PROCESSING BILIMBI INTO JUMBO RAISIN WITH DIFFERENT SUGAR ADDITIONS

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ABSTRACT

Based on its nutritional content, bilimbi contains high vitamin C, high water content, and has a relatively short shelf life. This study aimed to make jumbo raisins to produce raisins preferred by consumers, and analyze its quality based on its water content, vitamin C content, and the level of panelist acceptance. This study used a completely randomized design (CRD) single factor with variations of concentration of sugar solution (50%, 75% and 100%). The quality tests were including water content by drying using an oven, vitamin C content by iodometry, and the level of acceptance through organoleptic tests (taste, color and aroma). The results showed that bilimbi raisin with 100% sugar is preferred by panelists based on its taste (score 3) and aroma (score 3), and had a water content of 11.91% and vitamin C content of 5.13 mg / 100 g.

Keywords: Jumbo Raisins, Sugar, Bilimbi, Vitamin C

INTRODUCTION

Bilimbi is one of the fruits which is rich in vitamin C, a maximum of 26.98 mg/g (Ariharan et al., 2012). Vitamin C content in bilimbi is a natural remedy which is quite handy in treating sore mouth and gingivitis. In addition to its fruit, bilimbi leaves and flowers can also be used as natural remedies for overall health. Bilimbi leaves can also inhibit bacterial growth (Saputra and Anggraini, 2016).

In Indonesia, the knowledge of the optimum use of bilimbi is still limited since this fruit is commonly consumed only as side dishes. The selling price of bilimbi is relatively low and not worth the price. This fruit is rarely consumed as fresh fruit since it has a high content of acid and water. Besides, bilimbi also has a short shelf life (around 4-5 days) due to its high water content (± 93%); for this reason, it rots easily (Agustin and Putri, 2014). One of the methods to develop bilimbi derivative products is by processing it into raisin to reduce its sour taste and water content. Raisin, moreover, is an easy-to-find food available in a practical package at an affordable price. Consuming raisin before a workout can be proven to effectively retain individual performance during the workout. 40 grams of raisin contains 28.5 grams of carbohydrate or glucose that equals 110 calories (Putri and Purwoko, 2018).

Raisin is a snack made of preserved fruit that is immersed in the sugar solution and then dried (Carina, Wignyanto, and Putri, 2012). According to Maulidiah, Hidayati, and Hastuti (2014), osmotic dehydration by using sugar solution can be a fast or slow process. Slow osmotic dehydration is performed by immersing the fruit for around 24 hours in a 30% sugar solution and then further immersing the fruit in a 40% sugar solution for 24 hours. This immersion process is then repeated with several levels of sugar solution concentration up to 70 percent sugar solution. When this concentration is achieved, the fruit is then immersed for 3 weeks and dried. Fast osmotic drying by using sugar solution can be conducted only in several hours by maintaining the temperature of the sugar solution at 60-65°C. Fruit and sugar are boiled to keep balanced water and sugar mass transfer in the inside and outside of the fruit so that it will result in dried fruit with good texture.
Making raisin from bilimbi can extend its shelf life, increase its selling price as well as reduce its sour taste and water content. Raisin from bilimbi is expected to have a good texture, have a similar taste as fresh bilimbi and similar size as real bilimbi. Some previous studies related to candied fruit or raisin made of fruit are including the study performed by Maulidiah, Hidayati, and Hastuti (2014) with different sugar solution immersion concentration of 40 %, 50 % and 60 % used in making dried-candied salak, the study performed by Joseph, Lalujan, and Sumual (2017) with using 30%, 40%, 50% and 60% of sucrose solution immersion concentration in making dried-candied red bell pepper and a study performed by Carina, Wignyanto, and Putri (2012) with variation in lime water immersion concentration and drying time process to make dried-candied bilimbi. From the background of studies, this study focuses on making raisin from bilimbi to obtain great quality raisin which is expected to become consumers’ favorite product. This research aims to produce jumbo raisin from bilimbi with the addition of different sugar concentrations. Besides, this research is also expected to determine raisin characterization which encompasses water content and vitamin C content test and to elaborate the acceptance rate of 30 panelists on jumbo raisin from bilimbi based on its taste, color and aroma.

