Application of Coatings in Preservation of Fresh *Salak* Bali (*Salacca zalacca*) with Different Emulsions of Fatty Acids

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Abstract. This study aims to determine the effect of emulsion coating of different fatty acids on the characteristics of *Salak Bali* fruit and to determine the right emulsion formulation. The experimental design used in this study was a simple randomized complete block design (CRD). The treatments were A0: *Salak* untreated (control). A1: *Salak* treated with oleic acid, A2: *Salak* treated with stearic acid, A3: *Salak* treated with palmitic acid, and A4: *Salak* treated with a mixture of oleic acid, stearic acid, and palmitic acid. The experiment was repeated three (3) times and observations were made every 3 days until day 15, including: weight loss, total soluble solids, pH, color and organoleptic tests. The results showed that emulsion coating with oleic acid, stearic acid and palmitic acid had a significant effect on the shelf life of *Salak* Bali fruit. Stearic acid emulsion (1%) is the best emulsion in fruit coating that produces the best fruit characteristics in terms of durability, color, weight loss, pH, suppressing the increase in soluble solids content and is the emulsion that gets the best choice from the calculation of the average number of panelists on organoleptic texture, color and overall acceptability of *salak* fruit.

1 Introduction

Salak is one of the cash crops whose cultivation area is more than half of the provinces in Indonesia [1]. This is not surprising because salak is one of the tropical plant's native to Indonesia. As a native Indonesian plant, the development of *salak* cultivation is included in the indigenous agricultural system [2]. Karangasem is the center of the *salak* crop in Bali, and from this area it spread to other areas so that today Balinese salak can be found in almost all districts in Bali.

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Fruits have a perishable nature and short shelf-lived, it is supported by a tropical climate hot and humid causing fresh fruits shelf life will be very short [3]. Generally fruits can only survive kept for ± 7 days at room temperature. The results reported by the Depkes RI [4] stated that the water content of the fruit is quite high at 78% and the carbohydrate content of 20.9% causes the fruit skin to rot more easily when stored at room temperature.

Bruised or damaged fruit has the potential for microbiological damage [5]. This is because bruised or damaged fruit is an entry point for microbes to damage the fruit. Therefore, we need a management effort to extend the shelf life and maintain the quality of fruits. Good handling can extend the shelf life and maintain the quality of fresh fruit in a shorter period of time, i.e. by reducing the respiration rate or delaying early ripening and preventing physical and microbiological damage. Thus, the freshness of the fruit can be maintained at a level acceptable to the consumer [6].

Several post-harvest handling methods are known and much is being done to extend the shelf life of fresh horticultural commodities, including cold storage, hypobaric storage, irradiation, and coating. Of the several methods already in general would be better if it continued to be created and developed new methods. One way to maintain the quality and freshness of the fruit is the fruit coating with wax emulsion or organic acids such as oleic acid, stearic acid and palmitic acid. Coating the surface of the fruit with wax emulsion or organic acids such as oleic, stearic and palmitic acid can help prevent water evaporation, which can slow down rotting, inhibit microbial growth, inhibit respiration rate and beautify the fruit skin, thus increasing its attractiveness to consumers.

Wax emulsion coating with an appropriate density and thickness can avoid aerobic state in the fruit and provide the necessary protection against cuts and scratches on the surface of the fruit [7]. Wax emulsion, as a coating material, must meet several necessary conditions. These include being odorless and tasteless, quick-drying, unbreakable, glossy, and slippery. It should not produce a thick surface, be inexpensive, and non-toxic [8], based on the above issues, this research was conducted to determine the effect of emulsion coating with oleic acid, stearic acid, and palmitic acid on *salak Bali* fresh fruit characteristics.

2 Materials and methods

2.1 Materials

Materials used in this study are the *salak Bali* (*Salacca zalacca*) fresh fruit, obtained from Sibetan Village, Bebandem District, Karangasem Regency. Palmitic acid, oleic acid (Zhengzhou, China), stearic acid (Hebei Hanlong Grease), emulsifier brands tween 80 (XGD, China), and $NaHCO_3$ (King Lei, China), and distilled water.

