International Journal on Food, Agriculture, and Natural Resources
Volume 05, Issue 04, Page 53-59
ISSN: 2722-4066
http://www.fanres.org

Original Paper

Effect of Porang Glucomannan Flour Formulation on the Characteristics of the Edible Coating Solution and The Quality of Manalagi Apples during Storage

Andrew Setiawan Rusdianto[1], Winda Amilia[1], Dewi Arum Puspitania[1]*
Departement of Agroindustrial Technology, Faculty of Agricultural Technology, University of Jember, Indonesia, 68121.
*) *Corresponding Author: andrew.ftp@unej.ac.id*

Received: 21 May 2024; Revised: 22 October 2024; Accepted: 06 December 2024
DOI: *https://doi.org/10.46676/ij-fanres.v5i4.346*

***Abstract*— Manalagi apples are an agricultural product that is easily damaged. Damage that occurs to Manalagi apples can be inhibited with an edible coating. The edible coating is a coating on the surface of fruit that can maintain quality and extend shelf life. Edible coatings can be made from hydrocolloids, including porang glucomannan. This research aims to determine the quality characteristics of Manalagi apples after being coated with an edible coating. Apart from that, to analyze the effect of glucomannan flour concentration on the quality characteristics of Manalagi apples, the viscosity of the edible coating solution, and the characteristics of the resulting coating and to choose the best treatment using the multiple attribute method. This research uses a Completely Randomized Design (RAL) with three replications. The treatment in this study was a glucomannan flour formulation of 5 levels, namely A0 (without treatment), A1 (0.5%), A2 (0.75%), A3 (1%), A4 (1.25%), carried out for storage for 7 days and observed on days 1, 3, 5, and 7 at room temperature (± 25°C). Porang glucomannan flour in edible coating significantly affected in respiration rate but had no significant effect on weight loss, L color, b color, and total dissolved solids. The best treatment based on calculation results using the multiple attribute method is A2 (0.75%) with the lowest weight loss was 2.97%, the highest L color with a value of 80, the lowest b color with a value of 15.1, the lowest total dissolved solids with a value of 11.6°Brix, the lowest respiration rate with a value of 0.006 ml CO_2/gr/hour.**

Keywords*— Edible coating, manalagi apples, porang glucomannan

I. Introduction

Manalagi apples (Malus sylvestris) are one of the apple varieties originating from Malang City. The characteristics of Manalagi apples include yellowish green skin, yellowish white flesh, round shape and sweet taste. Manalagi apple flesh is crunchier compared to other Malang apple varieties such as Rome Beauty and Anna [1]. Manalagi apples are one of the superior local apple varieties in the Indonesian market because they have a sweet taste, high nutritional content, are easy to obtain, and have an affordable price. According to the East Java Central Statistics Agency [2], apple production in 2022 in East Java will reach 523.326 tons and can increase every year. Apple production centers in Indonesia are in Malang (Poncokusumo), Batu and Pasuruan. The apples produced are sold in the Batu, Malang, Surabaya, Jember, Semarang, Jakarta and Bali areas [3]. The process of distributing apples to sales areas takes quite a long time. This distribution process will result in Manalagi apples experiencing a decrease in freshness and quality so that the apples will quickly experience damage and rot.

Manalagi apples are generally marketed on display at room temperature so that their freshness and quality easily decrease. Apples are climacteric fruits that still undergo respiration and transpiration processes after the harvesting process [4]. Apart from that, damage to apples can also be caused by gas diffusion into and outside the fruit which occurs through lenticels which are all over the surface of the fruit. The natural gas diffusion process can be inhibited by the wax layer on the surface of the fruit. However, if the wax layer decreases or disappears, the gas diffusion process will become increasingly uncontrolled, causing the respiration rate to increase [5]. The shelf life of Manalagi apples can be extended by cooling or packaging and storage in a controlled atmosphere. However, the weakness of cooling is that it requires high investment costs, while the use of plastic will cause damage to the fruit because the nature of plastic is not resistant to high temperatures and it will easily build up water vapor in it [6].

Edible coating is one method that can be used with the aim of extending the shelf life and improving the quality of fresh ingredients after the harvesting process which are stored at room temperature. Edible coating is applied by coating it onto the surface of the fruit and can be consumed together. The principle of applying edible coating is to slow down the process of evaporation, respiration, prevent the development of spoilage microorganisms, and delay maturity caused by inhibiting O2 and CO2 gases and dissolved substances by optimizing the movement of the semipermeable membrane around the fruit [7]. Edible coating is used to prevent biological damage to materials such as damage caused by fungi and pathogens to fruit and can reduce the aw (activity water) on the surface of the material so that damage by microorganisms can be avoided. The materials used to make edible coatings are hydrocolloids, one of which is polysaccharide based. One of the polysaccharides that has the potential to be used as an edible coating is porang glucomannan.