**METHODOLOGY**

**Place and Time of the Research**
This research was conducted in the Food Laboratory of Agroindustrial Technology Department of Politeknik Negeri Tanah Laut in March 2019 - June 2019.

**Ingredients**
Any ingredients used were 200 grams of Bilimbi, 100 grams of 50% granulated sugar, 150 grams of 75% granulated sugar and 200 grams of 100% granulated sugar, 300 ml of clean water, 10 grams of lime, distilled water, 1% starch solution, 0,01 N iodine solution and KI solution.

**Tools**
The tools used were including basin, knife, fork, stirrer, stove, pan, filter, tray, oven, porcelain cup, scale, volumetric flask, beaker glass, erlenmeyer flask, burette, stative, petri dish, stirrer rod, spatula, mortar, pestle, filter paper, tongs and gloves.

**Research Procedure**
The research procedure consists of a preparation step, processing raisin from the bilimbi, data collection, data analysis and the discussion on the research result.

**Method**
The formulation process of sugar solution concentration was performed by using Completely Randomized Design (CRD) with a variation of 50%, 75% and 100%. The process of producing raisin from bilimbi was executed by using an experimental method with the following treatment formulation:

| Treatment  | Bilimbi (g) | Sugar (g) | Lime (g) | Water (ml) |
|------------|-------------|-----------|----------|------------|
| K1 (50% of sugar) | 200 | 100 | 10 | 300 |
| K2 (75% of sugar) | 200 | 150 | 10 | 300 |
| K3 (100% of sugar) | 200 | 200 | 10 | 300 |

Description: Each treatment is repeated three times
**Work Procedure**

First, fresh bilimbi was picked and then washed with clean water. After drying, the top and bottom of the bilimbi fruit were cut out with a knife. Each side of the fruit was then pricked by using a fork and immersed in lime water overnight. On the next day, bilimbi was rinsed with clean water so that the lime water residual on the fruit can be cleaned out completely. Bilimbi fruit was then boiled in a sugar solution, with different sugar composition that is 50%, 75% and 100% for around 30 minutes until the water was reduced by half. Let it rest. After that, bilimbi fruit was then placed in the plastic tray and dried in the sun for around two days. During the drying process, bilimbi fruit was flipped so it can dry evenly. Each treatment was repeated three times.

**Water Content Testing**

The work procedure of water content testing on Bilimbi raisin was started by putting an empty porcelain cup in the oven with a temperature of 105 °C for 15 minutes. Then, the cup was then cooled in the desiccator for 15 minutes. Furthermore, the weight of the porcelain cup was measured as A (g). After that, 3 g of samples were put in the porcelain cup, measured and its weight was noted as B (g). The cup was put in the oven at the temperature of 105 °C for 2 hours and cooled in the desiccator for 15 minutes. The next step was measuring the weight of the cup and noted it as C (g). The result was calculated by using the following water content formulation (Hamzah and Sribudiani 2010):

\[
\text{Water Content (\%) = } \frac{B-C}{B-A} \times 100
\]

**Vitamin C Testing**

Vitamin C content testing was executed by using the iodometry method. These are the procedure of measuring vitamin C performed by Rahman, Ofika, and Said (2015):

1. **Making Iodine 0.01 N Standardized Solution**
   
   5.75 grams of KI was gradually dissolved in distilled water until it was dissolved completely and forming a concentrated KI solution. Then, 3.175 grams of iodine was added and dissolve again with distilled water, then it was poured into a 250 ml beaker glass. After that, distilled water was added to reach the glass limit so it resulted in an iodine 0.1 N solution. The next step was taking 10 ml of iodine 0.1 N and put it into 100 ml beaker glass. Then, the distilled water was added up to the calibration label, so that it will be iodine 0.01 N solution.

2. **Making 1% Amylum Indicator Solution**
   
   1 gram of amylum was mixed with 100 ml of hot water in the beaker glass until it dissolved completely. The solution was then heated until it became a clear solution. Amylum 1% was used as the indicator.

