mango

by Luh S Suryati

Ecogel incorporation nano-additives to increase shelf-life fresh cut mango

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Abstract— Fresh-cut mango is a very popular product currently, stimulated by the desires of the community will be quality, health, and safety. The raising of the fruit by cutting results in increased respiration, ethylene production, oxidation, and browning processes that can shorten the shelf life. One of the steps to overcome it is use edible coating. The natural ingredients that can be used such as edible coating is Aloe Vera, because it contains a variety of functional compounds. Edible coating of Aloe gel (Ecogel) also serve as an additive matrix to extend the life of fresh-cut mango. Antioxidant, acidulant, and antimicrobial additives can be incorporate into aloe gel. The ability of edible coating is strongly influenced by molecular structure, size and chemical constituents. Small particle as a nano determines the edible coating capability. The study aims to determine the influence of the incorporation of nano-additive material and its concentration to extend the shelf life of the mango. The design used is a complete random design of the factorial pattern. Ecogel with nano-additive mixture between citric acid, ascorbic acid and potassium sorbate concentration of 0.15% can extend the shelf-life of mango fruit.

Keywords: 1; Edible coating 2; gel 3; Aloe vera 4; self-life 5; mango

INTRODUCTION

The consumption of fruits in the world today has an increase that is stimulated by consumer awareness of health, storage technology, transportation, and marketing systems. Increased consumption of fruit in particular mango has become a global strategy and priority in improving the level of public health. Mango fruit contains bioactive components that are very beneficial to the health of the phenolic compounds, carotenoids, organic acids, vitamins and fibres. Besides the tasty fruit eaten mango also serves as functional food, facilitate digestion, overcome obesity, increase immunity, as an antioxidant, anticancer, anti-inflammatory, and antimicrobial (James and Ngarmsak, 2010).

Mango fruit is a volatile commodity, rotten and the weight. The physiological damage of the edible fruit parts such as the skin often determines the preference of consumers. The number of inedible pieces on the mango is relatively high about 22-29%, and the household waste donor. This leads to an increase in the sale of edible fruit parts, one of which is the minimum process product known as the Fresh-cut. The selection of fresh-cut products by consumers is driven by the consumption needs of quality products (fresh, healthy, comfortable, safe, nutritious) and lack of preparation time (Galgano *et al*., 2015).

Some of the advantages of fresh-cut products include: fulfill the wishes of consumers with a variety of options in one package, get the amount of fresh materials needed, facilitate the quality of the product purchased, reduce the volume of products, and Reduce transport costs. The weakness of fresh-cut products is very easily damaged (perishable) and the shelf life is shorter than the whole fruit (Alikhani, 2014). Minimal process results in tissue decay, so the material is subjected to physiological, pathological and physical damage. Such damages include increased tissue respiration, ethylene production, production of unexpected metabolites, degradation of sensory components (color, smell and flavor), decreased fruit integrity, and microbial growth (Galgano *et al*., 2014). Some ways can be done to make fresh-cut products until the consumer's hands remain in a fresh state (fresh quality) with the treatment of storage temperature and the use of edible coating (Siddiqui *et al*., 2011).

Edible coating is an environmentally friendly and biodegradable food packaging, a thin layer that can be eaten (Rahman *et al*., 2017). Edible Coatings also serve as carriers of additives, chemical change barrier, physical and biological and mass transfer barrier (Sánchez-Machado *et al*., 2017). Edible coating applications also function to improve appearance, retain moisture, prevent weight loss and antimicrobial, (Dhall, 2013). One large advantage of using an edible coating is that some of the active ingredients can be incorporated into the polymer matrix and consumed with food, thereby maintaining its nutrition and sensory attributes. Application constraints edible coating on fresh-cut products is the difficulty of the strain on the surface of sliced fruit that is hydrophilic. Edible coating with several types of additives can be applied to fresh-cut mango fruit (Sánchez-Machado *et al*., 2017).