Glucomannan is a polysaccharide hydrocolloid composed of 33% D-glucose and 67% D-mannose. Glucomannan content in porang is very high reaching 45%-65% [8]. Porang glucomannan can form a gel, form a thin layer (film) that has high swelling power, elastic, can be consumed and is transparent so it has the potential to be used as an edible coating material. Glucomannan edible coating on porang had a significant effect on the respiration rate of minimally processed papaya fruit during the storage process [9]. Glucomannan edible coating can maintain the quality of curly chilies such as texture, color, weight loss and vitamin C content [10]. Glucomannan with pineapple extract is effective in inhibiting browning in apples cut during storage [11]. Based on several studies that have been carried out previously, this research was carried out by determining the optimal porang glucomannan formulation for making edible coatings by observing the quality characteristics which include weight loss, color change, total dissolved solids, and respiration rate in Manalagi apples for 7 storage days. Apart from that, visual observations were also made of the layers produced on the surface of the apples and measurements viscosity of the solution in the specified formulation.

II. Materials and Method

A. Time and Place

This research commenced from January to March 2024. This research was conducted at the Industrial Technology and Environmental Engineering Laboratory, Faculty of Agricultural Technology, University of Jember.

B. Methods

Tools used include analytical balance, color reader, thermometer, Ostwald viscometer, hand refractometer, pycnometer, puff, water bath, volume pipette, zip lock plastic, thin wall box 500 ml, blender, dropper pipette, erlenmeyer, glass beaker, iron spatula, spatula, burette, spoon, label paper, stainless steel knife, aluminum foil, scissors, glass bottle, ¼ inch diameter water hose, SPSS software 25, and Microsoft Excel 2019.

Materials used are porang tuber glucomannan flour (Ikarie), distilled water, Manalagi Apples obtained from the Ambulu fruit market with an average harvest age of two days after arriving from the distributor, phenolphthalein indicators (Sentra Kimia), NaOH 0.1 N (Rofa), HCl 0.1 N (Rofa).

C. Research

This study used a Completely Randomized Design (RAL) with 1 factor. The factor is formulas of glucomannan namely A0 (no treatment), A1 (0.5%), A2 (0.75%), A3 (1%), and A4 (1.25%). The research was repeated 3 times in each treatment. Application is carried out using the dipping method and stored for 7 days at room temperature (± 25°C). The treats and code used is in (Table I):

TABLE I. Treatment Of Edible Coating Glucomannan Flour

Code	Glucomannan Flour Formulation (b/v)
A0	no treatment
A1	0,5%
A2	0,75%
A3	1%
A4	1,25%

D. Research Stage

Preparation of the coating solution

Porang glucomannan flour is weighed at 1 gr, 1.5 gr, 2 gr, and 2.5 gr. Then dissolve using 200 ml of distilled water and stir until evenly homogeneous using a glass spatula. Then the solution was heated in a water bath at 80℃ for 5 minutes [12]. After that, please leave it to a temperature of 40℃.

Application of the coating solution

Applying edible coating begins by selecting fresh Manalagi apples, without defect, and no rotten. Manalagi apples are washed with water to remove dirt and drain until dry. After the temperature of the edible coating solution has reached 40℃, the dried Manalagi apples are coated with the solution using the dipping method and dried for 24 hours.

E. Analysis Procedure for Parameters Assessment

Weight Loss

Weight loss measurements using the gravimetric method [13]. Samples were weighed using an analytical balance during storage. The weight loss was calculated as follows Eq (1) :

$$W\ (\%) = \frac{(mi-mt)}{mi} \times 100\% \qquad (1)$$

Where W is the weight loss, mi is the initial weight and mt is the final weight.

Color

Color measurements use a color reader by placing the sample in a clear zip lock plastic on a flat surface and pressing the measure button. Measurements were carried out at 3 different points to get more accurate results. The measurement point must be the same from the beginning of the measurement to the end. The measurements were expressed as L^* values (dark to light), and b^* represented blueness to yellowness [14].

Total Dissolved Solid

Total dissolved solids were measured using a refractometer. Measurement of total dissolved solids was carried out using a destructive method. The flesh of the Manalagi apple is crushed, and then the juice is dripped onto the prism of the refractometer. Total dissolved solids are expressed in °Brix [15].

