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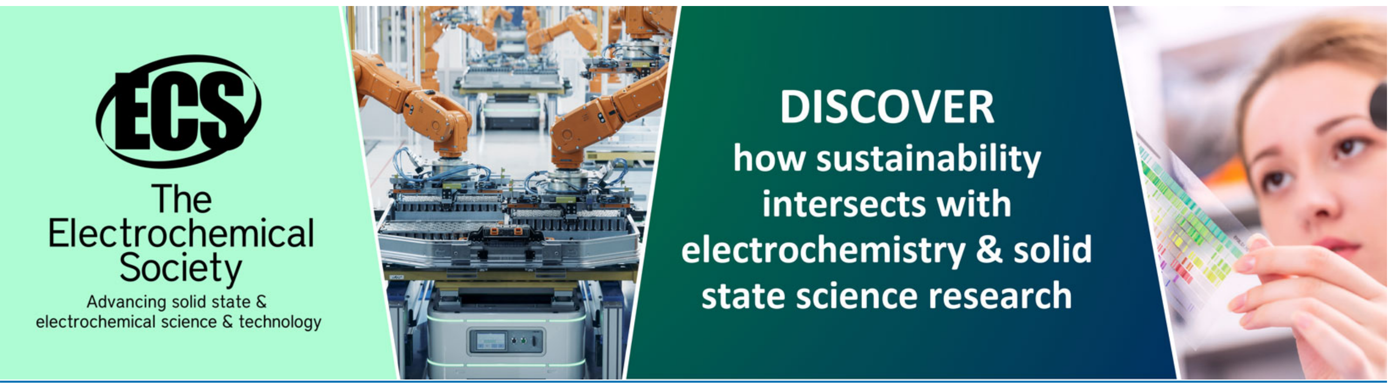

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Study of sweetness level of Ambon banana (musa acuminata colla) using X-ray radiation method

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Abstract. Banana is a climacteric fruit whose quality easily degenerates due to environmental factors. Bananas fruit will be continuing to do physiological activities that can lead to initial maturity before it reaches to the consumer. This condition can accelerate the damage both physically and microbiologically; it is necessarily needed the techniques that can keep the quality of fruit remains good. One of the techniques that can be used is a radiation technique. This study aims to determine the effect of X-ray radiation dose variation on the level of sweetness of Ambon banana (Musa acuminata Colla). X-ray radiation (X-type SF-100 BY) machine was used in Laboratory of Medical Physics at Universitas Negeri Semarang. Variation of radiation dose was used in the range (1.4 – 26.4) x10^{-9} gray. Measurement level of sweetness of Ambon banana was used a refractometer. Based on that measurement, Ambon banana irradiated with a radiation dose of (1.4 – 26.4) x 10^{-9} gray, the banana sweetness level of Ambon banana was decreased. At the same radiation dose but with different storage periods (1, 2, 3, and 4 days), it was found that the longer storage times, the sweetness of the Ambon banana was increased. The degree of sweetness of Ambon bananas after irradiated at radiation dose (1.4 – 26.4) x 10^{-9} gray is equal to (13.1 – 7.8) °Brix. The level of sweetness that is almost the same as irradiated Ambon banana at a dose of radiation of 1.4 x 10^{-9} gray on a 4-day storage period. It was found that the optimum value for the sweetness level of Ambon bananas preserved by the irradiation method using X-rays was at a radiation dose of 1.4 x 10^{-9} gray.

1. Introduction

Ambon Banana is including types of bananas, widely consumed by the people of Indonesia and demand is greater than other types of bananas. The first banana seed in Indonesia is an Ambon banana and then followed by Cavendish bananas as the second. Characteristics of Ambon banana are easily damaged, uniform quality and bulky [1]. Banana fruit will continue to do physiological activities that can lead to initial maturity before it reaches the consumer. This condition will also accelerate the damage of Ambon banana both physically and microbiologically. It is necessary need techniques that can keep the fruit maintained quality before reaching the consumer [2].

One of the preservation technique is quite promising on the reducing of physically and microbiologically activities food especially Ambon banana is irradiation techniques [3]. Food irradiation is a method of exposure to food either by using radioactive substances or accelerators to prevent the occurrence of decay and damage to food and liberate from pathogenic microorganism [4].

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This irradiation technique can secure post-harvest agricultural commodities from damage during distribution and storage [5]. In addition to increasing the storage capacity of food, irradiation is also able to maintain quality and maintain food hygiene.