Some natural ingredients can be used as preservatives as well as the edible coating one of which is aloe gel, because it consists of a polysaccharide containing functional components (Ergun and Satici, 2012). It is thought to contain more than 75 chemical compounds (Rahman *et al.,* 2017). The advantages of the use of edible aloe gel coating is its biodegradability, permeabilization to oxygen, antioxidant power, low toxicity effects, inexpensive and easy to apply, (Sánchez-Machado *et al*., 2017). In addition to having the advantages of aloe gel also has weakness that is unstable, easy to dilute, oxidized, discoloured, and enzymatic activities are very high. The viscosity decreased dramatically near the viscosity of water when stored at room temperature for 24 – 36 hours (Suriati, 2018). Consistency and stability of aloe gel can be maintained with the addition of citric acid additives, ascorbic acid and potassium sorbate and calcium chloride (Siddiqui *et al*., 2011). Antioxidant citrate and ascorbic acid are incorporated into the edible coating to control the oxygen permeability and reduce the decline in vitamin C during storage (Ayranci and Tunc, 2004). Antimicrobial substances such as sorbate acid can also be used to avoid microbes in fresh-cut products.

The ability of edible coating as an additive matric is strongly influenced by molecular structure, size and chemical constituents. The small particle size (nano) generates a larger surface area so that it has the potential to increase solubility, the absorption of active compounds and controlled release (Sekhon, 2010). The technology of Nano food field has gained considerable attention nowadays. One example of a nano-technology application is as a nano-additive on a wide range of products, including edible coating food packaging (Hewet, 2013). Temperature contributes to some post-harvest setbacks of mango fruit. Upstream to downstream temperature control is crucial to minimize the effects of mechanical injuries, reduce enzyme activity and metabolic rate so that the shelf life of fresh-cut products is longer. Based on this, it is necessary to research the formulation and application of Ecogel with various additives and the treatment of mango fruit storage temperature. The purpose of the study: 1) determine the type and concentration of nano-additives that produce a formulation of the best Ecogel, 2) Characterization of fresh-cut fruit coated Ecogel during storage at the temperature 7 ± 1°C.

RESEARCH METHODS

The research was conducted in February – October 2019 at the Food Analysis Laboratory of Warmadewa University and the Laboratory Bioindustries of Udayana University. The tools used are digital scales, refractometer, spectral colorimeter CS-280, chiller, Viscometer NDJ8S, digital pH meter, oven, Probe sonicator Q125 misonic USA and Texture analyser. The material used is aloe vera plant obtained from the village of Taro Gianyar Bali. The mango fruit will be coated with an edible coating obtained from the village Panji Buleleng Bali. Additive materials of citric acid, ascorbic acid, potassium sorbate, and analytical materials acquired in Denpasar.

Formulations Edible Coating of Aloe Gel with Nano-additive Ecogel.

The design used on the formulation of Ecogel is complete random design spit plot pattern. Factors I type of nano-additive: citric acid, ascorbic acid, potassium sorbate, and the mixture. Factor II of the additive concentration: 0%, 0.15%, 0.30% and 0.45%. Ecogel production starts with sorting Aloe vera leaves, then washed with water to remove yellow mucus. The stripping using a stainless knife. Treatment continued with a process of homogenization for 5 minutes. Glycerol 1% added on aloe gel extract as emulsifier. Additive citric acid, ascorbic acid, potassium sorbate and a mixture of all three are added to the stabilization of Ecogel. Additives with concentration 0.15%, 0.30%, and 0.45% (b/V) Added when warming up at 70±1°C for 5 minutes. Ecogel is cooled at room temperature for 1 hour and then formed the nano particle size by the Probe sonicator probe for 30 minutes. Ecogel is stored at cold temperatures (7 ± 1°C) for 15 days. The variables observed in this study were colours, transparency (Dadali *et al*., 2007), pH (AOAC, 2019), and viscosity. The Data obtained in this study further tested the statistics with ANOVA.

Application of ECOGEL on Mango fruit

The best formula of Ecogel applicated on the fresh-cut mango by dyeing method for 1 minute. Fresh-cut mango dried for 20 minutes. Product packed with plastic boxes and stored at temperature 7±1°C, observed periodically for 15 days. The variables were weight shrinkage, colour L*a*b* (Dadali *et al*., 2007), texture, water content, total acid, the level of vitamin C, the total soluble solids (AOAC, 2019).