Respiration Rate

The respiration rate was tested using the titration method with modifications to the ripening stage. Respiration rate measurement must be in a tight condition and not exposed to oxygen. The respiration rate was calculated as follows Eq (2) :

$$Respiration\ rate = \frac{(t\ sample - t\ blanko)\ x\ N\ HCl}{sample\ weight\ /\ ripening\ time} \qquad (2)$$

Where t is the amount of titration solution used and N is normality. The apples that have been treated are placed into a plastic container equipped with a small hose and then flowed into a glass bottle filled with 25 ml of 0.1N NaOH. After 6 hours, the 0.1N NaOH solution, which had bound CO_2 was added with 2 drops of Phenolphthalein indicator and titrated with 0.1N HCl solution until the appearance was clear [16].

Viscosity

The viscosity of the edible coating solution was measured using an Ostwald viscometer. The viscometer washed and dried is then filled with an edible coating solution at a temperature of 40°C. The edible coating solution is inserted into the viscometer to the initial limit. The flow time from start to finish is calculated using a stopwatch. The viscosity was calculated as follows Eq (3):

$$\frac{\eta_1}{\eta_2} = \frac{\rho_1 . t_1}{\rho_2 . t_2} \quad (3)$$

Where η_1 and η_2 is the viscosity of the reference solution and viscosity of the solution being tested. ρ_1 and ρ_2 is the specific gravity of the reference solution and specific gravity of the solution being tested. t_1 and t_2 is the time required for the comparison solution and time required for the solution to be tested [17].

F. *Data Analysis*

The research results were analyzed statistically using ANOVA analysis of variance with a significance level of 5% using the SPSS software. If there is a significant difference in treatment continue with Duncan's New Multiple Range Test (DMRT) analysis at $P \leq 0.05$. The selection of the best treatment using the multiple attribute method [18].

III. Results And Discussion

A. *Weight Loss*

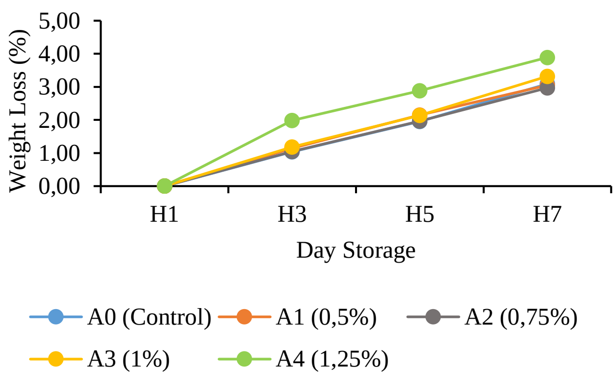

Fig. 1. The result of calculating weight loss on Manalagi apples

The research results indicate that treating Manalagi apples with an edible coating made from porang glucomannan flour did not lead to a different response in terms of weight loss during storage. This shows that the concentration of glucomannan has not been able to prevent the evaporation of water. The results of ANOVA calculations showed that the porang glucomannan formulation in the edible coating on the quality of Manalagi apples during 7 days of storage had no significant effect on weight loss (Sig. > 0.05).

Manalagi apples with all treatments experience water loss every day caused by respiration and transpiration processes. Apples are a climacteric type of fruit that undergoes respiration and transpiration processes even though it has been harvested. The respiration process will result in the burning of sugar which produces CO_2, water, and energy. The components produced will experience evaporation so that the fruit will experience weight loss. Meanwhile, during the transpiration process, water loss due to evaporation will occur. High evaporation occurs because there is a difference in water pressure outside and inside the fruit skin so that water vapor comes out [19]. Water loss will have a direct effect on the texture, nutrient content, wilting, and surface shrinkage of the fruit [20]. A high weight loss value indicates that more weight or water is lost in Manalagi Apples.

B. *L* Color*

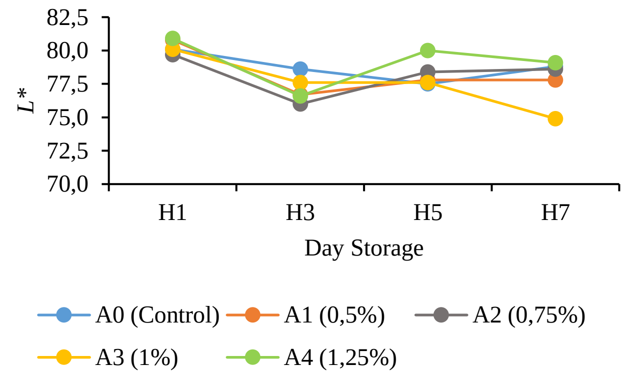

Fig. 2. The result of measuring *L** color on Manalagi apples

The research results indicate that treating Manalagi apples with an edible coating made from porang glucomannan flour did not lead to a different response in terms of *L** color during storage. This shows that the concentration of glucomannan has not been able to prevent the color change process. The results of ANOVA calculations show that the porang glucomannan formulation in edible coating on the quality of Manalagi apples during 7 days of storage had no significant effect on *L** color (Sig. > 0.05).