3. **Measuring Vitamin C Content**
   
   20 grams of sample were ground and added with 20 ml of distilled water. It was then filtered by using a cloth to separate its filtrate. Then, 10 ml of sample extract was transferred to the Erlenmeyer flask and added with 2 ml of amylum solution 1% and 20 ml of distilled water. Subsequently, the titration process was executed by using iodine 0.01 N. The volume of iodine 0.01 N that was needed to change the solution color into dark blue must be noted. (Slamet et al., 1989 in Rahman et al. 2015).

\[
\text{Formulation: Vitamin C (mg/100g) = } \frac{\text{VI2 x 0.88xfp}}{\text{Ws}} \times 100
\]

**Description:**

- \(\text{VI2}\): Volume of iodine (ml)
- 0.08 : 0.88 mg of ascorbic acids ~ 1 ml of iodine 0.01 N
Ws : Sample weight (g)
Fp : Dilution factor

Data Analysis
The data were analyzed using ANOVA (*Analysis of Variance*). If there is an impact on the different treatment of the test result treatment, the process was continued with LSD (Least Significant Difference) test. Besides, an organoleptic test was performed by 30 panelists who like to consume raisin. The panelist was given 9 samples of bilimbi raisin and was asked to write down the assessment result on the provided paper. The assessment of organoleptic test based on the characteristic of taste, color and flavor/aroma by using a scale of 1-4, those are extremely like (4), like (3), dislike (2) and extremely dislike (1). The data of the assessment sheet was calculated by using the formulation of SNI 01-2346-2006 with the trust level of 95%, that is:

\[
P \left( \bar{x} - (1.96 \frac{S}{\sqrt{n}}) \right) \leq \mu \leq P + (1.96 \frac{S}{\sqrt{n}})
\]

\[
\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}
\]

\[
S^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}
\]

\[
S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}
\]

Description:
n is the number of panelists;
S\(^2\) is the diversity of quality value
1.96 is the coefficient of standard deviation in 95% level;
\(\bar{x}\) is the average quality value;
\(x_i\) is the quality value of the panelist -1, where \(i = 1, 2, 3, \ldots \ldots n\);
S is the standardized deviation of quality value

RESULTS AND DISCUSSION

1. Water Content and Vitamin C Content
One of the most important quality parameters of food is water content. The percentage of water in the food refers to water content (both wet basis and dry basis). Water becomes one of the main factors of the physical and chemical reactions of certain ingredients. Therefore, water content becomes one of the main determinants in food shelf-life (Buckle et al., 1985). Principally, the water content of an ingredient will be inversely related to the shelf-life of the food. The kind of water measured in food is free water.

The result of water content measurement shows that the different concentration of sugar solution affects the water content value of the product. In this case, the concentration value of the sugar solution used is inversely related to the product's water content value tested. The lowest average water content in K3 (the concentration of 100% sugar solution) is 10.64 %. The average water content for K2 treatment with the concentration of 75% sugar solution is 13.30% and the highest water content is found in K1 treatment with the concentration of 50% sugar solution that is 16.09%. The result of the water content data is supported with the statistical test result or ANOVA test as well as the advanced test, which is the LSD test. Here, the F calculation of the ANOVA test (61.72) is higher than F in the table (5.14). In the LSD test, the average K1 differs significantly with K2 and K3 which states the addition of sugar affects the water content. From the testing result, the best water content is found in K3 that is 10.64%, which was lower than K1 and K2 treatment. The water content in K3 treatment has conformed to SNI 01-4862-1998 of raisin water content that is maximally 18%.
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Table 2. The Average Results of Water and Vitamin C Content of Bilimbi Raisin

| Treatment     | Appearance | The Average Water Content (%) | The Average Vitamin C (mg/100g) |
|---------------|------------|-------------------------------|---------------------------------|
| K1 (50% sugar) | ![Image](image1.png) | 16.09 ± 0.88                 | 7.77 ± 0.25                     |
| K2 (75% sugar) | ![Image](image2.png) | 13.30 ± 0.35                 | 6.16 ± 0.44                     |
| K3 (sugar100%) | ![Image](image3.png) | 10.64 ± 0.43                 | 5.13 ± 0.25                     |

Description: Any number followed by a different letter indicates a real difference.