The type of radiation that can be used for food preservation is electromagnetic radiation with wavelengths below 10 nm [6]. The resulting photon must have enough energy, so it can make the material through which ionization and excitation occur. This type of radiation is called ionizing radiation. Examples of ionizing radiation include gamma rays and X-rays [7]. According to the Codex General Standards for Food Irradiation compiled from the results of the Joint Expert Committee on Food Irradiation (JECFI) decision, the radiation sources allowed to be used for irradiating food are Cobalt-60 (60Co) and Cesium-137 (137Cs) gamma radionuclide rays with energy equal to 1.17 MeV and 1.33 MeV (60Co) and 0.662 MeV (137Cs), electron beam with maximum permissible energy for food irradiation ie not exceeding 10 MeV, X-rays with maximum energy limit of not exceeding 5 MeV [8]. X-rays are electromagnetic radiation with a range of energy between 100 eV to 100 keV resulting from electron collision with metal [9]. The intensity of X-rays can be easily controlled by adjusting the filament voltage and current [10]. The use of an X-ray source is to have great penetrating power, not to induce radioactivity in food or food packaging, freshness of food does not change, does not cause chemical residues, does not result in temperature rise in the material or food packaging so it is safe for food that can not stand hot [8]. Also, the X-rays machine is available at the Physics Laboratory. Food irradiation has many benefits in the preservation of food, but there are effects of irradiation, such as changes in chemical composition and nutritional value of food from the fruit [11]. Effect of the radiation process on sweetness levels as a function of the increases the dose of radiation. The sweetness level also affected on the storage process, which is the fruit was stored on room temperature can produce higher sugar content compared to low temperature on storage process [12]. It’s because the storage process at low temperature can inhibit the respiration process of Ambon banana. That condition can maintain the change of glucose reaction [13].

The decomposition of glucose continues into a simpler element that is in the form of acid and alcohol [5]. According to a previous study [14], in the process of ripening of climacteric fruit one of which is banana, carbohydrate content (starch) and sugar will always change. Starch content will decrease during the cooking process that causes mass shrinkage. This mass shrinkage is associated with changes in starch to fructose and glucose. Changes from starch to fructose and glucose will continue until no starch is available, so elevated levels of glucose and fructose lead to increased sugar content (sucrose). Based on Marisa and Sakhir [12] research, the higher radiation dose given effecting on the level of sweetness will be lower.

The aim of this research is to study the effect of the radiation dose on the sweetness level of Ambon banana by using X-ray radiation method. In this research also to determine the optimum radiation dose on purpose maintain the sweetness level of Ambon banana.

2. Experimental Setup

The material was used as a sample is Ambon banana from the area of Gunungpati Semarang. The instrument was used on the radiation process is X 100 BY X-ray machine, which is available at Medical Physics Laboratory of Universitas Negeri Semarang. First-stage X-ray machine was controlled at 32 mA current with a voltage of 40-90 kV within 2 seconds, and the sample distance on X-rays is 80 cm. Sweetness level testing by using refractometer was available at Chemical Laboratory, Universitas Negeri Semarang. Before the irradiated process, the Ambon banana sample is washed first to remove the sap present on the skin of the fruit. For the radiation process, the voltage of the X-ray machine was varied of 0 kV (test/control sample), 40 kV, 50 kV, 60 kV, 70 kV, and 80 kV. The set time of the radiation process is 1 second. The tool also required in this research is a survey meter that serves to measure the rate of radiation dose of X-rays fired. Once the dosage rate is known then it can be found the absorption dose using the equation:

$$D = D^* \times t \tag{1}$$

with D^* is dose rate (gray/s), D is total dose absorbed (gray), t is irradiation times (s). After radiated, the Ambon banana was put on storage box for storage process for 4 days. The purpose is to know the level of Ambon banana sweetness in every day.

3. Results and Discussion

In this research, the amount of Ambon banana as a sample is six Ambon banana from the area of gunungpati Semarang. Figure 1 shows the sweetness level of Ambon banana versus radiation dose on storage process for 4 days. Ambon banana sample in this research takes from the same bunches. It means the Ambon banana has identical characteristics such as the level of hardness of bananas, size, and banana peel color.