Manalagi apples with all treatments experienced an average change in *L** color every day which was caused by the degradation process of the chlorophyll pigment in Manalagi apples. The lost chlorophyll will break down into carotenoids which accelerate the color change to a darker color [21]. Carotenoid color pigments will experience changes during the storage process caused by enzymatic isomerization and oxidation processes. Color changes are caused by the activity of microorganisms which cause pigment damage as a result of cutting the pigment structure into other simpler components so that the color changes to a darker color [22]. The activity of microorganisms can also damage the tissue and lignin layer, which is the layer that makes the surface of the fruit brighter and shiny so that the brightness of the fruit can decrease and over time it will turn blackish brown [23].

The color of Manalagi apples changes over time due to the degradation of chlorophyll pigment, which breaks down into carotenoids, causing the apples to darken. This process is accelerated by enzymatic isomerization and oxidation [21]. Microorganisms also contribute to changes in color by damaging the pigment structure and the fruit's tissue. This results in a darker color, and decreased brightness, and eventually causes the fruit to turn blackish-brown over time.

C. b Color*

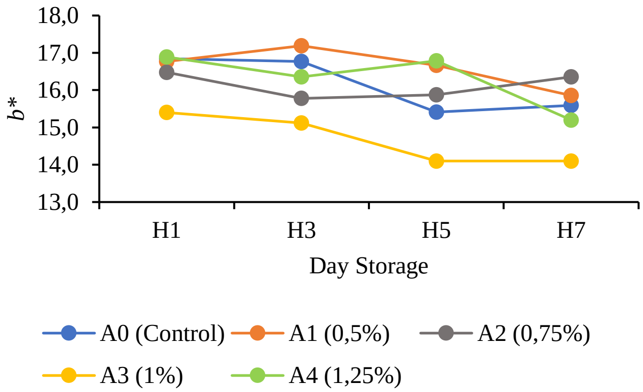

Fig. 3. The result of measuring *b** color on Manalagi apples

The research results indicate that treating Manalagi apples with an edible coating made from porang glucomannan flour did not lead to a different response in terms of *b** color during storage. This shows that the concentration of glucomannan has not been able to prevent the color change process. The results of ANOVA calculations show that the porang glucomannan formulation in edible coating on the quality of Manalagi apples during 7 days of storage had no significant effect on *b** color (Sig. > 0.05).

Manalagi apples with all treatments experienced color change every day caused by the degradation process of the chlorophyll pigment in Manalagi apples. The decreasing color b indicates that the yellow color of the Manalagi apple is fading. Manalagi apples have chlorophyll pigment which can fade during the ripening process, causing a color change from green to yellow [24]. Longer storage will damage skin tissue due to the respiration and transpiration processes in apples which cause contact between polyphenol compounds and oxygen. Polyphenol oxidase helps the browning process enzymatically, producing brown quinone compounds.

D. Total Dissolved Solid

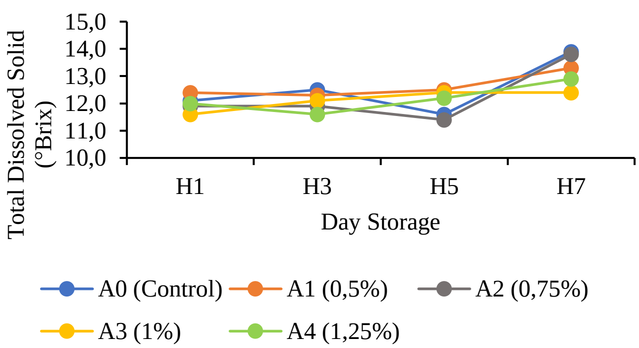

Fig. 4. The result of measuring total dissolved solid on Manalagi apples

The research results indicate that treating Manalagi apples with an edible coating made from porang glucomannan flour did not lead to a different response in terms of total dissolved solid during storage. This shows that the concentration of glucomannan has not been able to prevent the color change process. The results of ANOVA calculations show that the porang glucomannan formulation in edible coating on the quality of Manalagi apples during 7 days of storage had no significant effect on total dissolved solid (Sig. > 0.05).

