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Identification of Ultraviolet (UV) Levels in the Caramelization Process of Sale Pisang

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***Abstract*— Sale pisang is a typical Indonesian food made from dried bananas. Usually, this drying is done by drying directly in the sun. Drying bananas in the sun is not very effective because it takes a long time and is very dependent on weather conditions. After innovation was made by making a dryer, sale pisang was produced which had a hard texture and low moisture content that affected the caramelization process. Therefore, a dryer is needed that can replace the drying process under the sun. One of the contents of sunlight is ultraviolet light. Irradiation of ultraviolet light, especially UVC light, can help shrink the cell wall of bananas so that the evaporation of water during drying is small. This study aims to identify good UV levels for the caramelization process to produce the same sale pisang as drying under the sun using 5 different treatments, namely, without UV lighting, 15 minutes irradiation, 30 minutes irradiation, 1-hour irradiation, and 2 hours irradiation. Irradiation for 15 minutes produces a water content of 11%, irradiation for 30 minutes produces a water content of 12%, irradiation for 1 hour produces a water content of 18%, and Sale pisang with irradiation for 2 hours produces a water content of 20%. Based on the texture analysis produced by irradiation for 1 hour produces a texture that is almost the same as drying directly under the sun.**

***Keywords*—Drying; sale pisang; moisture content; caramelization; UVC.**

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I. INTRODUCTION

Bananas are one of the most consumed horticultural crops. Bananas are also an agricultural commodity that is widely developed by the people of Indonesia. Almost all regions of Indonesia are banana producing areas. In 2021, banana production in Indonesia reached 8.74 million tons[1]. Sale pisang is one of the processed bananas in the form of semi-wet food made by drying or smoking either with preservatives or not[2][3][4]. So far, the drying process is still done manually, namely drying directly under the heat of the sun. This traditional method is not very effective in the processing process because it depends on weather conditions and takes a long time. When the weather is sunny, drying takes 3 to 5 days, but during the rainy season the production process takes longer even causing bananas not to dry so that sale pisang cannot be produced and moldy[5]. Therefore, a drying device is needed that can replace the drying technique directly under the heat of the sun and drying does not take a long time. This dryer is a special cabinet consisting of several shelves and has a heating element as a heat source. However, the use of a dryer produces a sale pisang that has a hard texture and excessive sweetness so that the distinctive taste of sale pisang is lost. This shows that the sugar content contained in sale pisang is high. The higher the sugar content in the material, the less water is retained in the material so that the texture of the material is more compact and sturdy [6][7]. The low moisture content and high sugar content in the material cause the texture of the material to break easily and hard[8]. High sugar content causes crystallization on the surface of the material[6]. Crystallization causes the caramelization process when drying to be inhibited. Caramelization is a reaction of sugar-sugar interaction at high temperatures[9][10][11]. A good caramelization process produces a banana texture that is not too dry and not too wet. This shows that the moisture content of sale pisang affects the caramelization process. The amount of moisture content will determine the amount of sugar content in the sale pisang. A decrease in water content

will cause an increase in sugar content in sale pisang and vice versa[12][13]. The amount of moisture content during the drying process is determined by the amount of water evaporated by the heat energy of the dryer. The hotter or higher the temperature, the faster the decrease in moisture content in the drying process[14][15][16][17]. A good sale pisang according to SNI is a sale pisang that has a maximum moisture content of 40% and a minimum sugar content of 35%. To get the same sale pisang as the traditional results, which have a texture that is not hard and flexible (not soft) where the sale pisang undergoes a perfect caramelization process, a dryer is needed that not only consists of heating elements but other components that can replace the content of sunlight. One of the content of sunlight that affects the drying or drying process is ultraviolet light. Ultraviolet (UV) light is electromagnetic radiation against waves that are shorter than the visible light region and longer than X-rays. Ultraviolet (UV) light has a spectrum that extends from 400nm to 100nm. Based on its wavelength range, UV light consists of three parts, namely UVA with a range of 315-400nm, UVB 315-280nm, and UVC 280-100nm[18][19][20]. Ultraviolet light that can be used in the drying process is UVC. According to Suparman in his research in 2003, UVC light not only functions as a sterile but also is radiation that can penetrate the tissue[21]. UVC can decrease the permeability of fruit tissue which causes the space between cells to be tighter resulting in lower water loss[22][23]. Through its ability, UVC can help regulate water extraction during drying so that the sugar and water content needed for caramelization is sufficient. However, ultraviolet light that is too excessive can eliminate the effectiveness of ultraviolet light[24]. Therefore, it is necessary to identify ultraviolet (UV) levels to produce sale pisang with good quality and taste.

