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Homemade Pectin, Made of *Musa Acuminata Cavendish*'s (Cavendish Banana) and *Musa Paradisiaca Formatypica*'s (Horn Shaped Banana) Skin, and Its Effectiveness Analysis as Heavy Metal Absorber by Using Laser-Induced Breakdown Spectroscopy (LIBS)

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ABSTRACT

Heavy metal pollution in water, especially in the North Jakarta area, has become severe from time to time. A heavy metal adsorbent is one of the alternative solutions to clean the waste water from industries before it is released into the environment. In this paper, we create pectin that has been proven to be an effective absorbent for heavy metal (Pb) and is made of *Musa* a*cuminata Cavendish* (cavendish banana) and *Musa paradisiaca Formatypica* (horn shaped banana). These two banana species can be easily found in the markets of Jakarta. Therefore, we compare the two species to find out which is more effective to use as heavy metal adsorbent. The selection is based on the reduction of the Pb concentration after the introduction of banana pectin by means of Pb emission intensity reading taken using commercially available laser-induced breakdown spectroscopy (LIBS) system. The effectiveness of pectin from the two banana skins as Pb adsorbent is comparable either in pellet form or solution in water. The result shows that the average effectiveness of homemade pectin as Pb adsorbent is 37.5%, which is lower than the commercial pectin available in the market.

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In the future, the technique of producing homemade pectin will be improved to get better Pb absorption efficiency.

Keywords: Banana, heavy metal, LIBS, Pb adsorbent, pectin

INTRODUCTION

Banana, with more than 50 varieties, is one of the main fruits well grown in tropical countries such as Indonesia (Setyobudi, 2000). It has nutritional value and composes 45% of the fruits consumed by most people (Hapsari & Lestari, 2016; Setiawan, Sulaeman, Giraud, Driskell, 2011). Since many of Indonesia's cuisine, especially snacks, use bananas as their basic ingredient, there are a lot of banana skins left as waste. The waste, in fact, has been used for biomass fuel production, organic fertilizer, and organic cattle food in the farm. However, it is also interesting to use it for other useful things.

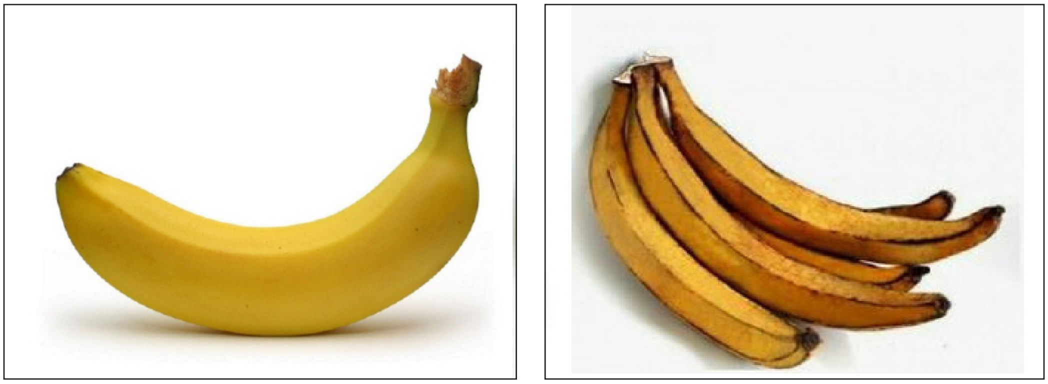
In this paper, we introduce how to recycle the banana skins into pectin (Emaga, Ronkart, Robert, Wathelet, & Paquot, 2008; Mohnen, 2008) in the traditional way. Pectin is widely used in the industry as gelling agent and stabilizer. It is used in jams, jellies, frozen foods, low-calorie foods, or as fat/sugar replacer (Thakur, Singh, Handa, & Rao, 1997) and at the same time, the pectin can also be used as a heavy metal adsorbent in water (Li, Yang, & Zhao, 2007; Wan Ngah, & Hanafiah, 2008).