The results showed that the total dissolved solids in apples experienced fluctuations. The increase in total dissolved solids in Manalagi apples during storage occurs due to the transpiration process, namely the release of water from the apples and then accumulating as water vapor so that the dissolved materials will also come out of the cells. The increase in sugar during storage is caused by the availability of starch which can still be broken down into sugar. The increase in total sugar was caused by starch degradation, while the decrease occurred because some of the sugar was used for the respiration process [9]. The fluctuating total dissolved solids results were also caused by the measurement of total dissolved solids being carried out destructive method where different samples of apples were used during observation. Fruit ripeness can also be indicated by sugar and acid levels. Young fruit contains more acid, while older fruit becomes less acidic and sweeter [25].

E. Respiration Rate

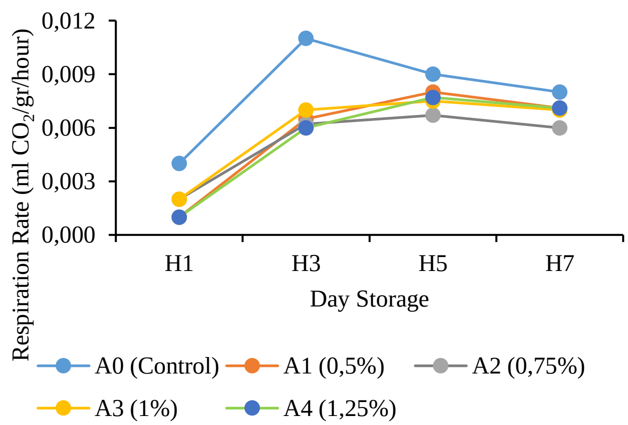

Fig. 5. The result of calculating respiration rate on Manalagi apples

The respiration rate of Manalagi apples increased and decreased. This is because apples are climacteric fruits. The respiration rate pattern of climacteric fruit is that the fruit will experience a peak respiration rate and then experience a decrease in the respiration rate [19]. The results of ANOVA calculations show that the porang glucomannan formulation in edible coating on the quality of Manalagi apples during 1 and 3 days of storage has a significant effect on the respiration rate (Sig. < 0.05). The results are followed by the Duncan Test.

Manalagi apples with control treatment (A0) experienced an earlier peak respiration rate compared to Manalagi apples with edible coating. Manalagi apples without coating showed that the respiration rate increased on the 3rd day and decreased on the 5th and 7th days. Meanwhile, for Manalagi apples with edible coating, the respiration rate increased on the 5th day and decreased on the 7th day. This shows that coating with porang glucomannan edible coating can delay the peak respiration rate of Manalagi apple fruit during storage. Edible coatings are able to block oxygen from entering for respiratory activities and limit the diffusion of carbon dioxide out of the tissue [26]. The edible coating of porang glucomannan flour can inhibit the evaporation of water from apples after the heating process. This is because porang glucomannan has hydrophobic properties caused by the deacetylation process using alkali or a base accompanied by heating [12]. With these properties, Porang glucomannan edible coating can prevent dehydration, fat oxidation and browning on the surface and can reduce respiration rates by controlling the composition of carbon dioxide and oxygen gases in the atmosphere [19]. The concentration of edible coating used must be considered because if the concentration of edible coating is too high it will produce a solution that is too thick so that the use of edible coating will be more difficult and can cause anaerobic respiration which will cause faster damage [27]. The lowest respiration rate was experienced by Manalagi A2 apples with a porang glucomannan concentration of 0.75%.

F. *Viscosity*

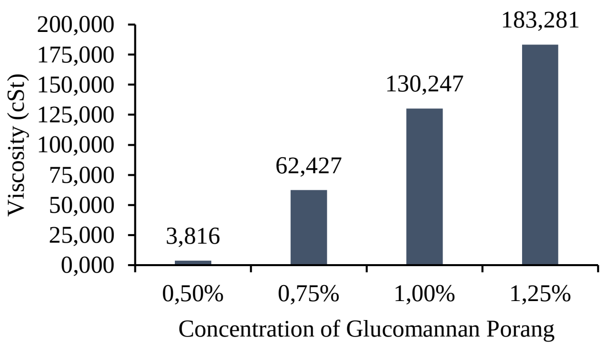

Fig. 6. The result of calculating viscosity on edible coating solution

Viscosity is the thickness of a liquid. Measuring the viscosity of porang glucomannan edible coating is very important because it affects the resulting coating. The higher the concentration of porang glucomannan used, the higher the viscosity of the edible coating solution. This is because porang glucomannan flour is a polysaccharide hydrocolloid which is able to bind water, causing the formation of a thicker solution. The mechanism that occurs in this thickening process is that the D-glucose and D-mannose in the glucomannan granules are connected by hydrogen bonds [29]. If the glucomannan granules are heated it will cause the hydrogen bonds to break so that water enters the glucomannan granules. The incoming water will form hydrogen bonds with D-glucose and D-mannose. The seepage of water into the granules causes the glucomannan granules to swell. This causes the solution to become more stable and the viscosity to increase. The optimal viscosity value for a good edible coating is 113-255 cSt [24].

