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Submission date: 30-Mar-2023 09:37AM (UTC+0700)
Submission ID: 2050537290
File name: e_for_maintain_freshness_of_Strawberry_fruit_during_storage..pdf (898.33K)
Word count: 4097
Character count: 20570

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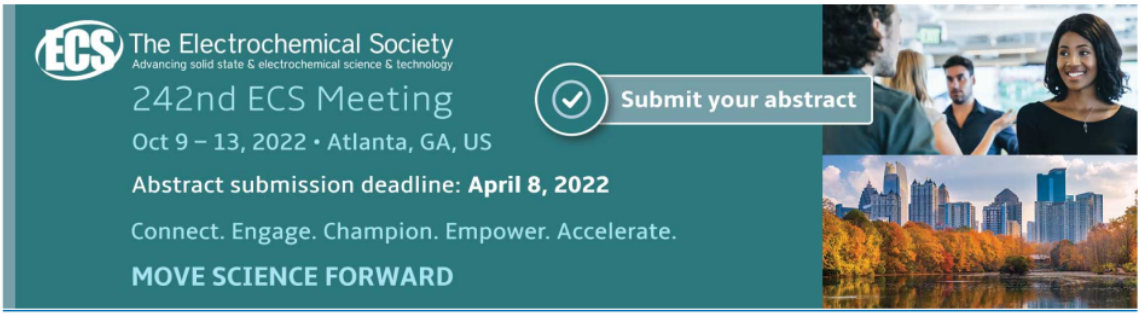
To cite this article: L Suriati and N M A Suardani 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1098** 062055



Application Ecogel Incorporation additive for maintain freshness of Strawberry fruit during storage

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Abstract. Strawberries are popular fruits with high economic value and nutritional content, which are easily damaged. Therefore, the edible coating is one of the steps used to extend the shelf-life of strawberry and maintain its quality. This process uses aloe gel, which contains glucomannan, capable of cross-linking with other ingredients, to bridge the mass transfer of destructive components. The purpose of this study is to examine the influence of additives against the stability of ecogel as an edible coating method for Strawberry fruit in order to maintain its freshness during storage. The method used a factorial complete randomized design to determine the treatment of additives such as acid, potassium sorbate, and calcium chloride into Aloe gel. Secondly, it determines the storage time of Strawberry fruit for 0, 3, 6, 9, 12, and 15 days. The result showed that the Ecogel treatment with the addition of ascorbic acid additives retains the freshness of strawberry fruit till the 9th in cold temperatures of 7 ± 1°C. It also reduces the weight, vitamin C, pH, and total soluble solid of the fruit, while retaining the moisture content.

1. Introduction

Presently, the use of edible coating is one of the most popular alternatives used to maintain the fruit's freshness in post-harvest seasons. The edible coating is a thin layer made from consumable materials and easy to untangle in nature [1]. This layer serves as a barrier to chemical, physical, and biological changes, carrier of additives, barrier to mass transfer, water vapor, as well as the exchange of O_2 and CO_2 gases [2]. The main components of the compiler of edible coatings are hydrocolloid, lipid, and composite [3]. Hydrocolloid used in the manufacture is in the form of protein or polysaccharide. However, one of the numerous advantages of using the edible coatings is due to the combined additive of some active ingredients into polymer matrices and consumed with food, in order to maintain nutrition and sensorial attributes [3].

The number of dangerous synthetic preservatives raises concerns to the community due to the increased adverse effect on human health. Some natural ingredients are widely used as fruit preservatives that are directly eaten without peeling the skin, such as strawberries. This fruit is which has high economic value, tends to break before getting to consumers easily. It has very thin cell walls, which make the texture soft and vulnerable to physical damage [4], therefore, this fruit requires proper post-harvest handling.

Ecogel is one of the natural materials potentially applied as an edible coating on strawberry because it consists of polysaccharides with many functional components. In addition, it also has antimicrobial

properties that are able to inhibit the post-harvest damage [1]. According to Hamman [5] and Ahmed Ecogel [6] also has antimicrobial and antioxidant capabilities. It also has a natural structure capable of keeping the moisture and water-soluble components, and easily applied to increase fruit's shelf-life. Despite these advantages, there are some drawbacks, such as instability, easily diluted, and change in colour from pink to brown after coming in direct contact with air [6]. Ecogel viscosity decreases when stored at room temperature for 24 – 36 hours due to the hydrolysis of polysaccharides with high enzyme activity [7,8].