Heavy metal pollution in water especially in the coastal areas of Indonesia is severe and is mainly caused by the waste of industries. (Hosono, Su, Delinom, Toyotae, Kaneko, & Taniguchi, 2011; Nienhuis, 1986). Pectin can be one of the alternate solutions for reducing the heavy metal waste in water, and for this purpose, we make pectin that can be used as a low-cost adsorbent of heavy metals waste from industries. The pectin is mixed with the waste water that is able to transform into gel structure, which leaves the uncontaminated waste water as a result. In fact, pectin can be produced from any kind of fruit skin. However, in this paper, we focus on banana skins which are easily found in Indonesia. Finally, the adsorption effectiveness of banana pectin made in this study is applied as a Pb absorbent in waste water.

MATERIALS AND METHODS

Preparation of Banana Pectin

In this experiment, we used the skin of banana from genus *Musa Acuminata Cavendish* (Cavendish banana) and *Musa Paradisiaca Formatypica* (horn shaped banana) as the basic material of pectin, that is utilized as a low-cost heavy metals adsorbent, as shown in figure 1. The skin structure of both bananas is different in that the skin of Cavendish banana is softer than horn shaped one. Both skins were 4 cm diced and heated in the 500 watts oven until they dried separately with water concentration of less than 5%. Later, the dried skin



(a) (b)

Figure 1(a). Musa Acuminata Cavendish (cavendish banana), and *(b). Musa Paradisiaca Formatypica* (horn shaped banana)

was blended into powder. Every 25 g of the powder and 25 g of citric acid ($C_6H_8O_7$) was dissolved in 1 liter distilled water by using stirrer. The above solution was then heated at 100^{o}C to finally get dry pectin powder.

Further, the dried pectin powder was pulverized until its grain size was less than 50 µm. In order to check the effectiveness of homemade pectin as adsorbent of Pb heavy metals in water, we prepared four 50 ml beaker glasses, each of which is filled with 40 ml water containing 0.1 g $PbCl_2$, along with: (i) no pectin, (ii) 0.1 g cavendish banana pectin, (iii) 0.1 g horn shaped banana pectin and (iv) 0.1 g commercial available pectin. The mixtures were stirred using a magnetic stirrer for 30 minutes at room temperature, and was then filtered through 20 µm filter paper. The resulting solution was used as samples. A separate experiment was carried out to check the absorption rate of Pb by the pectin, using the same technique as mentioned above, utilizing only cavendish banana pectin. The mixtures are stirred using a magnetic stirrer for between 5 to 60 minutes at room temperature, at 5 minute increments, and was then filtered through 20 µm filter paper. The resulting solution was used as samples.

Laser-Induced Breakdown Spectroscopy Measurement

The schematic diagram of the experimental setup for spectroscopic measurement is given by Figure 2 as we have reported previously (Suyanto et al., 2012). The laser used in this experiment was a nano-second (ns) Nd:YAG laser (New Wave, 200 mJ maximum energy, 1064 nm, 8 ns) operated in Q switched mode at 10 Hz repetition rate and a reduced output energy of 100 mJ. The laser beam was directed onto the sample in the chamber through a quartz window of the chamber. A convex lens of 150 mm focal length was used with -5 mm defocused condition to yield a power density of around 250 MW/cm^2 on the sample surface.