An increase in the viscosity of the porang glucomannan edible coating solution was followed by a faster gel formation time and a stronger and firmer tissue structure. The formation of hydrophobic glucomannan gel is caused by the diacetylation process using alkali or base accompanied by heating. Glucomannan will lose its acetyl group in alkaline conditions which causes an increase in hydrophobic interactions. Glucomannan which loses the acetyl group then gathers and combines with hydrogen bonds and the glucomannan chain will form new bonds. The alkali contained in glucomannan flour is sodium chloride (NaCl) which is used to remove calcium oxalate in porang tubers. NaCl solution can reduce calcium oxalate levels in porang due to the ionization process of NaCl in water into Na+ ions and Cl- ions [30]. Negative ion in NaCl will increase the hydrophobic interaction in the heated glucomannan solution. Negative ion cause salinity and increase the hydrophobicity of the glucomannan matrix in water, thereby helping the solution transition into glucomannan gel [31].

G. *Characteristics of the Edible Coating Solution After Application to the Apple Surface*

Fig. 7. Apples that have been coated with edible coating. a. A1. b. A2. c. A3. d. A4

The layer produced when applying edible coating is closely related to the viscosity of the solution. Edible coating solutions formulations A1 and A2 cannot coat the surface of apples evenly, while formulations A3 and A4 can coat the surface of apples evenly. This is because the viscosity of solutions A3 and A4 is higher than that of A1 and A2. Edible coating solution that is too dilute will result in less than perfect coating results, while an edible coating solution that is too thick will result in a coating result that is too thick [28]. Apart from that, the uneven coating on the surface of Manalagi apples is caused by the fact that the cohesive force of the glucomannan solution on the surface of the apple is very high, so that the surface of the fruit and the edible coating solution cannot adhere well at low glucomannan concentrations. The higher the concentration of glucomannan used, the lower the cohesive force produced. This is because the structure of glucomannan is denser at high concentrations due to the deacetylation process of the glucomannan chain after heating. Glucomannan, which loses its acetyl group in an alkaline state, will gather with each other and join with hydrogen bonds and form new bonds in the form of a hydrophobic gel.

Apples that have been coated with porang glucomannan edible coating are then dried at room temperature for 24 hours. After drying, the edible coating solution will form a thin film that coats the surface of the Manalagi apple. This thin layer will become a barrier to oxygen and carbon dioxide which can speed up the rate of respiration. Manalagi apples with A1, A2 and A3 formulations can dry within 24 hours, while Manalagi apples with A4 formulation dry within 48 hours. Edible coating that has not dried is indicated by the presence of lumps at the bottom of the apple. This is because the A4 formulation has a very high viscosity so it takes longer for the edible coating to dry completely. High viscosity in edible coatings will require a longer time in the drying process and formation of a layer on the surface of the product [32].

Fig. 8. Apples that have been coated with edible coating after drying. a. A1. b. A2. c. A3. d. A4

H. Best Treatment

Based on the results of calculations using the multiple attribute method, A2 was selected as the best formulation. Manalagi A2 apples showed the lowest weight loss of 2.97%, the highest L* color with a value of 80, the lowest b* color with a value of 15.1, the lowest total dissolved solids with a value of 11.6 °Brix, the lowest respiration rate with a value of 0.006 ml CO2/gr/hour (Table II).

TABLE II. BEST TREATMENT

Parameters	Criteria	Value	Best treatment
Weight loss (%)	Minimal	2.97	A2*
*L** color	Maximal	80	A4
*b** color	Minimal	15.1	A3
Total dissolved solid (°Brix)	Minimal	11.6	A4
Respiration rate (ml CO_2/gr/hour)	Minimal	0.006	A2*

*Formulation with the best treatment based on calculation results using the multiple attribute method

The characteristics produced by the edible coating solution formulation A2 are viscosity with a value of 62.427 cSt. The advantage of the A2 formulation is that the applied coating can dry for 24 hours. If used in large scale industry, it will greatly save costs because it only requires a small amount of material and the resulting layer is very thin, while the disadvantage is that the resulting coating is uneven. Edible coating solutions with A3 and A4 formulations have a viscosity in accordance with standards, namely 113 – 225 cSt. However, the drawback is that the resulting layer is too thick so that anaerobic respiration will occur in the apples which causes rotting to occur more quickly. If applied to large-scale industry, there will be waste in the solution used and the costs incurred will be higher.