RESULTS AND DISCUSSION

Formulation of Ecogel

Colour Different (ΔE) of Ecogel

The parameters used to assess the color change of Ecogel before and after the addition of nano-additive is ΔE. The observation showed that the value of ΔE on all types of treatment and concentrations of nano-additives increased insignificant until day 10. A significant colour difference occurs in the 15th day storage except for the additive mix treatment. A mixture of three nano-additives is able to maintain Ecogel colour. The value of ΔE can be considered before applied as a coating on food products. Ecogel with low ΔE produces a visual appearance of the coated product does not change much. The smaller ΔE is nearing the base color. Increased nano-additive concentrations can increase ΔE. It is in accordance with the research of Saberi *et al*. (2016) which states the addition of additive concentrations in edible coating Peanut starch will increase ΔE. The average value of ΔE on the type treatment and concentration of nano-additives during storage can be seen in Figure 1.

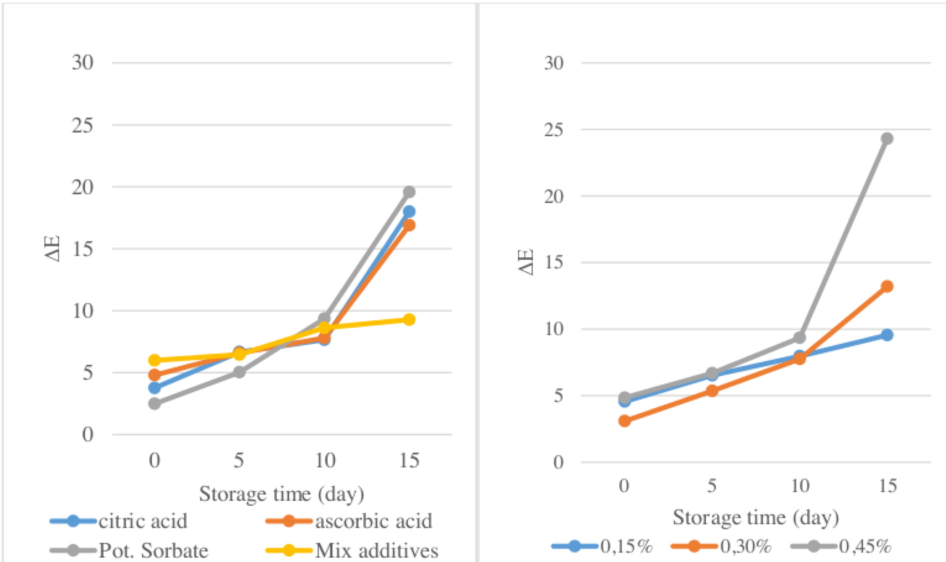

Fig. 1 Colour different of Ecogel (ΔE) on type and concentration of nano-additives

Transparency of Ecogel

Research results based on the type and concentration treatment of additive showed increased Ecogel transparency during storage. This is suspected as more and more nano-additives are likely to occur in various changes and the bonding mobility increases. Al-Hasan and Norziah (2012) reported that the degree of transparency of edible film with the addition of sorbitol increased. The addition of additives with a certain amount of high humidity causes the polymer tissue to expand and decrease intermolecular forces so that the transparency value increases. The transparency of Ecogel during storage can be seen in Figure 2. Ecogel with additive mix provides increased value of relative stability transparency compared to the other until day 15. The combination of the three additives produces a transparent clear white Ecogel display. The nano-additive concentration which produces the lowest transparency value is 0.15%. The lowest value of transparency is the clearest Ecogel display, so it won't change the look of the coated product. The condition of edible coating is both colourless and transparent (Galgano *et al*., 2015).

