Potential edible coating of pectin obtained from banana peel for fruit preservation

L Mahardiani\textsuperscript{1,*}, R Larasati\textsuperscript{2}, E Susilowati\textsuperscript{1}, B Hastuti\textsuperscript{1} and N L Azizah\textsuperscript{1}

\textsuperscript{1} Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Kentingan – Surakarta, Indonesia
\textsuperscript{2} MA An-Nawawi Berjan, Jl. Desa Lugosobo, Dusun IV, Sindurjan – Purworejo – Indonesia

*e-mail: mahardiani.lina@staff.uns.ac.id

Abstract. Edible coating is one of the strategies to preserve food because it provides protection by covering the food with its coating. Pectin is one of the sources of edible coating which can be obtained from biomass. This research aims to (1) investigate the potential banana peel as the source edible coating, (2) characterize the characteristics of pectin obtained, and (3) evaluate the edible coating effect on tomato in different temperatures storage. This research used the experimental method in the laboratory. The making of edible coating solution used banana peel pectin was varied with concentration of 2% and 10% added the following additives, namely: CMC, glycerol, potassium sorbate, and stearate fatty acids. The edible coating solution was applied to tomatoes with variations of temperature storage. The results showed that: (1) banana peel has potential as source edible coating, (2) the characterizations of pectin are in accordance with standard of international pectin quality, and (3) in the room and cold temperature storage, the coating tomato is 10% better than that of 2% and without treatment seen from the shrinkage value of weight.

1. Introduction
In the pandemic era of Covid-19, the needs of nutritious food are very essential for our body, including fruits and vegetables. As sources of vitamins, minerals, antioxidants, bio-flavonoids, dietary fibers and flavor compounds, fruits and vegetables are perishable, delicate, bruised and damaged easily [1-3]. Those damages are happened between handling, transport, storage and consumption, which eventually wax and formalin were applied to reduce the price loss of the fruit selling [4-5]. The use of formalin is banned due to negative effects on regular basis consumption, such as injurious to the nervous system, kidney, liver, asthma, pulmonary damage and cancer [6-7].

Preventing the used of formalin as fruit preservation and protection, some strategies such as edible coating is selected [8-9]. Edible coating is a thin layer that fabricated from edible materials with function of coating the food to increase the natural barrier for protection. With edible coating, the food will be protected in term of texture, color, appearance, flavor, nutritional values and microbial safety [1,8]. There are many materials that can be used to synthesis the edible coating, namely pectin as one of it. Pectin which is derived from plant is a group of polysaccharides that extracted from different citrus products under mild acidic conditions [1,3,8,10,11]. In food industry, the role of pectin cannot be separated since it mainly
uses as gelling agent [10,12] and stabilizer of acidified milk drinks and yoghurt [13]. Generally, source for pectin are from plant cell like fruit peel, namely banana peel [8,14].

Banana peel contains pectin compounds about 0.9% of their dry weight [15] and about 10-12% pectin along with lignin (6-12%), cellulose (7.6-9.6%) and galacturonic acid [16]. According to Central Statistics Agency, the banana production in 2019 was 7280658 tons which is not yet maximally utilize its economic value [17]. Therefore, there is a potential to increase the value of banana peel in form of pectin as edible coating especially for fruits, cuts or whole one [18-21].

In this work, we extracted pectin from banana peel and compared its pectin with standard value of commercial pectin. In addition, we applied it as edible coating on tomatoes with a variation of edible coating composition and storage temperatures based on their physical condition and firmness.

2. Experimental

2.1 Chemicals and materials
Banana peel was obtained from local farmer and tomatoes was bought from the local market in Surakarta regency. All chemicals, namely HCl, alcohol 96%, carboxymethyl cellulose (CMC), glycerol, potassium sorbate, stearic acid, NaOH, indicator solution PP, commercial pectin, were purchased from PT. Merck Chemicals and Life Sciences, Indonesia and were used as it is.

2.2. Methods

2.2.1 Extraction of pectin from banana peel
A 100 g of Ambon banana peels were cleaned and ground using a blender. After grinding, 1 M HCl solvent was added to the banana peels and they were sterilized at 80 °C for 2 hours. Furthermore, filtering was carried out to separate the sediment from the filtrate.