IV. CONCLUSIONS

The result showed that low glucomannan concentrations produce thin coating layers and low viscosity, while the highest glucomannan concentrations produce thick coating layers and high viscosity. The glucomannan concentration of porang has a significant effect on the respiration rate of Manalagi apples during 7 days of storage by slowing down the respiration rate during 2 days of storage compared to control Manalagi apples. Meanwhile, the weight loss parameters, L* color, b* color, and total dissolved solids did not have a significant effect. The best treatment based on the results of the Multiple Attribute method calculation that can be developed is treatment A2

REFERENCES

[1] Rahayu, J. N., Fauziyah, E., & Ariyani, A. H. 2012. Preferensi konsumen terhadap buah apel impor di toko buah Hokky dan pasar tradisional Ampel Surabaya. *Agriekonomika*. 1(1): pp:52–67.

[2] Badan Pusat Statistik. 2023. Produksi Buah-buahan Alpukat, Anggur, Apel Menurut Kabupaten/Kota dan Jenis Tanaman di Provinsi Jawa Timur (kwintal), 2021 dan 2022. [Accessed February 28, 2024]

[3] Arifin, M. 2016. *Apel yang Dijual di Batu dan Malang Berasal dari Tutur Pasuruan*. DetikFinance. https://finance.detik.com/industri/d-3206728/apel-yang-dijual-di-batu-dan-malang-berasal-dari-tutur-pasuruan. [Accessed March 02, 2024]

[4] Arti, I. M., & Manurung, A. N. H. 2018. Pengaruh etilen apel dan daun mangga pada pematangan buah pisang kepok (Musa paradisiaca formatypica). *Jurnal Pertanian Presisi*. 2(2): pp: 77–88.

[5] Usni, A., Karo-Karo, T., & Yusraini, E. 2016. Pengaruh *edible coating* berbasis pati kulit umbi kayu terhadap kualitas dan umur simpan buah jambu biji merah pada suhu kamar. *Jurnal Rekayasa Pangan Dan Pertanian*. 4(3): pp: 293–303.

[6] Husna, U. M. 2022. Pengaruh lama pencelupan alpukat mentega (persea americana mill) pada *edible coating* pati kulit singkong terhadap kualitas selama masa penyimpanan. *Skripsi*. Universitas Lampung.

[7] Kohar, T. A., Yusmarini, & Ayu, D. F. 2018. Aplikasi *edible coating* lidah buaya (Alove Vera L.) Dengan penambahan karagenan terhadap kualitas buah jambu biji (Psidium Guajava L.). *Sagu*. 17(1): pp: 29–39.

[8] Sari, R., & Suhartati. 2015. Tumbuhan Porang: Prospek Budidaya Sebagai Salah Satu Sistem Agroforestry. *Buletin Eboni*. 12(2): pp : 97–110.

[9] Hutauruk, B., Renate, D., & Hasnah, N. 2021. Pengaruh pemberian pelapis edibel dari glukomanan terhadap mutu dan umur simpan buah pepaya (Carica Papaya L.) terolah minimal pada suhu dingin. *Skripsi*. Universitas Jambi.

[10] Rusdianto, A.S., Purnamasari, D.A & Herlina. 2024. Characterization of Bubble Pearls from a Mixture of Tapioca and Glucomannan. *International Journal on Food, Agriculture, and Natural Resources*. 05(02): pp: 44-53.

[11] Supapvanich, S., Prathaan, P., & Tepsorn, R. 2012. Browning inhibition in fresh-cut rose apple fruit cv. Taaptimjaan using konjac glucomannan *coating* incorporated with pineapple fruit extract. *Postharvest Biology and Technology*. 73(1): pp: 46–49.

[12] Heldiyanti, R., Zuhriatika Rasyda, R., & Putri, D. A. 2022. Effect Of Glucomannan Concentration as an *Edible coating* On Moisture Content of Seaweed Dodol During Storage. *Food and Agro-Industry Jornal*. 3(1): pp: 46–54.

[13] Marlina, L., Purwanto, Y. A., & Ahmad, U. 2014. Aplikasi Pelapisan Kitosan dan Lilin Lebah untukMeningkatkan Umur Simpan Salak Pondoh. *Jurnal Keteknikan Pertanian*. 2(1): pp: 65–72.

[14] Hung, D. Van, Tong, S., Tanaka, F., Yasunaga, E., Hamanaka, D., Hiruma, N., & Uchino, T. 2011. Controlling the weight loss of fresh produce during postharvest storage under a nano-size mist environment. *Journal of Food Engineering*. 106(4): pp: 325–330.

[15] Javanmardi, J., & Kubota, C. 2006. Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. *Postharvest Biology and Technology*. 41(2): pp: 151–155.