Also, the consistency and stability of this fruit is maintained with the addition of additives of other natural ingredients. Therefore, further research needs to be conducted on the treatment of various types of additives and prolonged storage against the stability of Ecogel as an edible coating method. Furthermore this research aims to study the influence of the treatment of additives on the stability of Ecogel as an edible coating step on Strawberry fruit to maintain its freshness during storage.

2. Research methods

Edible coatings were produced from Aloe vera plant (*Aloe barbadensis*, Mill.), also known as Ecogel obtained from Taro Village Tegalalang District Gianyar Regency Bali Province. The strawberry fruit used is optimal ripe and obtained from the village of Pancasari Sukasada District Buleleng Regency. The additive material combined additive is ascorbic acid, along with Potassium sorbate and calcium chloride. In addition, the materials for analysis are obtained around the city of Denpasar.

This research was carried out using randomized, complete design two factors and three replicates. The first factor determines the types of additives, which consists of citric acid, ascorbic acid, and calcium chloride. The second determines the time of storage on 0, 3, 6, 9, 12, and 15 days. Observations were made to obtain the shrink weights, changes color, texture, total dissolved solids, and degree of acidity.

Ecogel is collected with a stainless knife and homogenized for 5 minutes using heat treatment to make the enzymes inactive, before adding the suitable additive. The formula of an edible coating comprising of combined additive was applied to the strawberry fruit and dyed for 1 minute. Furthermore, the Ecogel-coated strawberries were dried for 20 minutes and packed with plastic mica equipped with holes of 0.5 cm diameter. The next observation was conducted to determine the changes in the quality of Strawberry fruit during storage.

3. Results and discussion

Ecogel is composed of polymer polysaccharide, glucomannan, and acemannan. Therefore, its addition as an edible coating substance strengthens the polymer structure and retains the stability of strawberries. The average value of strawberry fruit freshness coated with edible coating along with its fruit weight, texture, pH, total soluble solids (TSS), moisture content, and vitamin C are shown in table 1.

Table 1. Effect of additives on weight, texture, pH, total soluble solids (TSS), water content, and vitamin C of strawberry during storage.

Day	Additive	Weight (g)	Texture	pH	TSS (%)	Water content (%)	Vit C mg/100g
0	Ascorbic acid	7.95	3.61	3.37	4.60	89.20	42.05
	Potassium sorbate	8.60	3.85	3.34	3.70	91.05	40.15
	Calcium chloride	7.81	3.84	3.20	4.20	90.15	39.20
3	Ascorbic acid	8.34	3.76	3.45	3.00	94.15	39.90
	Potassium sorbate	8.34	3.42	3.31	3.50	92.55	31.80
	Calcium chloride	7.64	3.80	3.22	3.00	93.05	37.40

Table 1. Cont.

6	Ascorbic acid	8.28	3.56	3.38	3.30	93.50	25.50
	Potassium sorbate	8.33	3.94	3.29	3.90	93.35	22.75
	Calcium chloride	7.60	3.26	3.50	3.60	90.30	19.05
9	Ascorbic acid	8.19	3.49	3.46	5.20	93.84	23.82
	Potassium sorbate	8.29	3.94	3.52	4.80	90.42	23.14
	Calcium chloride	7.49	4.00	3.54	5.30	90.18	22.85
12	Ascorbic acid	8.04	3.54	3.59	5.70	92.68	20.20
	Potassium sorbate	8.16	3.51	3.41	6.20	90.60	20.74
	Calcium chloride	7.36	3.59	3.54	5.55	90.21	20.01
15	Ascorbic acid	7.79	3.91	3.38	6.00	91.81	15.28
	Potassium sorbate	7.94	3.51	3.74	6.65	91.40	11.80
	Calcium chloride	7.21	3.59	3.56	6.00	92.72	15.53