2.2 Research design

The experimental design used in this study was a simple randomized complete block design (CRD). The treatment is performed as follows; A0: *Salak* were not given treatment (control). A1: *Salak* given treatment oleic acid (1%), distilled water (98%), tween 80

(0.5%), $NaHCO_3$ (0.5%); A2: *Salak* given treatment stearic acid (1%), distilled water (98%), tween 80 (0.5%), $NaHCO_3$ (0.5%); A3: *Salak* given treatment palmitic acid (1%), distilled water (98%), tween 80 (0.5%), $NaHCO_3$ (0.5%); and A4: *Salak* given treatment oleic acid (1%), stearic acid (1%), palmitic acid (1%), distilled water (96%), tween 80 (0.5%), $NaHCO_3$ (0.5%). The experiment was repeated three (3) times, in order to obtain 15 units experiment.

2.3 Implementation of experiment

The *salak* fruits used in this study are the *salak* Bali fruit varieties from the Sibetan Village, Bebandem District, Karangasem Regency. Implementation of the study as follows: freshly picked fruits weighed to determine the initial weight of fruits, and fruits coated with an emulsion that has been made in accordance with the treatment. Once coated, dried fruits with aerated and stored at room temperature for 15 days. Observations were made every 3 days until the 15^{th} day, include: weight loss, pH, total dissolved solids, colour, and followed by organoleptic tests. During fruit storage, we observed variables such as weight loss, total soluble solids, pH, and color. We also conducted organoleptic tests.

2.4 Method of analysis

During fruit storage, the variables that were observed included depreciation of weight [9], total dissolved solids [10], pH [10], colour [10], followed by an organoleptic test [11,]. The study was conducted with three repetitions for all treatments.

2.5 Statistical analysis

Data were analysed using SPSS statistical software (ver. 25.0 SPSS, Chicago, USA) and subjected to two-way analysis of variance (ANOVA). Duncan's multiple range test (DMRT) was used to compare means. Differences at ($p < 0.05$) were considered significant. Data were analysed using analysis of variance (ANOVA). If no treatment that significantly or very noticeable, followed by Duncan test.

3 Results and discussion

3.1 Depreciation of weight *salak Bali* fruit

Table 1. Losses weight of fruits.

Treatment	Depreciation of weight (%)		
	Day-6	Day-12	Day-15
A0	6.09	-	-
A1	X	5.72	-
A2	X	5.91	-
A3	X	4.91	-
A4	X	X	3.87

Description : sign (x) is a bark that is still in good condition and the sign (-) indicates is damaged.

Table 1 shows that after 15 days of storage at room temperature, the highest weight loss occurred in fruit treated with A0 (control), with a weight loss of 6.09% on day 6. Calculation of weight loss made from fruits that start to rot, with A0 indicates the treatment is the most perishable than 4 other treatments. Depreciation weight in treatment A1 (emulsion coating oleic acid), A2 (emulsion coating atearat acid) and A3 (coating with palmitic acid emulsion) occurs at day 12, where shrinkage occurs up to 5.72% in A1 ; 5.91 to 4.91 on the A2 and A3. Compared with 4 other treatments, treatment A4 (coating with a mixture of oleic acid, stearic acid and palmitic acid emulsion) levels of the lowest weight loss of only 3.87% per fruits sample. This is because the coating with the emulsified mixture of oleic acid, stearic and palmitic can inhibit respiration rate that causes shrinkage of the weight of the fruits are best compared to the four other treatments during 15 days of storage. So that the mixture of oleic, stearic and palmitic acid emulsion has the best effect on fruit preservation with a reduction in fruit weight. The most used lipids in coatings for minimally processed products are stearic acid, palmitic acid, and some vegetable oils such as soybean and sunflower ones [12].

3.2 Total dissolved solids *salak* Bali fruit

Table 2. Data of dissolved solids content of *salak* fruits

Treatment	Days to : (%Brix)					
	0	3	6	9	12	15
A0	14.73 ^{a}	17.40 ^{a}	18.13 ^{a}	-	-	-
A1	14.27 ^{ab}	14.47 ^{c}	18.00 ^{a}	18.00 ^{a}	18.80 ^{a}	-
A2	14.00 ^{ab}	14.60 ^{c}	18.87 ^{a}	18.00 ^{a}	18.47 ^{ab}	-
A3	14.53 ^{ab}	14.87 ^{bc}	17.20 ^{ab}	17.00 ^{ab}	17.80 ^{bc}	-
A4	14.33 ^{ab}	14.53 ^{c}	15.93 ^{b}	15.93 ^{b}	16.27 ^{c}	17.67

Description : The different letters behind the average value in the same column (one day of observation) showed significant differences ($p < 0.05$). Sign (-) indicates the decayed exterior of the fruit.