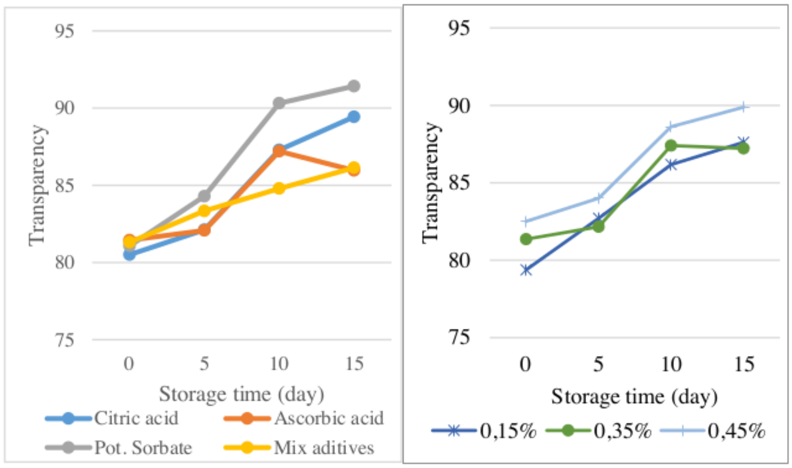

Fig. 2 Ecogel transparency on type and concentration of nano-additive

Viscosity of Ecogel

Viscosity are resistance to the flow of liquids or shear stress ratios against the shear rate. Increased viscosity is caused by increasing bonding structures or the ability of the gel to bind water, so that water survives in cells and gels increasingly viscous. It is in accordance with previous research stating that the greater concentration of filler material added to the solution will increase its viscosity value (Wang *et al*. 2015; Saberi *et al*. 2016; Martin *et al*. 2018). The average value of viscosities in the type treatment and concentration of nano-additives during storage can be seen in Figure 3. The viscosity of Ecogel with the most stable mix additives during storage. The mixture of nano-additives citric acid, ascorbic acid and potassium sorbate is able to synergize and strengthen the cohesion of Ecogel polymer bonding. Consistency and stability of aloe gel can be maintained with the addition of additives (Mikkonen and Tenkanen, 2012; Suriati, 2018). The 0.15% nano-additives% concentration also results in the lowest and relatively stable viscosities value compared to others. The entry of nano-additive into the bonds of acetyl Glucomannan on aloe gel can increase the molecular weight of Ecogel. The greater the molecular weight, the slower the flow rate of the solution will increase the value of viscosity. The enzyme on aloe gel is full of activity, which affects the bonds of compounds and also the viscosity of the gel (Sánchez-Machado *et al*., 2017).

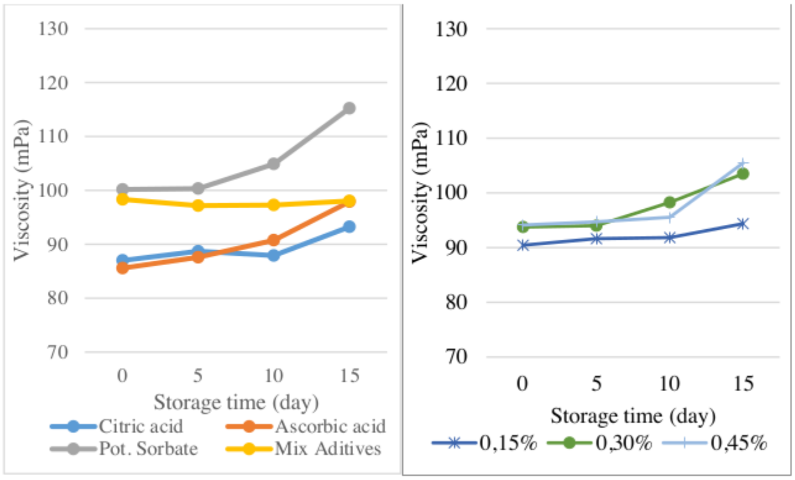

Fig. 3 Viscosity of Ecogel (mPa) in type treatment and concentration of nano-additives

Stabilization process done by proper processing technique, warming treatment, addition of preservatives and other additives such as potassium sorbate, citric acid and ascorbic acid (Suriati 2019). The addition of citric acid and ascorbic acid can reduce the activity of polyphenols oxidase, potassium sorbate as antimicrobial. According to Rex (1984), Aloe gel stabilization can be done by the addition of ascorbic acid 0.05%-0.5%, citric acid 0.01-0.5%.

pH of Ecogel

A solution can be acidic, alkaline or neutral depending on the concentration of H^+ ion or OH^- ion in the solution. The more H^+ ions then the solution is increasingly acidic (pH decreases), otherwise fewer ions OH^- then the solution is increasingly alkaline (pH increases) (Atina, 2015). Ecogel will function well if it has a pH that is almost identical to the coated fruit, because it is associated with adhesiveness or its ability to form cross linking to a polymer Ecogel with pectin compounds in the fruit. Ecogel with the addition of nano-additive potassium sorbate produces the highest pH 4.29-4.54 during storage and the lowest is the citric acid 3.02-4.26. Ecogel in acidic conditions can inhibit the growth of most microorganisms so that the shelf life is longer (Suriati, 2020). The change in pH value occurs due to changes in the hydrogen balance in Ecogel and increases in pH value due to decreased acid formation and organic acid content during storage. Concentration additives can contribute to lowering the pH of Ecogel during storage. According to Marpudi *et al*. (2011) Aloe vera solution added citric acid and ascorbic acid have a pH of about 4. The average value of the Ecogel pH can be seen in Figure 4.