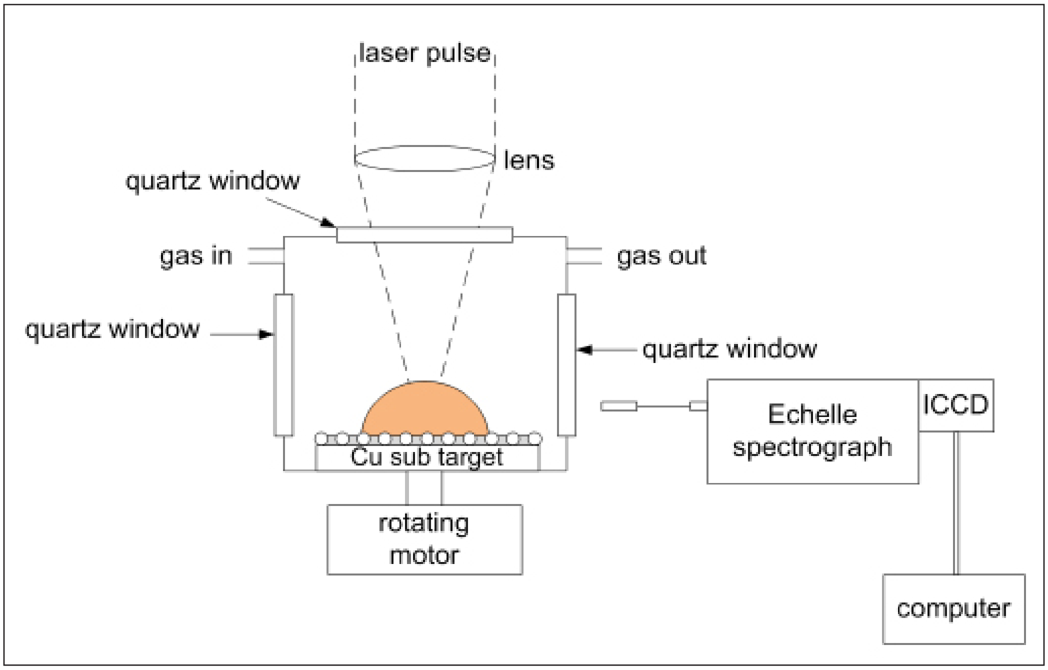


Figure 2. Experimental setup

The choices of the laser energy and focusing condition were determined in another preliminary experiment searching for the minimum ablation power density needed to yield stable and reproducible analyte intensities from the powder sample without inducing the Cu subtarget emission lines from the sample holder and causing blowing-off of the sample powder in a low pressure ambient gas. The chamber was equipped with an inlet and outlet ports for the continuous flow of ambient gas at a constant flow-rate to maintain the gas pressure at 30 Torr. The chamber had an additional quartz window for the observation of plasma emission. The plasma emission intensity was collected at one end of an optical fiber of 10 µm core diameter, with its other end connected to the entrance slit of an Echelle spectrograph (Mechelle M500 type equipped with a gated ICCD system, Andor iStar ICCD, 200-975 nm wavelength) for the measurement of emission spectrum in a broad spectral range. The samples were rotated during the measurement so that each laser pulse would hit a different spot on the sample surface.

RESULTS AND DISCUSSION

In order to know the rate of Pb absorption after the introduction of the pectin, the prepared samples as described in the previous section is used. Figure 3 shows Pb absorption rate after the introduction of cavendish banana pectin in a mixture of 40 ml water and 0.1 g $PbCl_2$. The emission intensity of Pb I 405.7 nm was obtained by irradiating the sample surface using 100 mJ laser energy in 30 Torr ambient air. The ICCD system was set at time integrated mode. One clearly saw that the maximum absorption of Pb element by the cavendish pectin occurs at around 30 minutes and almost no increment of Pb absorption even though the stirring time is increased up to 60 minutes. Based on this result, for the next experiment, 30 minutes stirring time was used. The spectrum of cavendish banana pectin and horn shaped banana pectin can be seen in Figure. 4(a) for cavendish banana and (b) for horn shaped banana.

In order to check the effectiveness of homemade pectin, four samples prepared as mentioned in the experimental procedures is used and the result is presented in Fig. 5 (a) without pectin; (b) with 0.1 g cavendish banana pectin; (c) with 0.1 g horn-shaped banana pectin and (d) with 0.1 g commercial pectin. By comparing Figure 5(a) with Figures 5(b) and 5(c), one sees that the maximum Pb absorption is almost the same (30%) for both banana type. Meanwhile total removal of Pb as shown in Figure. 5(d) is found for the case of commercial pectin.

Although the effectiveness of homemade low-cost pectin from banana skin is still lower than the commercial one, we believe that by improving the pectin preparation, through smaller pectin grain size as well as controlling the liquid temperature, the effectiveness of home made pectin will be enhanced. Further experiments are required and pectin should also be tested for other heavy metals.