On day 0, all treatments (A0, A1, A2, A3, A4) showed similar results. The coating treatment did not result in any noticeable differences in the total dissolved solids of the fruits. On day 3, changes and differences in the total dissolved solids content of the fruits began to occur in each treatment. The bark given treatment A0 (control) had the highest total dissolved solids content, while the bark given treatment A1 (coated with oleic acid emulsion) had the lowest total dissolved solids content.

On day 6, observations were made on the changes and differences in the total dissolved solids content of the fruit bark in each treatment. The highest total dissolved solids content was found in the bark treated with A2 (coated emulsion stearate), while the lowest total dissolved solids content was found in the bark treated with A4 (emulsion-coated mixture of oleic acid, stearic and palmitic).

On day 9 observations levels of total dissolved solids in the treatment A0 stopped because fruits which have started to rot. Followed by 4 treatments remaining, namely A1

(coated with oleic acid), A2 (coated emulsion of stearic acid), A3 (coated emulsion palmitic acid), A4 (coated emulsified mixture of oleic acid, stearic and palmitic), obtained observations of total solids dissolved the highest seen in bark given treatment A1 and A2 dam which has the lowest total dissolved solids are given treatment bark A4 (coated with oleic acid).

Observations day 12, total dissolved solids is highest in the bark given treatment A1 (coating with oleic acid emulsions), while total dissolved solids are the lowest found in bark given treatment A4 (coated with oleic acid, stearic and palmitic), this shows the A4 treatment (coated with mixture of oleic acid, stearic acid, and palmitic acid) gives the best effect for the stability of total dissolved solids fruits.

Observations on day 15 in treatments A1, A2 and A3 were stopped because the fruit was in the process of decay. what remains is the treatment of A4 which has a total dissolved solids 17.67%, by the percentage shown in Table 6, treatment A4 (coated with a mixture of oleic acid, stearic, and palmitic acid) shows the best effect in curbing the increase in dissolved solids content in fruits compared to other treatments. The low content of total solids in the fruit can reduce the chances of bacteria or microbes to live in the fruits, so that the damage can be minimized fruits. The increase in total dissolved solids in the fruit occurs due to the formation of simple sugars degradation results in a phase of maturity. Thus, the quality of fruits can be maintained [13].

Latifah [14] stated that during the process of fruit ripening, total dissolved solids will increase due to increased concentrations of dissolved compounds in fruit, especially sugar. According Pujimulyani [15], fruit maturation, the substances dissolved solids will increase. This increase will be even sharper in case of very rapid transpiration. This means showing that treatment with emulsion coating mixture of oleic acid, stearic acid and palmitic acid gives the best effect, because the acids are able to decrease the rate of respiration and transpiration processes that can inhibit an increase in the content of total dissolved solids. In addition, oleic acid, stearic and palmitic can increase production of antioxidants or prevent oxidation, hardens and strengthens the candle so that the total dissolved solids is maintained.

3.3 pH

Results of measurement of pH content of fruits are presented in Table 3. From the observation days 0-15, Everyday observations of fruit pH showed highly significant differences among the different treatments.

Table 3. Results of testing pH at *salak* fruits during storage

Treatment	Days to :					
	0	3	6	9	12	15
A0	3.56 ^{a}	3.70 ^{a}	3.90 ^{a}	-	-	-
A1	3.49 ^{a}	3.44 ^{b}	3.46 ^{d}	3.87 ^{b}	3.79 ^{a}	-
A2	3.52 ^{a}	3.60 ^{ab}	3.63 ^{bc}	4.12 ^{a}	3.59 ^{b}	-
A3	3.52 ^{a}	3.55 ^{b}	3.59 ^{cd}	3.79 ^{bc}	3.68 ^{ab}	-
A4	3.49 ^{a}	3.47 ^{b}	3.45 ^{d}	3.55 ^{d}	3.47 ^{c}	3.52^{a}

Description : The letters that are behind the average value in one column (one day of observation) showed highly significant differences ($p < 0.01$). Sign (-) indicates the decayed exterior of the fruit.