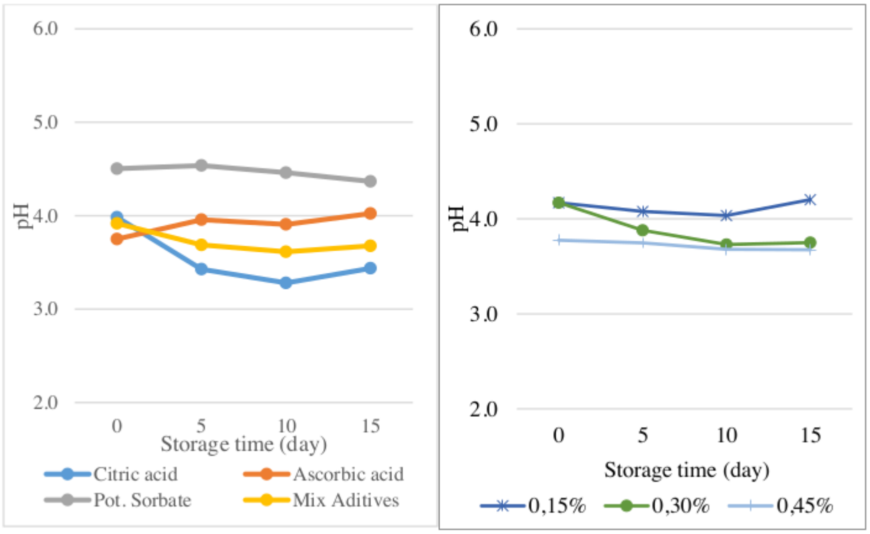

Fig. 4. Ecogel pH on type treatment and concentration of nano-additives

Thickness of Ecogel

The Ecogel thickness determines its functionality to protect the coated material. The addition of active ingredient into edible solution is needed to make the edible coating become active. There are different types of active ingredients that can be used, but each has its own distinctive properties. Lim *et al*. (2010) reported that the use of different active ingredients would result in the properties and impacts of different edible coatings. Sorbate in edible starch-based coating may increase its permeability value. The active nature of the edible coating is very dependent on its constituent components, namely the main or auxiliary components, types and quantities. The results showed that there was no significant thickness change with the old immersion. The thickness of Ecogel ranges from 0.24 to 0.26 mm. The larger the addition of nano-additives will improve the polymer composition of the Ecogel matrix, the total solids are getting larger so that the resulting layer will be thicker (Cicilia, 2018).