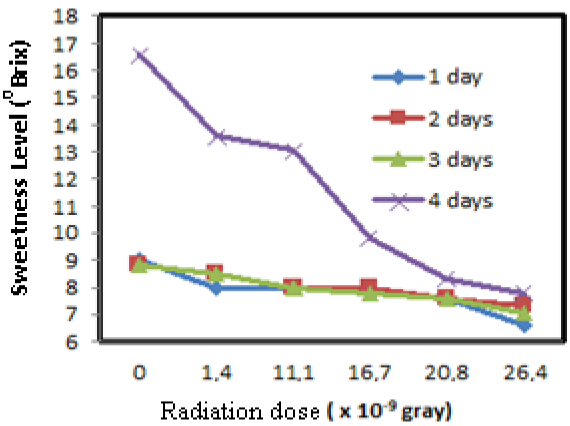

Figure 1. Sweetness level of Ambon banana versus radiation dose

From Figure 1, it can be seen that on the measurement of the sweetness level of the Ambon banana samples on the 1st day, the decrease in the sweetness level occurred from the control sample or non-irradiated sample up to the radiation dose of 1.4 x 10^{-9} gray. Then the radiation dose is increased to 11.1 x 10^{-9} gray; the sweetness level is the same as the Ambon banana sweetness level at the radiation dose of 1.4 x 10^{-9} gray. However, when the dose is increased up to 16.7 x 10^{-9} gray, the sweetness level of the Ambon banana will decrease continuously. On the 2nd day the result is almost the same as the 1st day that the increase of radiation dose given to the sample of the sweetness level is decreasing, but at the dose of 11.1 x 10^{-9} gray and 16.7 x 10^{-9} gray of sweetness value is 8.0 °Brix. Whereas, Ambon banana non-irradiated has a sweetness level of 8.8 °Brix on the 2nd-day storage process. On the 3rd day's post-irradiation process, the sweetness level was decreased when the radiation dose was increased. An un-irradiated of Ambon banana samples on the 3rd days, the sweetness value still same with the Ambon banana samples on 2nd days storage process around 8.8° Brix. The sweetness level of Ambon bananas un-irradiated on 2nd and 3rd days lower than on the 1st days. It is due to the Ambon banana has a uniform maturity though in one bunch. On the 4th day post-irradiation, the increasing of radiation dose of sweetness level on Ambon banana was decreased. On 4th day, the sweetness level was increased very sharply from the previous day. Particularly on un-irradiated Ambon banana samples, the sweetness level is 16.6°Brix. Based that, can be said that the longer time of the storage process will be affected on the sweetness level of Ambon banana which is on increasing of the sweetness level.

Furthermore, the sweetness levels of Ambon banana will decrease when the radiation dose was increased. In this research, the sweetness level of Ambon banana can only be tested until day 4. That's because the sweetness level on the 5th, 6th and 7th days have exceeded the maximum scale limit on the refractometer.

Changes in carbohydrates occur during the ripening of the fruit. In young fruits, many carbohydrates are in the form of starch, which is why the fruit has an unpleasant taste. During the process of ripening fruit through enzymatic reactions, starch contained in the fruit will be broken down into simple sugars such as glucose, fructose, and sucrose, so the fruit becomes sweet [15]. In fruits contain lots of carbohydrates and components of carbohydrates that have a fairly high value of glucose (sugar). According to Silaban [13], on the ripening of the fruit, the biggest change is the breakdown of carbohydrate polymers that can affect the texture and fruit flavor where the increase in sugar content will cause more sweet taste in the fruit. In the process of banana, maturation occur decreased starch content and the addition of sugar content. The content of starch in unripe fruit ranges between 20-25% of the total fresh weight, and about 2-5% can be converted into sugar and partially released in the form of CO_2 through the respiration process. The initial stage of fruit growth has a very low sugar concentration, but at the time of the cooking process, the sugar content in the fruit will increase sharply in the form of glucose and fructose [16].

Sweetness level decrease is proportional to the amount of radiation dose. This can be seen in figure 1. The decrease of sweetness level after the sample in irradiation is caused by the time of irradiation the oxidation process that produces the acid compound so that the acidity level and the sugar concentration decreases which shows the degradation of glucose [17]. Glucose levels will decrease with increasing radiation dose and decomposition of the glucose component which continues into simpler elements and forms alcohols and acids [5]. According to Marisa & Shakil [12], that the content of glucose in the dragon fruit has decreased significantly when stored in room temperature.

In the previous study [13] shown that the storage process in room temperature (28°C) caused the amount of sugar to increase compared to storage at low temperatures (6°C). This is because treatment with storage at low temperatures can inhibit the respiration process that occurs in the fruit, thus maintaining the starch reshuffling into sugar, whereas treatment with storage in room temperature strongly supports the process of transformation or a change of sugar becomes faster. In addition to storage temperature, storage time has a significant effect on the increase of sweetness level in fruit. The longer the storage time, the higher the sugar content contained in the fruit. This is due to the decrease in the levels of phenolic compounds that can cause the loss of sponge and the decrease of organic acids and the increase of substances that give the flavor and aroma typical of the fruit.

The decrease in glucose content is influenced by X-ray radiation, storage time and storage temperature. Storage at room temperature results in increased sugar content compared to storage at low temperatures. This is because the storage of low temperatures can inhibit the respiration process, to maintain the change of glucose [13]. The process of respiration will convert sugar into carbon dioxide and water. The complex compounds commonly found in carbohydrates will be broken down into simple molecules; carbohydrates will evaporate with water [18].

4. Conclusion

Measurement of the sweetness level of Ambon banana after was radiated using X-ray method has been done. The sweetness level of Ambon banana was decreased when the radiation dose was increased. Furthermore the sweetness level of Ambon banana increases as a function of the storage time process. Longer storage time process will be affected on the sweetness level become increases. The optimum value of the radiation dose given to the Ambon banana on the 4th day at a dose of 1.4×10^{-9} gray due to the condition of Ambon bananas in good condition, no damage to the physical, so good for the market and the selling price is high.

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