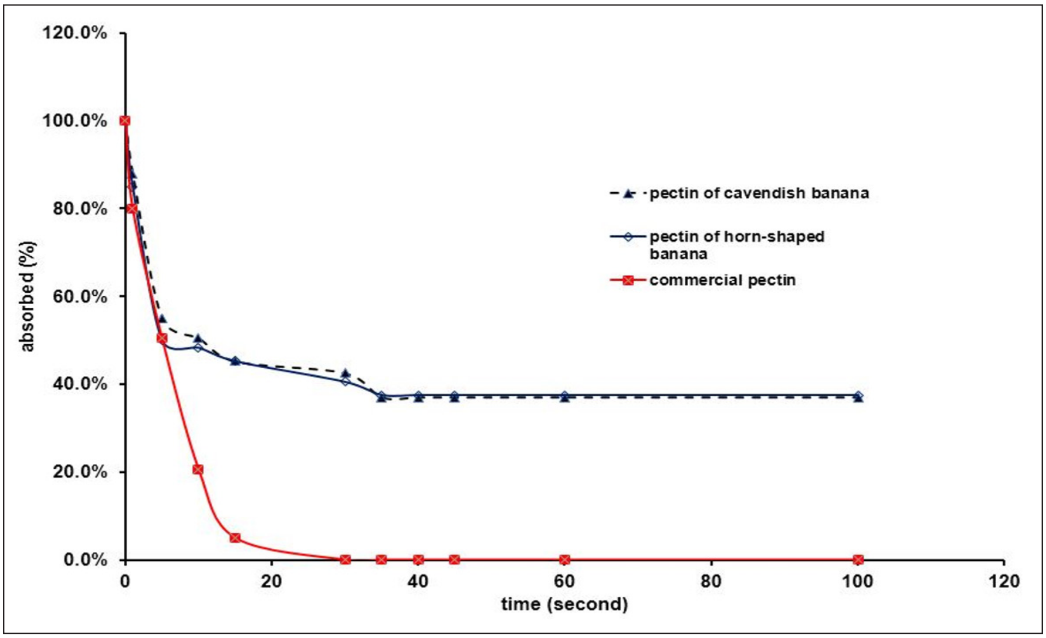


Figure 3. Pb I 405.7 nm emission intensity as a function of time after pectin introduction into the water which is containing 0.1 g $PbCl_2$.

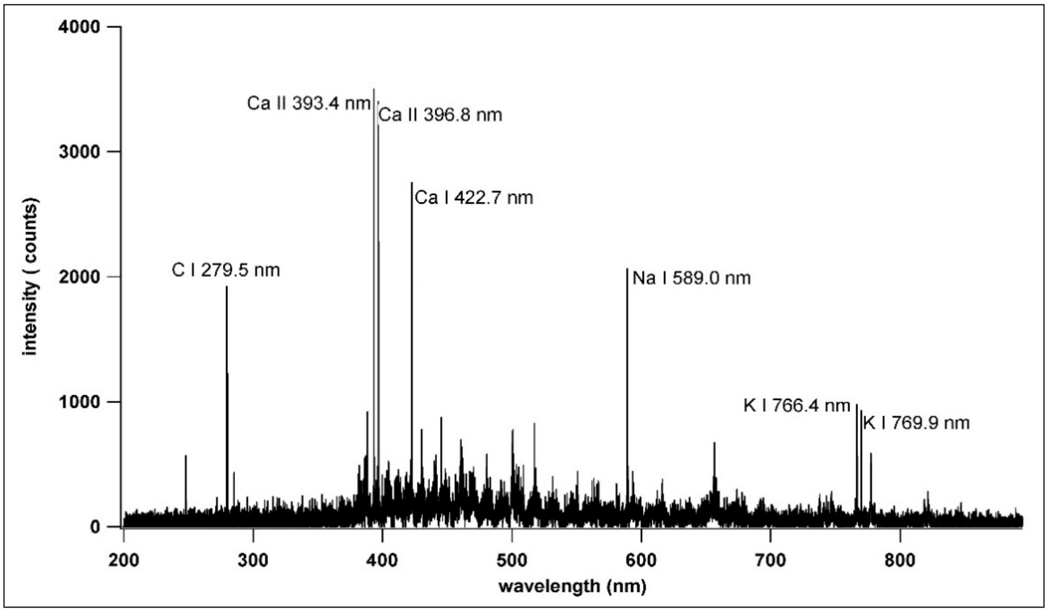


Figure 4(a). Spectrum of pectin made of cavendish banana.