In making raisin from bilimbi, adding more sugar will reduce the water content of the resulted product. According to Buckle et al. (1985) in Nusa, Fuadi, and Sanjaya (2014), the sugar content of food products will increase its ability to bind water because of the hydrogen bond between water molecules and sugar molecules so that the water content will be reduced. Moreover, the higher sugar addition of food products will be directly proportional to the length of its shelf-life. This is because increasing osmotic pressure prevents microbial growth of the product. High content sugar can also decrease the water activity (aw) of the ingredients and eliminate water content availability as the medium of microorganism growth. This condition is also found in the previous research performed by Joseph, Lalujan, and Sumual (2017) which stated that high sucrose concentration as a result of sugar solution immersion process leads to the reduced water content of candied chili pepper. The use of sugar solution in the immersion process will decrease the vapor pressure of the solution so that the water evaporation of the dried ingredients will be lower. Research conducted by Khanom, Rahman, and Uddin (2017) which examined the impact of sugar concentration on mass transfer of pineapple during the osmotic drying process also suggested that high sugar concentration will reduce the water content of the ingredient. This condition was also stated by Winarno (1997) where the concentration of sugar used in the solution is directly proportional to the water coming out of the ingredient as a result of high osmotic pressure in high concentrated sugar solution. Therefore, a highly concentrated sugar solution will be able to draw liquid into the food product. The low molecule weight of the sugar will also increase the quality stability of the product.

Vitamin is an organic compound required by our body in a tiny amount. Besides, our body cannot produce vitamin C and we can only take it from dietary sources. Vitamin is
classified into 2 types; those are water-soluble vitamin and fat-soluble vitamin. Water-soluble vitamin has many functions for our body metabolism, such as becoming co-enzyme components and a prosthetic group of an enzyme. Vitamin C has a typical characteristic of soluble in the water and is prone to damage compared to other vitamins (Almatsier, 2003).

Based on the data of vitamin C content testing on bilimbi raisin with different sugar addition of 50%, 75% and 100%, it can be seen that the average amount of the highest vitamin C content is K1 treatment, that is around 7.77 mg/100 g. On the other hand, K2 treatment has an average amount of vitamin C content around 6.16 mg/100 g. Meanwhile, the lowest vitamin C content is found in K3 treatment with an average of 5.13 mg/100 g. The result of the data on vitamin C content is supported by the result of a statistical test or ANOVA test, as well as an advanced test wherein ANOVA test, F value (24.05) is greater than F table (5.14). In the LSD test, the average K1 is significantly different from K2 and K3 which stated that the added sugar affects vitamin C content. From the test result, it can be seen that the best vitamin C content is found in K1 treatment of 7.77 mg/100g, which is higher than raisin with K2 and K3 treatment.

According to Santos and Silva (2008), any fruit which is dried with an osmotic process (immersing the ingredient in high-concentrated solution) similar to the making of raisin or candied fruit, will go through three types of mass transfer, that is water mass transfer from the ingredient to the solution, transfer of dissolved ingredient of the solution to the ingredient and the releasing process of ingredient components such as sugar, organic acid and vitamin, to the solution. Since this research used a sugar solution, the driving force is the gradient of sugar concentration between the ingredients and the solution (Cichowska et al., 2019). The higher the sugar concentration of the solution is, the higher level of mass transfer. This condition explains the above result where the vitamin C content of raisin is declining in the immersion process in a higher sugar concentration solution. Moreover, high sugar concentration in the immersion solution will decrease vitamin C content since the characteristic of water which can be easily bound in sugar solution will flow out, and vitamin C, as it is a water-soluble vitamin, will also flow out. Plasmolysis process of the ingredient and wall cell can also occur as a result of binding osmotic pressure from high concentrated sugar solution that the vitamin C becomes easily soluble in the water and diffused out from the ingredient. Vitamin C stability is relatively high in dry conditions, yet it will oxidize easily in the dissolved condition by the air, particularly in high temperatures. Different treatment of sugar addition of bilimbi raisin will affect the vitamin C content of the resulted raisin. Vitamin C is highly soluble in the water, so the less sugar is added; the less water flows out from the food product. Besides, sugar addition will bring a particular taste and aroma/flavor. This is in line with the research performed by Septya, Suhaidi, and Ridwansyah (2017) on the impact of sugar concentration on the quality of wet-candied papaya leaf stem which stated that sugar concentration is inversely proportional to its vitamin C content. This result is also consistent with the research result of Trapsila, Pratjojo, and Kusumastuti (2014) that presented processing of star fruit into dry candied with sugar cane juice as the natural preservative, where the highest vitamin C content of the candied star fruit was found in the variation of sugar cane juice immersion with the lowest volume.