Of the average data day 0 to day 15 in Table 3 above, the treatment A4 (coating fruits with emulsified mixture of oleic acid, stearic and palmitic) best effect in the coating of fruits compared to treatments other, because has the lowest pH between fruits were given treatment A0, A1, A2, and A3. pH remains stable in fruits can inhibit the development of microbes or bacteria that could ruin fruit durability. In contrast to the treatment of A0, A1, A2, and A3 in Table 3 shows the average pH unstable so the fruits are more likely to rot. According Karanth et al. [16], with the state of fruit bases will facilitate the development of bacteria or microbes to live, causing damage to the fruits [5].

3.4 Colors fruit *Salak Bali*

Table 4. Assessment of colors fruit salak

Treatment	Colors day					
	0	**3**	**6**	**9**	**12**	**15**
A0	1	3	7	10	10	15
A1	1	2	4	5	5	7
A2	1	2	3	5	8	10
A3	1	2	4	8	8	10
A4	1	2	4	5	5	6

Description : The figures in the table are the color chart number.

Assessment is done by matching the color of fruits by color barking without treatment (control) on the first day to the fifteenth. Table 4 demonstrates that the color of fruits treated with various methods differs. Emulsion consisting of 3 mixtures of acid and oleic acid emulsion gives the best effect in maintaining the color of fruits. In contrast, the control group exhibits the lowest color durability, making it the most easily damaged.

The comparison is clearly visible is the last day of observation, day 15. Color fruits on the 15th day of treated A4 (emulsion mixture of oleic acid, stearic and palmitic) and A1 is still similar to the color of fruits without treatment on day 6 in the appendix. Compared with the fruit given treatment A2 and A3, showed a value equivalent to the number 10 on comparison or similar color to the color of bark without treatment on day 10.

3.5 Organoleptic test

From the analysis of variance fruits are getting treatment A4 showed significant effect ($p < 0.05$) for texture, color, and overall acceptance fruits were stored for 15 days. In Table 5 are presented the results of organoleptic analysis of *salak* Bali fruits during 15 days of storage.

Table 5. Analysis organoleptic test

Treatment	The average value organoleptic test		
	Texture	**Color**	**Overall acceptance**
A0	1.15 ^{b}	1.15 ^{b}	1.2 ^{c}
A1	2.8 ^{a}	3.1 ^{a}	4.25 ^{ab}

A2	3.15 [a]	2.45 [a]	3.85 [b]
A3	3.15 [a]	2.55 [a]	4.05 [b]
A4	3.8 [a]	3.35 [a]	5.25 [a]

Description : The different letters behind the average value in the same column indicate significant differences ($p < 0.05$) on the assessment of the panelists on the texture, color and overall acceptance fruits were stored for 15 days.

Table 5 shows that the fruit treated with A4 had the highest mean values for organoleptic test results, including texture, color, and overall acceptance. The mean value for texture was 3.8 (normal - slightly crunchy), the mean value for color was 3.35 (equal to R - better than R), and the mean value for overall acceptance was 5.25 (very like). Comparison upside seen that the lowest average value for organoleptic test results include texture, color and overall acceptance in the fruits are fruits that are treated A0 (control), for an average value of 1.15 textures (hard broken-rather difficult to be broken), for the average color value 1.15 (worse with the R-bit worse with R), and for the average value of the overall revenues of 1.2 (very like-dislike).

4 Conclusion

Coating *salak* Bali fresh fruits with emulsion of oleic acid, stearic acid, and palmitic acid significantly improves their durability by reducing transpiration. This helps the fruits withstand the content of dissolved solids that remain low in fruits, stabilizes the pH of the fruit, and prevents the growth of bacteria or other microbes. The coating is also capable of reducing weight loss and maintaining the texture and color of the fruits. The emulsion mixture for coating fruits that produces the best chemical and physical characteristics consists of oleic acid (1%), stearic acid (1%), palmitic acid (1%), distilled water (96%), tween 80 (0.5%), and $NaHCO_3$ (0.5%). This formulation helps maintain the texture, color, weight, and pH of the fruits while suppressing the increase in soluble sugar content. It is important to note that this statement is based on objective evaluations and not subjective opinions. The emulsion formulation used to coat fruit bark consists of oleic acid (1%), stearic acid (1%), palmitic acid (1%), distilled water (96%), tween 80 (0.5%), and $NaHCO_3$ (0.5%). This emulsion was determined to be the best choice based on the average values calculated from panelists in an organoleptic test, which evaluated texture, color, and overall acceptance of the fruit.

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