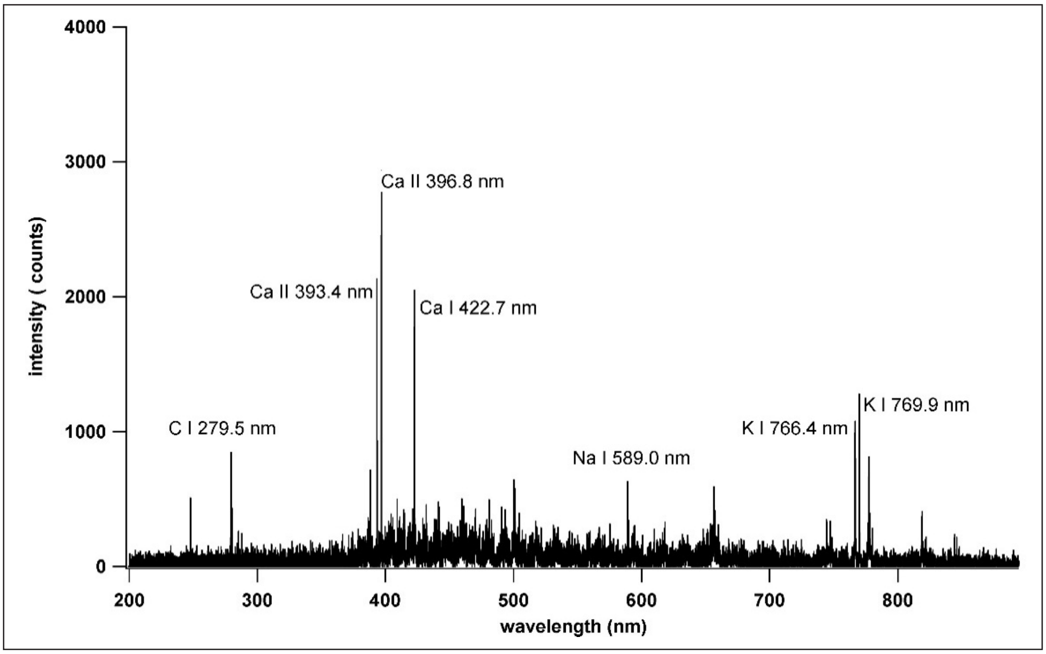


Figure 4(b). Spectrum of pectin made of horn shaped banana.

