, causing leakage, indicating that adsorbents packaged with teabags are not hygienic. Compared to adsorbents packed with silica gel paper, it can also inhibit changes in the quality of fresh bread and there is no leakage in the packaging because the silica gel paper material does not have large pores like tea bags. Silica gel paper has a material that is easily passed by water vapor so that the ability of charcoal to absorb moisture (H_2O) is more optimal [13].

The nipah frond charcoal adsorbent type is able to extend the shelf life of bread longer than the commercial silica gel adsorbent type. Fresh bread stored with nipah frond charcoal adsorbent in sample C4_200 with a charcoal adsorbent mass of 4 grams was able to extend the shelf life of fresh bread longer, namely 4 days and 8 hours, compared to fresh bread stored without adsorbent for 3 days and 5 hours. Powder size and adsorbent mass also have an effect, the finer the powder size, the more surface area so that the greater the adsorption ability of charcoal [14] and the greater the mass of the adsorbent, the more moisture (H_2O) is absorbed [15].

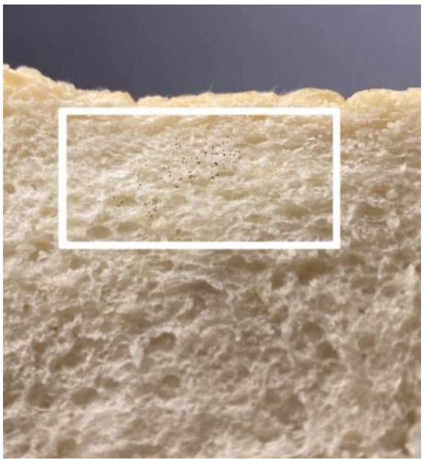

Figure 6. Visual appearance of C4_60 bread 2 grams adsorbent mass after storage.

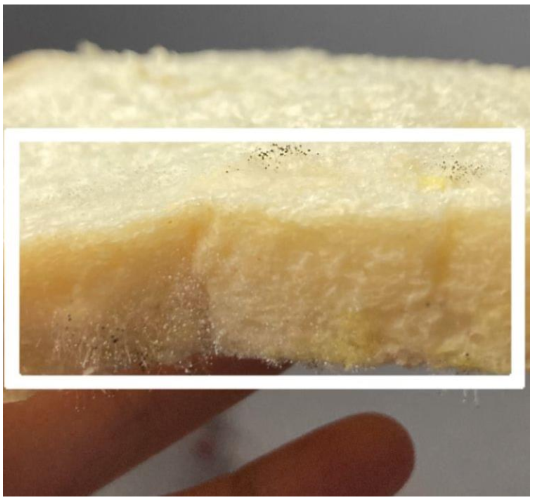

Figure 7. Visual appearance of bread C4_200 adsorbent mass 4 grams after storage.

4. CONCLUSION

Based on the test results, the best water content and iodine absorption in sample C4_200 of 0,61% and 875,61 mg/g have met the requirements of SNI 06-3730-1995 standards. Length of baking time, powder size variation, charcoal adsorbent mass and adsorbent packaging type affect the shelf life of fresh bread. The nipah frond charcoal adsorbent type was able to extend the shelf life of bread longer than the commercial silica gel adsorbent type. Fresh bread stored with nipah frond charcoal adsorbent in sample C4_200 with charcoal adsorbent mass of 4 grams was able to extend the shelf life of fresh bread longer for 4 days and 8 hours, compared to fresh bread stored without adsorbent for 3 days and 5 hours.

REFERENCES

[1] V. A. Dihni, Produksi Sampah Makanan Indonesia Tertinggi di Asia Tenggara, *Databoks*, 2022. https://databoks.katadata.co.id/datapublish/2022/06/27/produksi-sampah-makanan-indonesia-tertinggi-di-asia-tenggara (accessed Jan. 18, 2023).

[2] S. Sachriani, Y. Yulianti, Analisis Kualitas Sensori dan Kandungan Gizi Roti Tawar Tepung Oatmeal Sebagai Pengembangan Produk Pangan Fungsional, *Jurnal Sains Terapan*, vol. 7, no. 2, pp. 26–35, 2021.