A 96% of alcohol with a volume ratio (1:1) was added to banana peel pectin filtrate. Pectin precipitated for 24 hours was separated from the filtrate using filter paper. The pectin sediment was dried and weighed. Pectin from banana peel was obtained. Then, the characterization was carried out, namely the water content, ash content, equivalent content, methoxyl content, galacturonic acid content, and esterification degree.

2.2.2 Preparation of edible coating based on pectin
A 500 mL of distilled water was heated with a hot plate to a temperature of 70 °C. Pectin (2% and 10% (w/v)) was dissolved while being stirred for 3 minutes using a spatula assisted with a stirrer for the homogenization process. After that, CMC (2% and 10%) was added and stirred for 3 minutes. After pectin and CMC were homogeneous, glycerol (2% and 10% (w/v)) and potassium sorbet (0.5%(w/v)) were added while continuing to stir. After all chemical compounds had been dissolved, stearic acid (0.5% (w/v)) was added while being stirred until homogeneous. They were then cooled at the room temperature.

2.2.3 Application of edible coating on tomatoes
The edible coating solution was applied by dipping tomatoes 10 minutes. They were then drained and dried at ambient temperature. Storage was carried out at the cold temperature (4-10 °C) and room temperature (28-33 °C). The tomatoes not coated with edible coating solution were stored as the control. Storage was carried out until maturation occurred with the frequency of observation of every three days. Then, an observation of the shrinkage and physical condition of tomatoes was carried out.

2.2.4 Characterization
Pectin obtained from banana peel was tested for its quality based on water content, ash content, equivalent content, methoxyl content, galacturonic acid content, and esterification degree.

3. Results and discussion

3.1 Standard qualities of pectin
The standard qualities of pectin obtained from banana peel was compared with commercial pectin according to the International Pectin Producers Association and the results are shown in Table 1. The yield of pectin in this study was 15.16% which is average compared to other studies. Pagarra et.al extracted pectin using surface method gained 5.79 – 22.57% based on the dry weight of kapok banana peel [22]. In addition, banana cultivar from Bangladesh namely ‘Sagor’ content high pectin about 36.10-46.12% [23]. Lower yields can be caused by the inefficient diffusion of solvent into the peel. Increasing the extraction temperature at sufficient time will increase the solubility of the extracted pectin, thus providing a higher extraction rate [24]. However, studied conducted by Ragab et.al. showed value of that pectin extracted from banana with different pH, time and temperature was 12.77-13.21% [14].

Table 1. Content of Commercial Pectin and Pectin from Ambon Banana

| Quality factors                        | Commercial pectin | Research result |
|----------------------------------------|-------------------|-----------------|
| Methoxyl Content:                      |                   |                 |
| *High methoxyl pectin, %              | >7.12             |                 |
| *Low methoxyl pectin, %               | 2.5-7.12          | 2.60            |
| Galacturonic acid content, % min       | 35                | 41.18           |
| Water content, % max                   | 12                | 4.33            |
| Ash content, % max                     | 10                | 9.40            |
| Esterification degree:                 |                   |                 |
| *High ester pectin, % min             | 50                | 35.92           |
| *Low ester pectin, % max              | 50                |                 |
| Equivalent weight, mg                  | 600-800           | 666.67          |

The water content in pectin from Ambon banana peels is 4.33%. The water content obtained has met the commercial pectin standard according to Food Chemical Codex (1996), namely the commercial pectin moisture content of a maximum of 12%, so the pectin water content of Ambon banana peels is relatively low [25]. Low water content resulted in this study is needed for pectin for safe storage and to inhibit the growth of microorganisms that can affect quality due to the production of the pectinase enzyme [24]. Water content indicates the amount of water contained in pectin. The water content of the material affects the shelf life. High water content causes vulnerability to microbial activity [26].

Ash content produced from Ambon banana peel pectin is 9.40%. Ash content is inorganic residue from the dispersing of organic materials. Ash content indicates the mineral content of a material and the purity of the material. Ash content produced by pectin from Ambon banana peels has met the quality standards of commercial pectin according to Food Chemical Codex (1996) that the maximum commercial pectin ash content is 10%. Low ash content (below 10%) and a maximum limit of ash content at 10% are good criteria for gel formation [25]. Therefore, the ash content found in this experiment shows the purity of pectin. The lower ash content is also one of two criteria controlling the purity of pectin [14, 23].