II. Material and Methods

This study used a type of banana in the Pariaman, Indonesia area called "pisang masak sehari". This banana has a sour taste so it usually cannot be consumed directly. The sensor used is the CJMCU Guva S12SD sensor which functions to detect UV intensity. This sensor is capable of detecting light that has a wavelength of 240-370nm. As a source of ultraviolet (UV) light used UVC Cosmo lamps type CS-400 8 watts. This lamp emits light or light with a wavelength spectrum of 253.7 nm this spectrum is classified into the light spectrum from UVC. The research method used is experimental research. This research was carried out by creating a system that can measure the intensity or UV levels and identify the appropriate UV levels in the caramelization process during drying. The stage carried out for this study is first taking reference data to obtain UV levels during the drying process of sale pisang. The process of retrieving reference data is as follows:

1. Measuring UV levels from conventional drying treatment, namely directly from sunlight.
2. The measurement is done at the same hour during the drying process.
3. Experiments were conducted with the same type of banana.
4. Physical testing was carried out on the sale of bananas in the form of moisture content and texture produced.
5. After obtaining the test results, the data will be stored as a reference for testing on the dryer.

The next stage is test the tool. The process is as follows:

1. Drying using a dryer at 60°C with UV irradiation from a UV lamp.
2. Irradiation is carried out in 5 treatments, namely without irradiation, irradiation for 15 minutes, irradiation for 30 minutes, irradiation for 1 hour, and irradiation for 2 hours.

3. Processing drying data to identify appropriate UV levels for the caramelization process based on the texture produced according to the moisture content contained in the sale pisang.

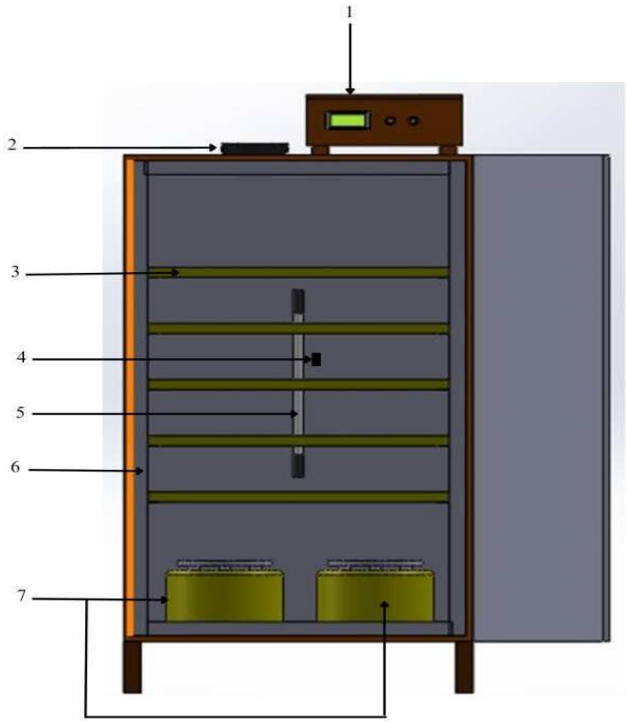

Fig. 1 Design of sale pisang dryer

Figure 1 shows the design of the sale pisang dryer. This dryer consists of:

1. Component box, serves as a box for placing electronic components such as power supply, microcontroller, LCD, system on/off button, UV lamp on/off button, and several other components.
2. Fan, serves as an exhaust fan that helps in temperature stabilization.
3. The baking sheet, serves as a placemat of banana slices that will be dried.
4. CJMCU Guva S12SD sensor, serves as a sensor that will detect UV intensity.
5. UVC lamp, serves as a UV source.
6. DS18B20 sensor, serves as a sensor that will detect the temperature produced by the heater.
7. Heater, functions as a heater so that the temperature in the dryer can increase.