3.1. Weight of strawberry

The decrease in fruit weight is an indicator associated with the loss of freshness due to the decrease in some nutritional components. Figure 1 shows that the weight of strawberry fruit decreases with an increase in storage time because the cooling treatment slows down the metabolic reaction. Prolonged storage causes water loss due to a rise in the respiration and transpiration process, which in turn increases the H_2O and shrinks the weight [9]. Furthermore, the addition of calcium chloride provides a smaller weight reduction value compared to ascorbic acid and Potassium sorbate. This is due to the ability of the calcium chloride and pectin strawberry fruit to form Ca-pectate on the surface and act as a barrier to the displacement of time [10]. Previous studies have indicated that fresh fruit coated with edible coating tends to delay weight loss [11].

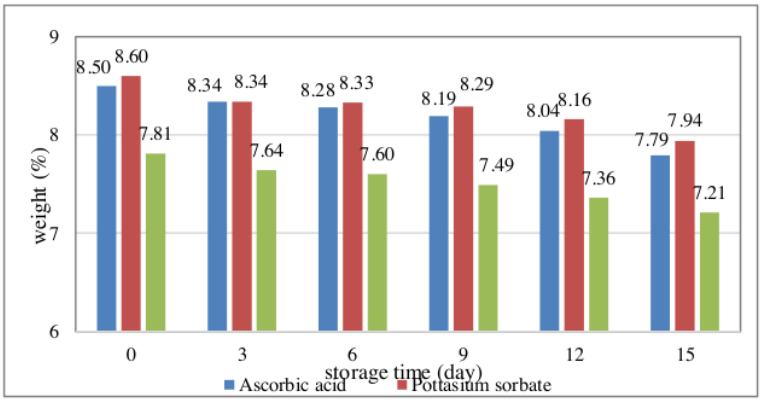

Figure 1. Weight (g) of strawberry fruit after Ecogel application.

3.2. Vitamin C

A prolonged storage time lowers the levels of vitamin C, as shown in Figure 2. Furthermore, the average value of vitamin C on strawberry fruit with Ecogel consists of 15.28-42.05 mg/100g ascorbic acid, 11.8-

40.15 mg/100g potassium sorbate, and 15.53-39.20 mg/100g calcium chloride. Retention time contributes to a decrease in vitamin C. Ascorbic acid additive treatment has a higher capability to maintain vitamin C with the survival of strawberries till the 6th day. This is because the ascorbic acid added to the edible coating acts as an antioxidant that prevents the decline of vitamin C in strawberries, which tends to decrease due to the oxidation process. Storage time stimulated the increase of tissue respiration, production of ethylene, unexpected metabolites, and decreases vitamin C [12-14]. This statement is also supported by Zhu et al [9], stating the storage of fruits in withering conditions, tends to rapidly reduce the content of vitamin C due to the respiration and oxidation processes, as well as the biosynthesis of UDP-glucoronate into ascorbic acid. In addition, the temperature, light, and air in the fruit is easily degraded and damages the spontaneous and non-spontaneous oxidation process of vitamin C [15].

The spontaneous oxidation process occurs without the use of enzymes or catalysts, in contrast to the non-spontaneous e.g. glutathione enzyme, which is a tripeptide consisting of Glutamic, cysteine, and glycine acid. This is a spontaneous oxidation reaction due to the influence of the surrounding air. The mechanisms occur as follows Ascorbic acid monoanions are subjected to oxidation attacks by oxygen molecules leading to radical ascorbic anions and H_2O, which is also followed by the formation of a dehydroascorbic acid and hydrogen peroxide. Dehydroascorbic acid is also known as L-dehydroascorbic is the oxidation of L-ascorbic acid with the presence of active vitamin C contents. However, it is very lability and tends to change to 2.3-L-Diketogulonate (DKG) with no active vitamin C [16].