[3] V. Puteri, L. Ramadhayanti, A. M. Miftah, N. Kurniaty, Perpanjangan Masa Simpan Roti dengan Penambahan Jahe Emprit (*Zingiber Officinale Var Amarum*), *Pros. Farm.*, vol. 5, no. 2, pp. 674–679, 2019.

[4] S. Sumartini, K. S. Harahap, N. Luthfiyana, Efektivitas Penambahan Serbuk Daun Mangrove (*Sonneratia caseolaris*) terhadap Kualitas dan Umur Simpan Roti Tawar, *J. Pengolah. Has. Perikan. Indones.*, vol. 25, no. 2, pp. 281–293, 2022.

[5] H. D. Rahmayanti, S. Ardiani, N. Akmalia, T. R. Kartika, M. Suryani, Karakterisasi Sifat Penyerapan Nata de Coco Kering Terpadatkan Terhadap Bolu, *J. Fis.*, vol. 12, no. 1, pp. 37–41, 2022.

[6] I. Apriyani, R. Farma, Pembuatan Elektroda Karbon Aktif Dari Tandan Kosong Buah Aren Dengan Variasi Suhu Karbonisasi, *Komun. Fis. Indones.*, vol. 18, no. 58–63, p. 58, 2021.

[7] S. Suryadi, H. Syafria, Pengaruh Level Inokulum Jamur Tiram Putih Terhadap Kandungan Fraksi Serat Pelepah Nipah, *J. Peternak. Indones.*, vol. 24, no. 3, pp. 298–303, 2022.

[8] A. W. Y. P. Parmita, A. D. Laksono, M. I. Zulkarnain, A. F. B. Hartanti, R. V. Mudhawammah, Karakteristik Buah Nipah Karbon Aktif dari Serabut Nipah Teraktivasi Potassium Hydroxide (KOH), *Specta J. Technol.*, vol. 4, no. 3, pp. 72–79, 2020.

[9] T. Evila, P. Sri, M. Nurhilal, R. Dwityaningsih, Analisis Proksimat dan Bilangan Yodium Sebagai Kajian Awal Aarang Tempurung Nipah Sebagai Bahan Intermediate Karbon Keras, *J. Teknol. Ramah Lingkung.*, vol. 6, no. 3, pp. 248–260, 2022.

[10] L. Legiso, H. Juniar, U. M. Sari, Perbandingan Efektivitas Karbon Aktif Sekam Padi dan Kulit Pisang Kepok sebagai Adsorben pada Pengolahan Air Sungai Enim, *Prosiding Seminar Nasional Sains dan Teknologi*, pp. 1–13, 2019.

[11] A. Rahman, R. Aziz, A. Indrawati, M. Usman, Pemanfaatan beberapa jenis arang aktif sebagai bahan absorben

logam berat cadmium (Cd) pada tanah sedimen drainase kota medan sebagai media tanam, *J. Agroteknologi dan Ilmu Pertan.*, vol. 5, no. 1, pp. 42–54, 2020.

[12] A. A. Yarangga, C. Danisworo, A. Harjanto, Studi Grafit Berdasarkan Analisis Petrografi dan Sem/Edx pada Daerah WindesiKabupaten Teluk Wondama, Provinsi Papua Barat, *Prosiding Seminar Nasional XII Rekayasa Teknologi Industri dan Informasi*, pp. 185–191, 2017.

[13] T. Kusumaningtiyas, Pemanfaatan Asam Askorbat sebagai Penyerap Oksigen (*Oxygen Absorber*) untuk Memperpanjang Umur Simpan Roti Tawar, Bachelor Thesis, Institut Pertanian Bogor, Indonesia, 2018.

[14] R. Idrus, B. P. Lapanporo, Y. S. Putra, Pengaruh Suhu Aktivasi Terhadap Kualitas Karbon Aktif Berbahan Dasar Tempurung Kelapa, *Prism. Fis.*, vol. 1, no. 1, pp. 50–55, 2013.

[15] W. Wardalia, Pengaruh massa adsorben limbah sekam padi terhadap penyerapan konsentrasi timbal, *Jurnal Teknika*, vol. 13, no. 1, pp. 71–80, 2017.