Tohis sale pisang drying machine is in the form of a box made of plywood with a size of 60 cm long, 60 cm wide, and

100 cm high. The inner wall of the box is coated with aluminum bubble foil which functions as a heat absorber so that the heat inside the box cannot be absorbed by the plywood and is not distributed to the environment. This drying machine uses a rice cooker heater as a heater.

III. Result and Discussion

A. UV Intensity Measurement of Sunlight

Solar UV Intensity Testing aims to determine the solar UV intensity received by the earth. Data collection was carried out in the Pauh area, Padang. Data collection time is carried out every 8 am, 12 pm, and 5 pm. The amount of UV intensity obtained depends on weather conditions.

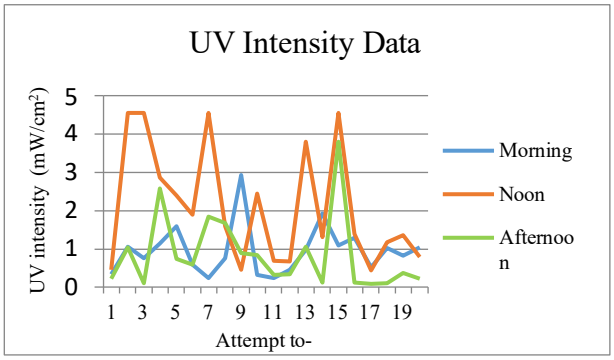

Fig. 2 Solar UV intensity measurement chart

Figure 2 shows a graph of solar UV intensity measurement data. From the graph, it can be seen that the highest UV intensity is at a value of 4.55 mW/cm^2 where the weather conditions are hot and the lowest at a value of 0.09 mW/cm^2 where the weather conditions are cloudy. The highest average intensity value is at noon. This happens because at that time the angle of incidence of the sun is at an angle of 90° so that solar irradiation occurs optimally.

In addition, the size of the UV intensity received by the earth is also influenced by differences in latitude. Areas that fall asleep at latitude 90° will receive little solar radiation so that the UV intensity received is also small. Areas at 0° latitude will receive greater solar radiation because they are closer to the sun so the UV intensity received is also large. The clarity of the atmosphere also affects the size of the UV intensity received by the earth. The clarity of the atmosphere affects the reflection and scattering of sunlight. The lack of clarity of the atmosphere causes incoming sunlight to scatter and bounce before reaching the surface of the earth. This lack of clarity can be caused by gases such as dust, smoke, volcanic ash, and pollutants. Areas that have atmospheric clarity will receive greater UV intensity than areas that are dusty, smoky, exposed to volcanic ash, or polluted [25].

TABLE I
UV INTENSITY OF THE SUN

Experiment	Morning (mW/cm2)	Noon (mW/cm2)	Afternoon (mW/cm2)	Average UV Intensity
1	0.34	0.46	0.22	0.34
2	1.06	4.55	1.04	2.22
3	0.76	4.55	0.11	1.81
4	1.15	2.86	2.57	2.19
5	1.6	2.4	0.74	1.58
6	0.59	1.89	0.59	1.02
7	0.24	4.55	1.85	2.21
8	0.76	1.6	1.67	1.34
9	2.92	0.46	0.9	1.43
10	0.33	2.44	0.84	1.20
11	0.25	0.7	0.32	0.42
12	0.46	0.68	0.34	0.49
13	0.97	3.79	1.06	1.94
14	1.92	1.31	0.12	1.12
15	1.09	4.55	3.79	3.14
16	1.29	1.4	0.13	0.94
17	0.52	0.45	0.09	0.35
18	1.03	1.17	0.11	0.77
19	0.83	1.36	0.37	0.85
20	1.04	0.79	0.22	0.68
Average	0.96	2.09	0.85	1.30

Table 1, the results of measurements of the sun's UV intensity received by the Earth. Data collection was carried out twenty times. The average UV intensity in the morning is 0.96 mW/cm^2. The average UV intensity during the day is 2.09 mW/cm^2. The average UV intensity in the afternoon is 0.85 mW/cm^2. Based on tests conducted in one day, the average UV intensity is 1.30 mW/cm^2.