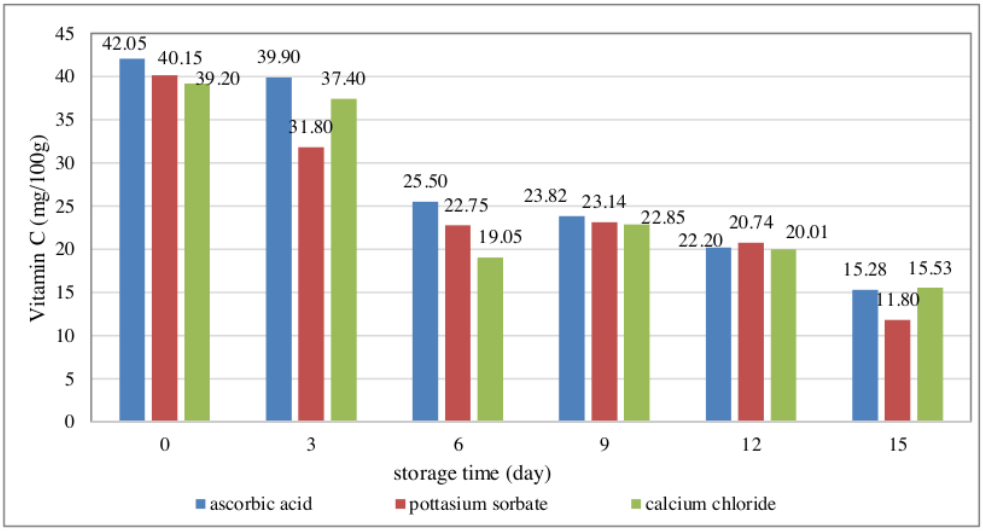

Figure 2. Vitamin C (mg/ 100g) of strawberry fruit after Ecogel application.

3.3. Texture

Food texture is a major determinant of consumer acceptance and preference for foods and beverages. The analysis result in figure 3 showed that the addition of additives on edible coating ecogel has the ability to retain strawberry fruit texture till day 15. The value of texture on strawberry fruit on the ascorbic acid additive, potassium sorbate, and calcium chloride are 3.49-3.91, 3.42-3.94, and 3.26-3.80, respectively. This shows that the edible coating has the ability to protect the strawberry fruit from the environmental influence to prevent the biochemical process. Furthermore, damages associated with fresh-cut exfoliation include increased tissue respiration, production of ethylene, and decrease in fruit softening [17,18].

After harvest, the fruits undergo a life process o physiological, enzymatic, and chemical changes. According to research, photosynthesis, respiration, and transparency are some of the factors capable of affecting the physiological nature and quality of the product. These processes cause changes in the content of various substances in the product, characterized by discoloration, texture, taste, and smell [9]. Potassium chloride is a white salt that is soluble, odorless, colorless, and inflammable capable of extending the shelf life of fruits [19]. Calcium causes the wall structure of the lamella middle cells to be rigid by slowing down the activity of polygalakturonase, and maintaining the structure and functional membrane [20]. It also binds the acid pectat and galakturonate, forming a cross bond that amplifies the molecular bond between the constituents and maintains the durability of the fruit cell wall [3]. The treatment of exogenous calcium chloride by 1% delays the Browning reaction, soften the fruit, and increase the strawberry's thickness during storage at cold temperatures [1,20].

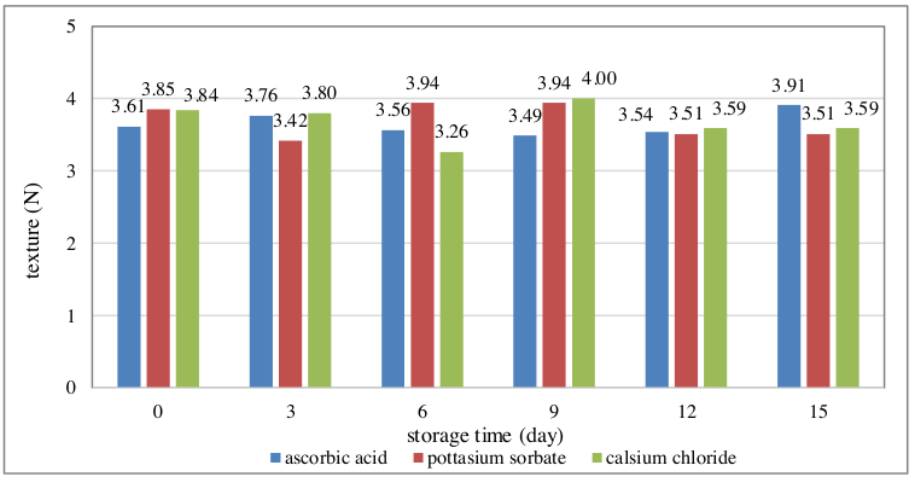

Figure 3. Texture of strawberry fruit after Ecogel application.