[16] Hasbullah, R. 2007. Teknik pengukuran laju respirasi produk hortikultura pada kondisi amosfir tekendali. *Jurnal Keteknikan Pertanian*. 21(4): pp: 419–428.

[17] Togatorop, E., Erdawati, & Priyanto, S. 2019. Karakterisasi minyak hasil pirolisis berbahan dasar serut gergaji kayu akasia (Acacia mangium) dengan variasi suhu pada pirolisis. *Jurnal Riset Sains Dan Kimia Terapan*. 9(1): pp: 1–7.

[18] Zeleny, M. 1982. *Multiple Criteria Decision Making*. New York: Mc Graw Hill.

[19] Amalia, U. N., Maharani, S., & Istiqomah Widiaputri, S. 2020. Aplikasi *edible coating* pati umbi porang dengan penambahan ekstrak lengkuas pada buah pisang. *Edufortech*. 5(1): pp: 37–43.

[20] Kusumiyati, Farida, Sutari, W., Hamdani, & Mubarok. 2018. Pengaruh waktu simpan terhadap nilai total padatan terlarut, kekerasan dan susut bobot buah mangga arumanis. *Jurnal Kultivasi*. 17(3): pp: 766–771.

[21] Esmeralda, M., Renate, D., & Leila Rahmi, S. 2016. Pengaruh suhu dan lama penyimpanan terhadap karakteristik produk cabai merah giling. *Pengaruh Suhu dan Lama Penyimpanan Terhadap Karakteristik Produk Cabai Merah Giling*. Universitas Jambi.

[22] Siswati. 2014. Pengaruh penambahan kulit buah melinjo dan lama penyimpanan terhadap kualitas puree cabai merah keriting (Capsicum anum L.). *Skripsi*. Universitas Jambi.

[23] Hesthiati, E., Kumalasari, A. R., Rawiniwati, W., & Inkorena. 2023. Penggunaan beberapa jenis pati sebagai *edible coating* untuk memperpanjang umur simpan buah belimbing. *Seminar Nasional UNS*. 7(1): pp: 2615–7721.

[24] Anggarini, D., Hidayat, N., & Mulyadi, A. F. 2016. Pemanfaatan pati ganyong sebagai bahan baku *edible coating* dan aplikasinya pada penyimpanan buah apel anna (Malus sylvestris) (Kajian konsentrasi pati ganyong dan gliserol). *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*. 5(1): pp: 1–8

[25] Lastriyanto, A., Sumardi, Y., & Melati, R. M. 2016. Karakterisasi kimia keripik Apel Manalagi hasil penggorengan vakum dengan menggunakan minyak goreng berulang. *Jurnal Keteknikan Pertanian Tropis Dan Biosistem*. 4(2): pp: 157–172.

[26] Moalemiyan, M., & Ramaswamy, H. 2012. Quality retention and shelf-life extension in mediterranean cucumbers coated with a pectin-based film. *Journal of Food Research*. 1(3): pp: 159.

[27] Rusmanto, E., Rahim, A., & Hutomo, G. S. 2017. Karakteristik fisik dan kimia buah tomat hasil pelapisan dengan pati talas. *E-J. Agrotekbis*. 5(5): pp: 531–540.

[28] Qotimah, K., Dewi, E. N., & Suharto, S. 2022. Pengaruh *edible coating* berbasis gelatin-alginat terhadap kemunduran mutu bakso ikan lele (Clarias sp.) pada penyimpanan suhu ruang. *Jurnal Ilmu Dan Teknologi Perikanan*. 4(2): pp: 93–99.

[29] Fitri, E. 2023. Uji efektivitas carboxymethyl cellulose (CMC) dan pektin sebagai bahan *edible coating* buah stroberi: Review. *Jurnal Pangan Dan Gizi*. 13(2): pp: 56–63.

[30] Widari, N. E., Subaidah, W. A., & Muliasari, H. 2021. Ekstraksi dan penetapan kadar glukomanan dari umbi porang (Amorphophallus muelleri Blume) menggunakan metode DNS. *Jurnal Sains dan Kesehatan*. 3(3): pp: 383-391.

[31] Liu, Z., Ren, X., Cheng, Y., Zhao, G., & Zhou, Y. 2021. Gelation mechanism of alkali induced heat-set konjac glucomannan gel. *Trends in Food Science & Technology*. (116): pp: 244-254.

[32] Vatria, B., Primadini, V., & Novalina, K. 2021. Pemanfaatan limbah kulit udang sebagai edible coating chitosan dalam menghambat kemunduran mutu fillet ikan kakap skinless. *Manfish Journal*. 2(1): pp: 174-1