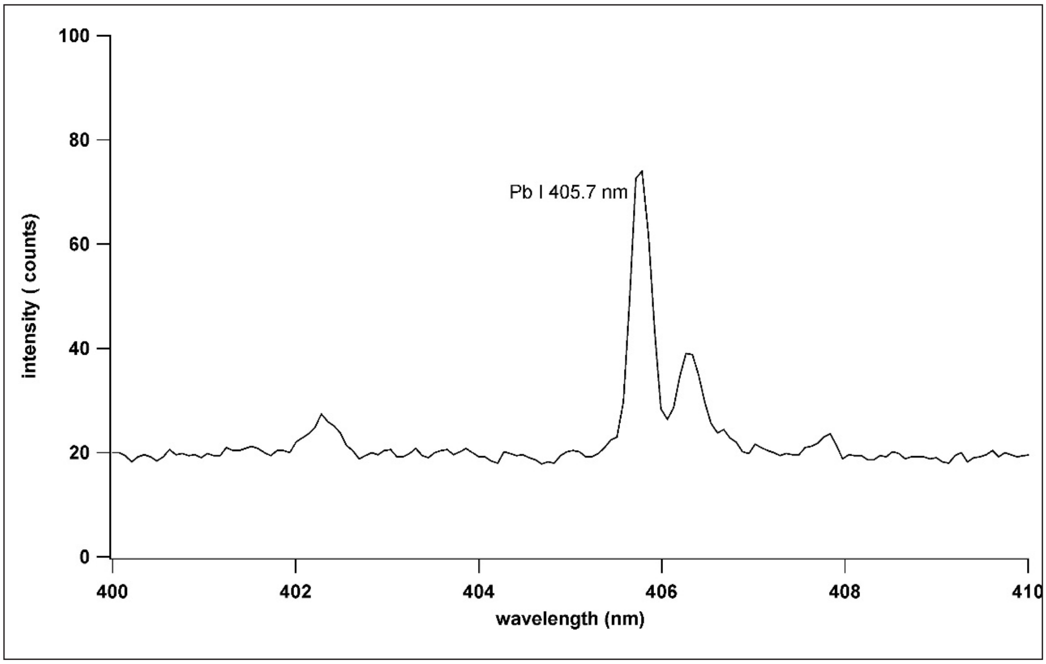


Figure 5(a). The effectiveness of Pb I 405.7 nm adsorption in liquid by using pectin and the spectrum of 40 ml H_2O + 0.1 g $PbCl_2$