3.4. pH

Figure 3 shows that an increase in storage leads to a rise in the pH. Therefore, the use of edible coating with ascorbic acid additive produces a pH relatively equal to the initial value due to its ability to maintain quality during storage. The change in acidic content is due to the combined effects of leaching and oxidation of organic acids in the biological matrix [21]. The pH values showed a significant increase during storage with ascorbic acid additive, potassium sorbate, and calcium chloride values of 3.37-3.46, 3.29-3.74 and 3.20-3.59, respectively as shown in Figure 4. There is also a correspondence between the behavior of the titratable acidity and pH values, during storage [21].

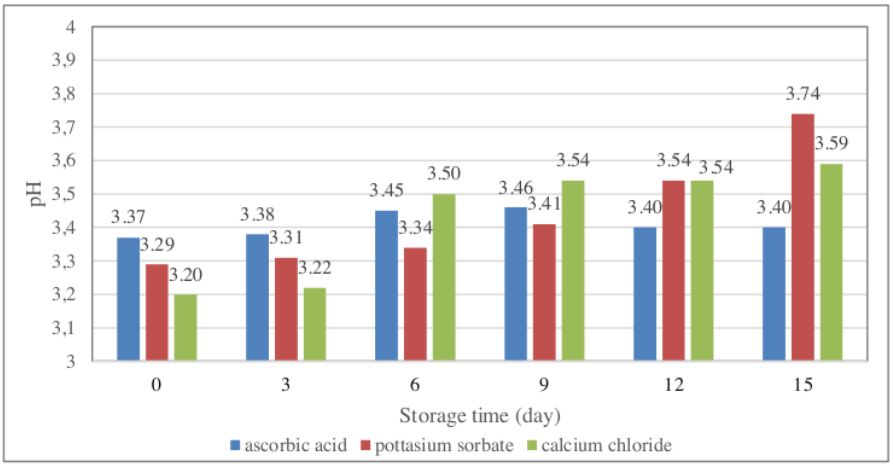

Figure 4. pH of strawberry fruit after application Ecogel.

3.5. Water content

Strawberry fruit moisture tends to be constant for all treatment with a wide range of additives used to prevent losses. Figure 5 shows that the moisture with ascorbic acid additive, potassium sorbate, and calcium chloride are 89.2-94.15, 90.41-93.35, and 90.13-95.05, respectively. Ecogel contains natural polymer with the ability to cross-link and protect the fruit from dehydration. The cooling treatment slows down the metabolic reaction due to the transpiration and slow-running of the respiration process and H_2O [9]. The water content for all coated samples was approximately the same and increased in value over time. In addition, the strawberry has constant water content with less hydrophilic ascorbic acid. Therefore, edible coating is used to protect the fruit from the outside environment, such as gas, water evaporation, odor, microorganisms, dust, shock, vibration, and pressure [3,22]. Edible coatings offer a possibility to extend the shelf life of fresh-cut produce by providing a semi-permeable barrier to gases and water vapor, thereby reducing respiration, and enzymatic browning [23].