Application of Ecogel on Fresh-cut Mango Fruit

Colour (L*a*b*) of Fresh-cut Mango

This color change measurement will use the numerical color codes measured through the Chromameter tool. Numerical color codes are L*a*b* data or often referred to as "Hunter" notation. The average value of L*a*b* fresh-cut mango during storage can be seen in Figure 5. The L* notation states the reflected light that has the white, grey, and black accordion colour. The decline or increase in the L* value means the brightness of the color of the fruit is getting darker or brighter during storage. The changes in the L* values during the play are shown in Figure 5. The Brightness (L*) of the Mango without Ecogel as long as storage continues to decline, while the mango with Ecogel is relatively stable until day 6 and decreases drastic on the 9th day. The value of L* Mango fruit with Ecogel is around (2.8-42,38), while that is without Ecogel around (32,38-51,99). Ecogel is able to retain the brightness of the mango until the 6th day, as it can withstand the rate of respiration and Color degradation. Edible Coatings act as a barrier shifting water vapor and gas exchange (O_2, CO_2), Carrier additives (Dhall, 2013; Sánchez-Machado, 2017). The edible coating application also serves to improve the appearance of bright and shiny colours (Ergun and Satici, 2012; Dhall, 2013). The a* notation in hunter notation is a chromatic color with a mixture of red and green where the value of mango fruit with an Ecogel is approximately 1.21-3.45, while the one without Ecogel is around 6.19-11,32. The use of Ecogel may delay the maturation process or inhibit the development of red Mango fruit. The maturation process is triggered by a respiratory process with oxygen availability around the fruit. Ecogel as the primary packaging protects fresh-cut mango from environmental influences. The main purpose of packaging is to protect the products from the effects of gas (O_2, CO_2), water, evaporation, odour, microorganisms, dust, shock, vibration and pressure. Oxygen Gas is crucial in food packaging, as the main thing in some reactions affecting food shelf life. For example, microbial growth, discoloration, lipid oxidation impacting the rancidity, maturation of fruits and vegetables (Mikkonen and Tenkanen, 2012; Dhall, 2013). The b * notation is a mixture of blue with yellow, where the b * fresh-cut mango value is around 1.21-3.45, while the one without Ecogel is around 6.19-11,32. Ecogel is able to maintain the fresh-cut yellow color of the mango until the 6th day and turns brown drastic on day 9. Cold storage can slow down the metabolic process so as to extend the shelf life, but cold storage on the mango fruit over a long period of time resulting in metabolism is not running or the disruption of the meta Thus causing tissue death in the fruit. From the observations that have been done L*a*b* generated during storage of 9 days then it is seen that fresh-cut mango stored at a temperature of 7±1°C has been experiencing symptoms chilling injury.

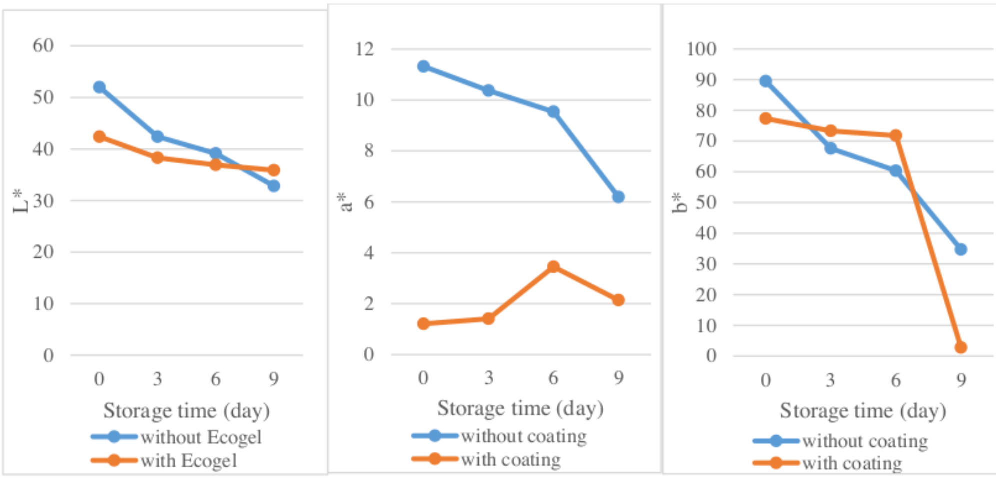

Fig. 5. The value of L*a*b* Ecogel on type and concentration of nano-additives

pH of Fresh-cut Mango

Organic acids are a major component of cell builders that undergo changes during the maturation of the fruit. The main acids found in the mango are citric acid, malate, and Ascorbic. On the young fruit many contain organic acids and will decline during the maturation of the fruit. Decreased acidity is considerable in the maturation of mango fruit with pH shifting. The pH changes during the mango fruit storage in this study can be seen in Figure 6. The results showed that Ecogel can maintain the fresh-cut Mango pH, shown with a noticeable difference during storage. This is because the Ecogel protects the fruit so that the acid reshuffle can be avoided. Fresh-cut Mango uncoated Ecogel showed a significant increase on the 3rd day and its grapevine decreased drastic until day 9. The mango fruit used is an optimal ripe so that maturation occurs until day 3. The subsequent pH decline occurred because the fresh-cut mango began to enter the post-harvest decline (fermentation) and produce undesirable acids. This organic acid in addition to affect the flavour also affects the scent of fruit, so it is used to determine the quality of fruits (Muchtadi *et al*., 2010).