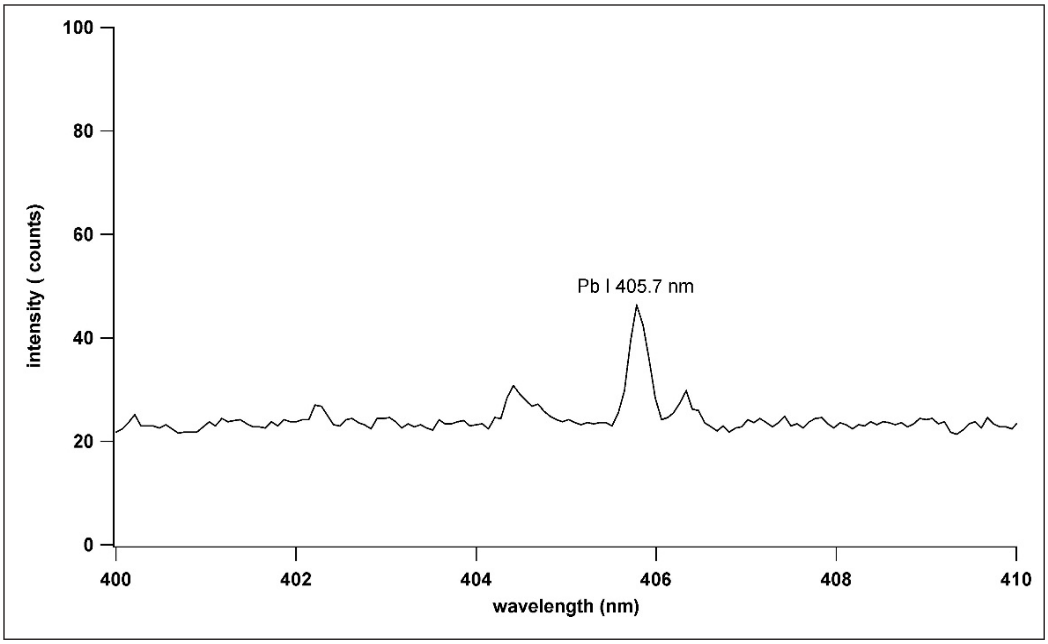


Figure 5(b). 40 ml H_2O + 0.1 g $PbCl_2$ + 0.1g pectin of cavendish banana

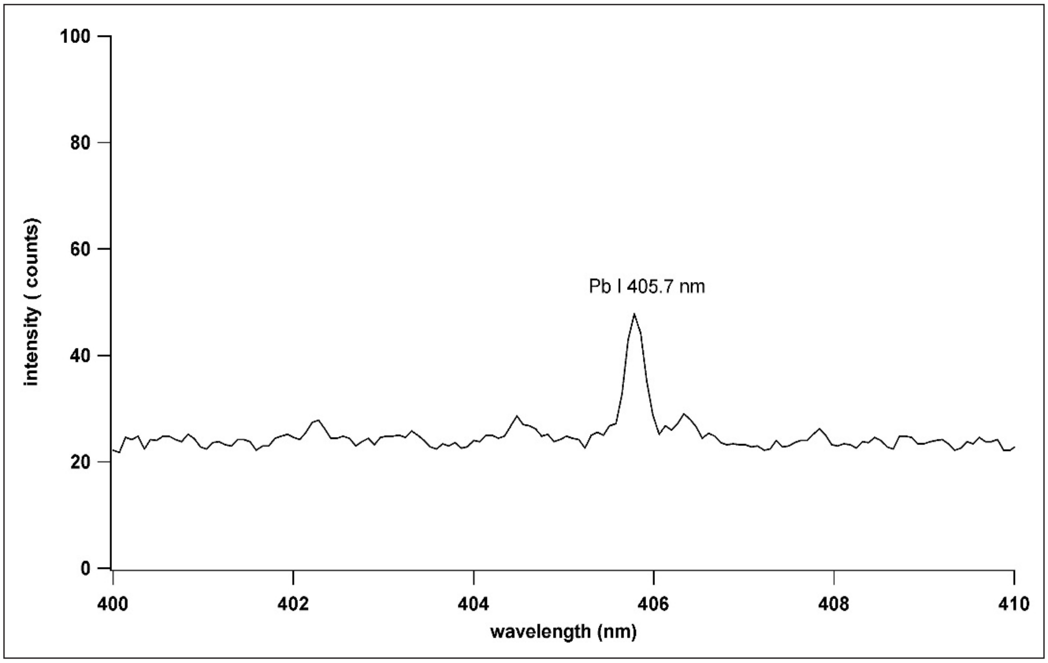


Figure 5(c). 40 ml H_2O + 0.1gr $PbCl_2$ + 0.1 g pectin of horn shaped banana

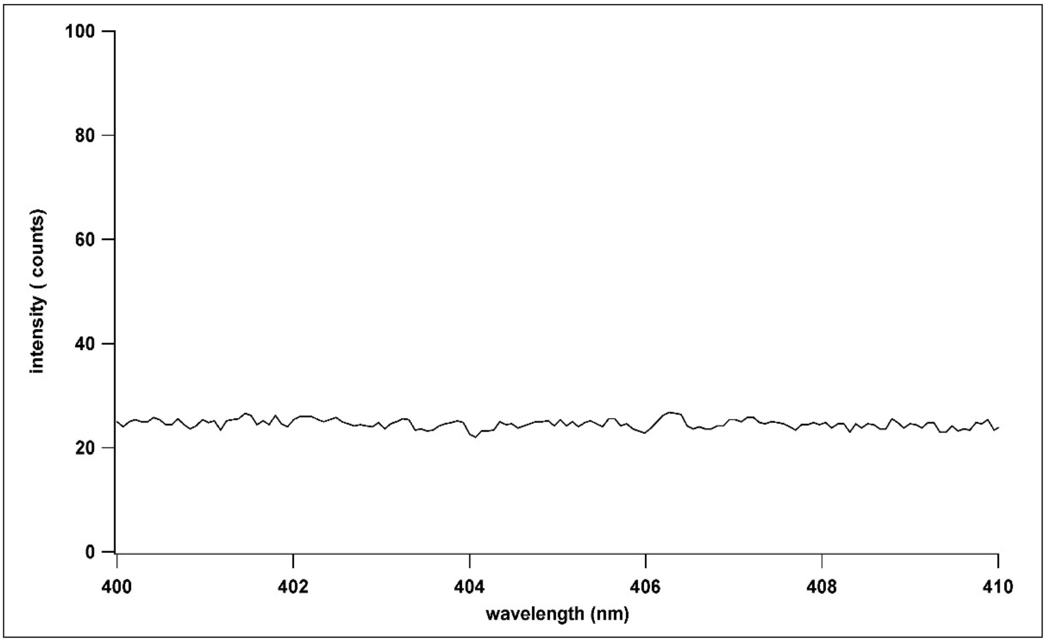


Figure 5(d). 40 ml H_2O + 0.1gr $PbCl_2$ + 0.1g commercial pectin.

CONCLUSION

Pectin is a useful compound that is used on a daily basis in the pharmaceutical or food and beverages industries. Moreover, pectin can be used as an alternate solution to adsorb heavy metals elements in waste water. Although many kinds of fruit can be used as pectin, each will produce the pectin differently, and the selection of banana skin in this experiment proves that their waste can be used as pectin. Although their effectiveness as adsorbent is only 37.5%, we still can improve the way to make the low-cost pectin by improving the sample preparation in the future.

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