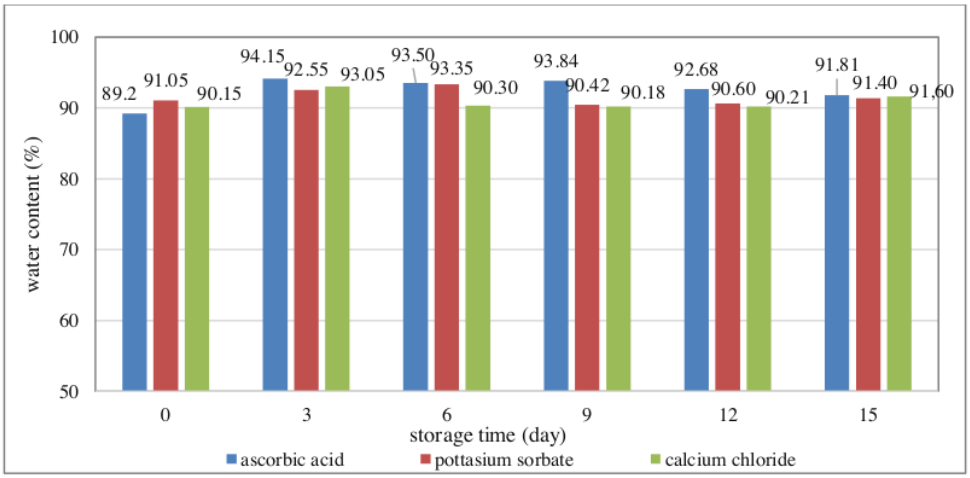

Figure 5. Water content (%) of strawberry fruit after Ecogel application.

3.6. Total soluble solid

The total soluble solid in strawberry, decreased on the third day and further increased till the fifteenth day, with similar tendency by the three additives. Figure 6 shows that the average total soluble solid on strawberry fruit with the application of Ecogel increased the ascorbic acid additive, potassium sorbate, and calcium chloride by 3.0-6.0, 3.5-6.65, and 3.0-6.0, respectively [11]. The Fresh fruit coated with edible coating delayed weight loss and increased the solubility of the solid content due to its ability to turn the polysaccharides into sugar, such as sucrose, glucose, and fructose during the post-harvest period [20]. The formulation of sucrose requires Phosphate carrier UTP (Uridine triphosphate), glucose-1-Pospat produces uridine d-phosphoglucose (UDPG) and Pyrophosphate. UDPG also reactions with fructose-6, to produces sucrose-phosphatee, and further breakdown leads to the formation of glucose and fructose [24].

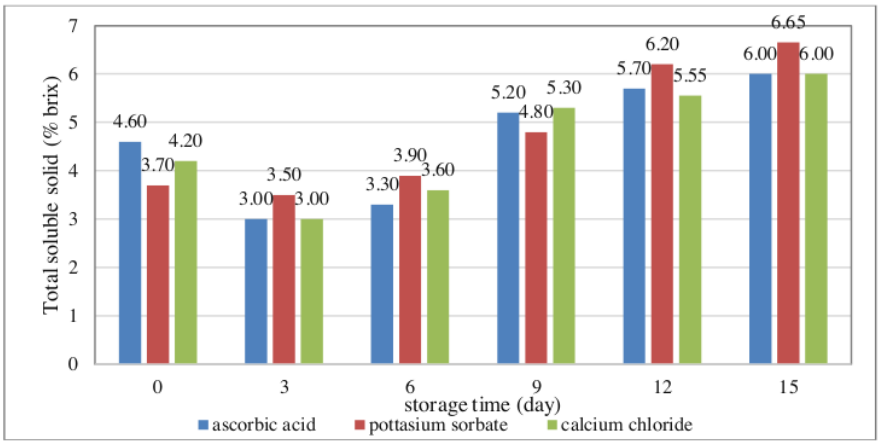

Figure 6. Total soluble solid (% brix) of strawberry fruit after Ecogel application.

4. Conclusion

In conclusion, the edible coating formula of Ecogel is stable with the addition of ascorbic acid, which has the ability to retain the strawberry fruit freshness up to 9 days. This technique has the ability to suppress heavy shrinkage, decrease vitamin C, increase pH, dissolved solids, and retains moisture content during storage. Therefore, its use of strawberries needs to be combined with the cold temperature of 7 ± 1°C.

Acknowledgment

This research was supported by the competitive grant in the scheme of Strategic Research of National Excellency, Directorate General of Higher Education, Republic of Indonesia. The authors are grateful to the Rector and the Head of Research Institute of Warmadewa University in facilitating to get the grant.

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