Equivalent weight is a measure of the content of free galacturonic acid groups (unesterified) in the molecular chain. The equivalent weight produced by pectin from Ambon banana peels is 666.67 mg. The results of equivalent weight in pectin from Ambon banana peels have met the quality standards of commercial pectin according to Food Chemical Codex (1996) that the equivalent weight of commercial pectin is 600-800 mg [25]. In addition, similar results were also reported in which pectin obtained from banana peel calculated from 555.56 – 751.57 mg [14, 23]. The higher the equivalent weight value the better the ability to form gel [14,27].

Ambon banana peel methoxyl content is 2.60%. The obtained methoxyl content is included in the category of low methoxyl content, which is below 7%. The standard limit of commercial pectin quality according to Food Chemical Codex (1996) for the low methoxyl content of commercial pectin is a maximum of 7% [25]. This result also in agreement with one carried out by Ragab et.al. with values of 5.69 and 6.66% [14]. In the contrary, banana peel from Bangladesh gave value of methoxyl content of 12.40 and 26.66% [23]. Pectin methoxyl content
has an important role in determining the functional properties of pectin and can affect the structure and texture of pectin gel, such as pectin solubility and gelling power ability. Higher methoxyl content decrease the polarity of pectin molecules [14].

The galacturonic acid content produced by Ambon banana peel pectin is 41.18%. The galacturonic acid content obtained from Ambon banana peel pectin has met the quality standards of commercial pectin according to Food Chemical Codex (1996) that the minimum content of commercial galacturonic acid pectin is 35% [25]. The galacturonic acid content test is to determine the purity of pectin because galacturonic acid is a constituent of polygalacturonic acid. Polygalacturonic acid is the basic framework of pectin compounds that describe the purity of pectin. The greater the polygalacturonic acid content is, the higher the purity of pectin will be because it has smaller organic contents such as arabinosa, galactose, rhamnosa and other types of sugar.

The value of esterification degree is obtained from methoxyl and galacturonic acid contents. Based on the results of the research, the degree of esterification produced from Ambon banana peel pectin amounted to 35.92% which is of the high category below 50%. According to the commercial pectin quality standard of Food Chemical Codex (1996), the maximum esterification level of commercial pectin is 50%. Then, pectin from Ambon banana peel has good gel forming ability because the higher the degree of esterification is, the better the ability of gel formation [25] will be.

3.2. Characteristic of Edible Coating Solution Application to Tomatoes

3.2.1 Effect of coating concentration and storage temperatures

Observation of the firmness of tomato was evaluated based on shrinkage value of tomato weight at different temperature and coating concentration. It showed an increase in weight shrinkage in tomatoes after experiencing storage until the end of the observation (Table 2).

| Table 2. Shrinkage Value of Tomato Weight at Room Temperature Storage (28-33 °C) |
|---------------------------------|------|------|------|------|------|------|------|
| Day                            | 1    | 3    | 7    | 13   | 14   | 16   | 21   |
| Control (%)                    | 0    | 1.96 | 3.67 | 5.64 | -    | -    | -    |
| Coating 2%, (%)                | 0    | 1.59 | 2.29 | 2.94 | 3.45 | 4.5  | -    |
| Coating 10%, (%)               | 0    | 1.30 | 1.99 | 2.39 | 2.80 | 3.54 | 4.06 |

As shown in Table 2, the concentration of coating treatment influences the increase in tomato weight shrinkage during storage at the room temperature of 28-33 °C. The greatest increase in weight shrinkage was found in the control tomatoes, which were not given edible coating treatment. Without coating, tomato only available until day 13, whilst tomato coated with 10% edible coating lasted for 21 days with weight lost about 4.06%. This is because the higher the concentration of pectin is used; the thickness and darkness of the layers are also higher. Thus, the pores of tomatoes are increasingly closed resulting the pressure of respiration and transpiration processes. The thickness of the layer will affect the permeability of gas and water vapor, so the thicker the coating is, the smaller the permeability of the gas and water vapor will be, and it will protect the product being packaged [12,26]. Furthermore, storage at room temperature for tomato coating treatment of 10% is more durable than that of 2% and without treatment (control).