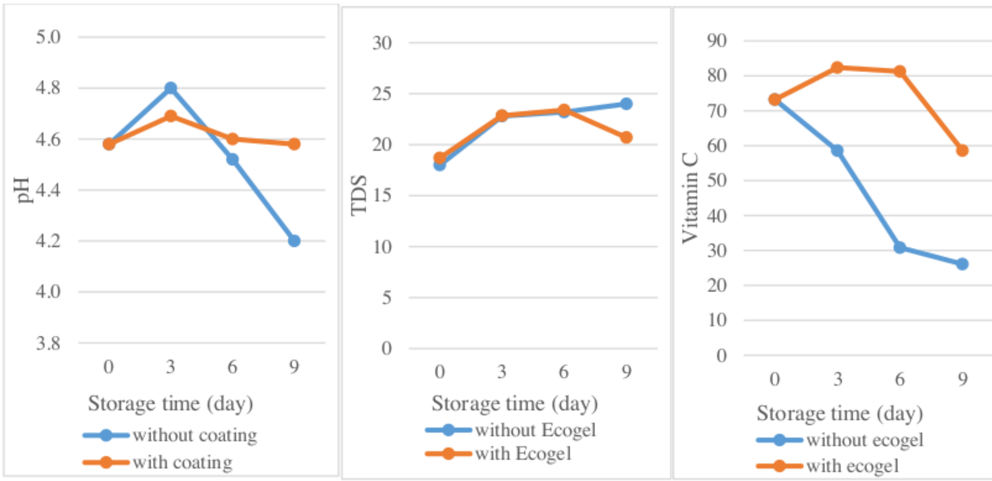

Fig. 6 pH, total soluble solid and vitamin C fresh-cut mango on the type and concentration of nano-additives

Total Soluble Solid of Fresh-cut Mango

The Ecogel treatment does not give a significant effect on the total soluble solid of the fresh-cut mango during storage. The total observation of dissolved solids in mango fruit was observed using a refractometer. If most dissolved solids are sugar, the reading is expressed as a Brix degree. Mango fruit is made up of water, proteins, fats, and carbohydrates. Carbohydrates consist of starch, sugar, and pectin. In young fruit such as apples, mangoes, bananas contain lots of starch. Some fruit starch content will continue to increase during the maturity of the cell. Sugar content of some types of climacteric fruits such as mango, sometimes it will increase during cell maturity (Muchtadi *et al*., 2010). Many kinds of sugar are found in fruits, but the real sugar content changes only include three kinds of sugar, namely glucose, fructose, and sucrose. From the observation results the total change in the dissolved solids was seen that there was an increase in the total dissolved solids during storage. The total increase in the dissolved solids in the mango as long as the storage is not too high, possibly caused by the optimal ripe fruit. The total dissolved solids value ranges from 18-24°Brix. The total Parameter of the dissolved solids correlated with the symptoms of chilling injury, which can be seen from the undoing of starch reshuffle process into glucose.

Vitamin C of Fresh-cut Mango

Vitamin C is one of the nutrients that acts as an antioxidant and effectively addresses free radicals that can damage cells or tissues from oxidative damage inflicted by radiation.

Mango fruits contain several nutrients which are beneficial for the improvement of people's nutrition. Vitamin C is one of which highly needed by the body and can be used as a source of which. Vitamin C level of mangoes is strongly influenced by their varieties, environments, places, fertilizers, maturity levels, and so on. Levels of vitamin C will increase until the fruit is ripe, and will decrease when the maturity level has been exceeded, as seen in Figure 6. Loss of vitamin C is possible because during storage occurs oxidation so as to lower vitamin C. Oxidation may occur due to the presence of air that enters the pores of the packaging. Vitamin C is one of the vitamins that is easily soluble in water so it will be easy to participate in a juice that contains mostly water than fibre that is only coarse starch. Vitamin C is a compound that is very easily soluble in water, it is acidic so it is more stable in acid solution than alkaline solution. Vitamin C levels will decrease with the maturity level of the fruit. Vitamin C on the fruit that has been cooked will turn into glucose. Transpiration process causes the fruit to lose the water content because of the evaporation process that is affected by the temperature and the length of storage, causing the fruit to be damaged so that the production of the acid oxidase enzyme stored in the tissue will come out so that the more vitamin C is oxidized. In the same time simultaneously, the fruit absorbs O_2 so as to increase the oxidation of vitamin C that will release CO_2.