B. UV Intensity Testing on Dryers

UV intensity testing on dryers aims to determine the effect of UV intensity on the moisture content of sale pisang in the drying process. The amount of moisture content contained in sale pisang shows the success of the caramelization process experienced by sale pisang during drying. This is because if the water content is small, the sugar in the sale pisang will clump together to form crystals so that the resulting sale has a hard texture. The higher the sugar content in the material, the less water is retained in the material so that the texture of the material is more compact and study. Low moisture content and high sugar content in the material cause the texture of the material to break easily. High sugar content causes crystallization on the surface of the material [6].

As a source of ultraviolet (UV) light used UVC Cosmo lamps type CS-400 8 watts. This lamp is capable of emitting UV light with an intensity of 0.5 mW/cm^2.

TABLE II
MOISTURE CONTENT TEST RESULTS WITH UVC LAMPS

Duration of UVC lamp irradiation	Starting weight (grams)	Final weight (grams)	Moisture content (%)
Without irradiation	332	76	10
15 minutes irradiation	328	81	11
30 minutes irradiation	329	89	12
1 hour irradiation	333	94	18
2 hour irradiation	338	107	20

Table 2 shows the percentage of moisture content contained in the sale pisang. This moisture content is obtained after drying for 5 hours and 30 minutes. The duration of irradiation is directly proportional to the percentage of moisture content. The longer the irradiation of UVC lamps, the greater the moisture content contained in sale pisang. This happens because UVC irradiation affects the permeability of banana tissue. Permeability is the ability of tissues to pass a certain substance, in this case, water. The irradiation of UVC lamps causes the space between cells to shrink so that water loss is smaller [22], [23].

Fig. 3 Irradiation without UVC lamp

Figure 3 shows the drying result of sale pisang without UVC lamp irradiation. This sale pisang has a harder texture compared to the sale pisang with UVC lamp irradiation. In addition, the sale pisang was drier than the sale pisang with UVC lamp irradiation.

Figure 4 shows the drying result of sale pisang with UVC lamp irradiation for 15 minutes. This sale pisang has a softer texture compared to sale pisang without UVC lamp irradiation.

Figure 5 shows the drying result of sale pisang with UVC lamp irradiation for 30 minutes. This sale pisang has a softer texture and is quite soft compared to sale pisang with UVC lamp irradiation for 15 minutes.

Fig. 4 15 minutes irradiation

Fig. 5 30 minutes irradiation

Fig. 6 1 hour irradiation

Figure 6 shows the drying result of sale pisang with UVC lamp irradiation for 60 minutes or 1 hour. This sale pisang has a soft and chewy texture compared to sale pisang with UVC lamp irradiation for 30 minutes.

Figure 7 shows the drying result of sale pisang with UVC lamp irradiation for 2 hours. This sale pisang has a texture that is too soft compared to sale pisang with UVC lamp irradiation for 1 hour. This is because the sale pisang contains too much water so that the sale produced is softer than the previous test.

Fig. 7 2 hour irradiation

Based on the test, sale pisang with 1 hour of UVC lamp irradiation produced a good texture, soft, not too dry, and not too soft. This is because 1 hour of irradiation produces good water content and sugar content for the caramelization process.

IV. Conclusion

UVC irradiation can affect the moisture content of sale pisang. Sale pisang without irradiation produces a moisture content of 10%. Sale pisang with irradiation for 15 minutes produces a moisture content of 11%. Sale pisang with irradiation for 30 minutes produces a moisture content of 12%. Sale pisang with irradiation for 1 hour produces a moisture content of 18%. Sale pisang with irradiation for 2 hours produces this 20% moisture content. Irradiating banana slices with a UVC lamp for 1 hour produces sale pisang with a soft and chewy texture. This shows the caramelization process with UV levels of 0.5 mW/cm^2 and UVC lamp irradiation for 1 hour can produce sale pisang that are almost the same as drying directly under the sun.

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