The observation of shrinkage value of tomato weight at cold temperature storage was also conducted and presented in Table 3.

| Table 3. Shrinkage value of tomato weight at cold temperature storage (4 -10 °C) |
|---------------------------------|------|------|------|------|------|------|
| Day                            | 1    | 3    | 7    | 14   | 21   | 28   |
| Control (%)                    | 0    | 1.86 | 1.73 | 2.64 | 3.37 | 5.15 |
| Coating 2%, (%)                | 0    | 1.46 | 1.61 | 2.38 | 2.94 | 4.52 |
| Coating 10%, (%)               | 0    | 1.21 | 1.34 | 1.73 | 2.42 | 3.95 |
Shrinkage of tomato weight increases as the storage time increases. The highest weight shrinkage was found in the control tomatoes. Increased weight shrinkage in tomatoes is due to transpiration and respiration. The transpiration and respiration processes cause a decrease in water content in the fruit. The transpiration process is water loss due to evaporation. High evaporation is due to differences in water pressure outside and inside the tomatoes. Water pressure inside the material is higher than that outside the material so that moisture will come out of the material. In respiration, there is a burning of sugar or substrate which produces CO$_2$ gas, water and energy. Water, gas, and energy produced in the respiration process will experience evaporation so that the fruit will experience weight shrinkage [12,18,20]. The high weight shrinkage in tomatoes is caused by loss of water and other volatile components from the fruit during storage. There was no barrier that prevented this loss because the control tomatoes were not given an edible coating treatment.

Based on the results, in addition to the concentration variation of the coating treatment on tomatoes, the temperature treatment also affects the shrinkage of tomato weight during storage. This is caused by the ripening process in tomatoes is higher when compared to the process in tomatoes with a coating treatment of 10% at the cold temperature. In other words, the process of metabolism and water loss in tomatoes by coating treatment 2% at the room temperature is faster.

3.2.2 Observation of tomato physical condition

The observation results of the last physical condition of tomatoes that have been given edible coating treatment for room temperature storage can be seen in Figure 1 below.

![Figure 1](image)

**Figure 1.** The physical condition of tomato at room temperature (28-33 °C)

Tomatoes without treatment (control) in the room temperature storage only last for 13 days with the physical condition of the rotten parts of tomatoes (brown spots appear). Meanwhile tomatoes with 2% of edible coating treatment last for 16 days with the physical condition of tomatoes with spot signs of rotting. These spots may be bacteria that will spoil the tomatoes. The 10% of edible coating treatment lasts the longest that is 21 days with the condition of fresh tomatoes, but the black spots are signs of rotting. The 10% of coating treatment has a longer shelf life than the 2% of coating and without treatment (control).

Compared to the physical condition of tomato stored at cold temperature of 4-10 °C, all tomatoes were able to be observed until day 28. Tomato without edible coating (control) showed wrinkled skin. As for tomato with 2% of edible coating treatment sign of rotting was appeared after 28 days. The 10% of edible coated tomato also had wrinkled skin however after cutting opened the tomato meat is still tick and fresh. This suggested that cold temperature storage showed no difference at keeping the freshness of tomatoes for both control and edible coated.

![Control Coating 2% Coating 10%](image)
Day -28  Day -28  Day -28

**Figure 2.** Physical condition of tomato at the cold temperature of 4-10 °C

4. Conclusion

Extraction from banana peel yields pectin of 15.16%, water content of 4.33%, ash content of 9.40%, equivalent weight of 666.67 mg, methoxyl content of 2.60%, and galacturonic acid content of 41.18 %. These have met the 2002 International Quality Pectin Producers Association (IPPA) standard. Tomatoes with 10% of coating treatment in the cold temperature storage (4-10 °C) have longer shelf life than those with 10% of coating treatment in the room temperature storage (28-33 °C). In addition, the tomatoes with 10% of coating treatment in the room and cold temperature storage are better in maintaining their freshness compared to those with 2% of coating treatment and those without coating seen from the value of weight shrinkage.