Water Content of Fresh-cut Mango

Fresh-cut mango water content coated with nano-additives is likely to increase by day 9. This increase occurs because during storage there is a process of respiration that is to reshuffle carbohydrates and produce water. While the fresh-cut without Ecogel increased until day 6 and decreased drastic on the 9th day. Ecogel is able to withstand fresh-cut water loss during storage. This is because the Ecogel with nano-additives forms a polymer with a cross-pinkies binding of the acetyl group that is stronger holding water. Coating with nano-additives is in demand due to the nature of acceptable barrier and structural integrity (Dhall, 2013; Galgano, 2015). The use of the edible coting on fruits processed minimally with applications on the surface of the fruit pieces aims to provide a modified atmosphere, gas transfer inhibitors, reduce water and aroma loss, delay discoloration, and Improve appearance (Sánchez-Machado, 2017).

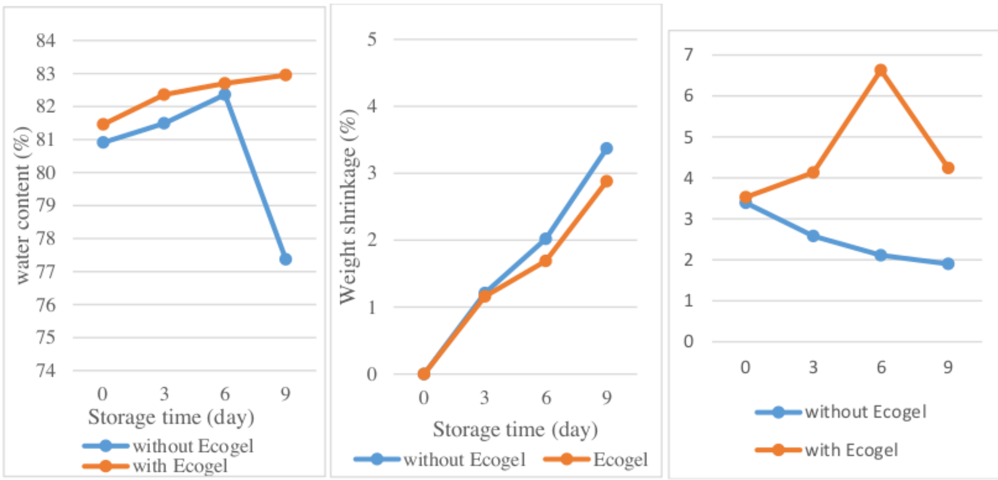

Figure 7. Moisture content, shrinkage the weight and texture of fresh-cut mango on the type and concentration of nano-additives.

Weight Shrinkage of Fresh-cut Mango

The weight of the fresh-cut mango increases during storage, because it includes the climacteric fruit. The climacteric fruit that shows the increase in the activity of sharp and rapid respiration immediately after harvesting, the climacteric fruit is normally ripe in the tree, but in general the fruit is harvested before the initial climax (Muchtadi, 2010). In the given fruit Ecogel coating treatment shrinkage lower than that without Ecogel for 9 days storage, the average weight of 1.16-2.88% and fresh-cut mango that without Ecogel is 1.21-3.37% as seen in Figure 8. According to Muchtadi *et al*., (2014), cold storage has an influence on refrigerated materials, such as losing weight. Loss of fruit weight during storage is mainly caused by water loss, besides this water loss can also reduce quality and inflict damage

Texture of Fresh-cut Mango

Changes in hardness during storage were measured based on the fruit resistance to the texture analyser suppressor with speed 10 and distance 20. Changes in violence during storage can be seen in Figure 7. The longer the storage the texture value will drop. This is in accordance with previous research (Aaron, 2014) of dragon fruit coated wax and that is not coated experienced a decline during storage. Decreasing the hardness of mango fruit due to the process of maturation where the longer kept mango fruit is increasingly soft that influenced by pectolytic enzymes. During storage there is a partial change in Protopectin which is insoluble in water, thus lowering the cohesion of the cell wall that binds cells to one another, consequently the hardness of the mango fruit decreases and becomes mushy (Muchtadi, 2014).

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