Acknowledgment

The authors would like to thank the Universitas Sebelas Maret, Surakarta – Indonesia for the funding through Penelitian Unggulan, PNBP 2020 with contract number 452/UN27.21/PN/2020.

References

[1] Ragnav P.K, Agarwal N, and Saini M 2016 *IJSRME* 1(1) 188
[2] Xing Y, Li W, Wang Q, Li X, Xu Q, Guo X, Bi X, Liu X, Shui Y, Lin H and Yang H 2019 *Molecules* **24** 1695
[3] Dhall R.K 2013 *Crit Rev Food Sci Nutr* **53** 435
[4] Li J, Li Q, Lei X, Tian W, Cao J, Jiang W and Wang M 2018 *J.Food Qual.* **9351821** 1
[5] Nowshad F, Islam Md N, and Khan M.S 2018 *Agric. Food Secur.* **7** 17
[6] Mamun M.A.A, Rahman M.A, Zaman M.K, Ferdousi Z, and Abu Reza M 2014 *IOSRJESTFT* **8**(9) 47
[7] Lirin Mary M.K, Nipu Sam P.G, and Kavya R 2019 *EJPMR* **6**(3) 194
[8] Valdes A, Burgos N, Jimenez A, and Garrigos M.C 2015 *Coatings* **5** 865
[9] Mhd Haniffa M.A.C, Ching Y.C, Abdullah L.C, Poh S.C, and Chuah C.H 2016 *Polymers* **8** 246
[10] Misra R.K, Banthia A.K, and Majeed A.B.A 2012 *Asian J Pharm Clin Res* **5**(4) 1
[11] Kantha S, Vijaya N, Pandeeswari R and Premalatha M 2016 *IRJET* **3**(7) 1385
[12] Sucheta S, Chatyrevdi K, Sharma N, and Yadav S.K 2019 *Int. J. Biol. Macromol.* **133** 284
[13] Willats W.G.T, Knox J.P, and Mikkelsen J.D 2006 *Trends Food Sci Technol* **17** 97
[14] Ragab M, Osman M.F, Khalil M.E and Gauda M.S 2016 *J. Agric. Res. Kafir El-Sheikh Univ.* **42**(4) 88
[15] Tchobanoglous G, Theisen H, and Vigil S 1993 *Integrated Solid Waste Management: Engineering Principles and Management Issues*, McGraw-Hill pp. 3-22
[16] Mohapatra D, Mishra S, and Sutar N 2010 *J Sci Ind Res India* **69** 323
[17] Badan Pusat Statistik 2020 [https://www.bps.go.id/indicator/55/62/1/produksi-tanaman-buah-buahan.html](https://www.bps.go.id/indicator/55/62/1/produksi-tanaman-buah-buahan.html) accessed on October 23rd 2020.
[18] Maftoonazad N and Ramaswamy H.S 2019 *Coatings* **9** 285
[19] Kundu P, Adhikary N.K, and Maji S 2020 *CJAST* **39**(27) 116
[20] Shehata S.A, Abdeldaym E.A, Ali M.R, Mohamed R.M, Bob R.I and Abdelgawad K.F 2020 *Agronomy* **10** 1466
[21] Al Tayyar N.A, Youssef A.M, and Al-Hindi R.R 2020 *SM&T* **26** e00215
[22] Pagarra H, Hartati, Purnamasari A.B, Rachmawaty and Rahman R.A 2019 *IOP Conf. Series: Journal of Physics: Conf. Series* **1317** 012100
[23] Sarker B.C, Ahmed H, Fancy R, Bhadhury S.K, and Anika Z 2020 *AJAAR* **14**(2) 9
[24] Tanaid R.A 2018 *IJFE* **4** 308
[25] Committee of Food Chemicals Codex 1996 *Institute of Medicine, National Academy of Science* 4th ed. Washington D.C: National Academy Press.

[26] Muhmadzadeh J, Sadeghi-Mahoonak A.R, Yaghbani M, and Aalami M 2010 *World Appl. Sci. J.* 8 21

[27] Shaha R.K, Nayagi Y, Punichelvana A, and Afandi A 2013 *Res J Agr Forest Sci* 1(2) 1