The initial vitamin C levels of 100 g fresh bilimbi is 25 mg. After being processed into a raisin, vitamin C content of the fruit decreases to around 17.23-19.87 mg/100 g. Any factor causing the loss of vitamin C in bilimbi raisin is the processing of raisin from washing, immersing and drying. Winarno (2008) and Lean (2006) in Joseph, Lalujan, and Sumual (2017) stated that vitamin C is more vulnerable than any other vitamins, having high water solubility and also easily decomposed by oxidation as a result of light or heat exposure. This condition is also explained in the research conducted by Mawarni and Yuwono (2018) which stated that increasing temperature and the cooking duration will decrease vitamin C levels of a food product since this vitamin can be easily damaged due to the heating process. Different sugar addition of each treatment also leads to vitamin C loss of the ingredient. The less sugar is added, the higher vitamin C found in the raisin. Vitamin C can be dissolved by water so that the more sugar is added to the product, the more water is flowing out to dissolve the vitamin C. Vitamin C content of raisin can be an antioxidant source requires by
our body since vitamin C is a good electron donor (reduction), and giving its electron will prevent other compounds oxidized (Padayatty et al., 2003).

2. Organoleptic Test (Preference Test)

Table 3. Organoleptic Test

| Treatment | Taste  | Color | Aroma/Flavor |
|-----------|--------|-------|--------------|
| K₁        | 1.92   | 1.90  | 2.09         |
| S¹        | 0.16   | 0.16  | 0.18         |
| S         | 0.40   | 0.41  | 0.42         |
| Value interval | 1.78 < μ < 2.07 | 1.76 < μ < 2.04 | 1.94 < μ < 2.24 |
| Final value | 2 (dislikes) | 2 (dislikes) | 2 (dislikes) |
| K₂        | 2.89   | 2.62  | 2.78         |
| S¹        | 0.26   | 0.25  | 0.24         |
| S         | 0.51   | 0.50  | 0.49         |
| Value interval | 2.71 < μ < 3.07 | 2.44 < μ < 2.80 | 2.60 < μ < 2.95 |
| Final value | 3 (likes) | 2 (dislikes) | 3 (likes) |
| K₃        | 3.40   | 2.73  | 3.24         |
| S¹        | 0.26   | 0.58  | 0.28         |
| S         | 0.51   | 0.76  | 0.53         |
| Value interval | 3.22 < μ < 3.58 | 2.46 < μ < 3.01 | 3.05 < μ < 3.43 |
| Final value | 3 (likes) | 2 (dislikes) | 3 (likes) |

Description: Final value is taken from the rounded and smallest value interval
Taste, color, texture and aroma/flavor are some quality determining factors of a food product. The followings are panelists' acceptance level based on organoleptic hedonic analysis with different sugar addition:

a. Taste

Food product taste is a combination of several different types of taste, that is collectively emerging a whole taste and affected by the concentration and types of chemical compounds and also temperature. The interaction between each food component is a factor that influences the taste of certain food, so that good and bad taste will be a subjective matter, depends on consumers' preference. The taste of certain food does not only depend on how our tongue perceives taste but also how other senses work together to detect the taste. Consumers' acceptance of certain food is much affected by the taste derived from the character of its basic ingredients or other additional components used in processing the food (Kartika, 1988).

Sugar is a dominant component that brings taste to jumbo raisin from bilimbi. According to Kartika (1988), the comparison of sucrose and glucose of certain food is directly proportional to its sweetness level until, in certain concentration limits, there will be a decrease in that good taste or sweetness levels it contains. The organoleptic result shows that different sugar addition brings different taste acceptance on the bilimbi raisin. The higher sugar concentration is added, the panelists tend to like the taste more. Panelists score 2 (dislike) to jumbo raisin from bilimbi with 50% sugar addition, 3 (like) to jumbo raisin from bilimbi with 75%, and 100% sugar addition.

b. Color

Color is a determining factor in the physical appearance of particular food since it brings the first impression for the consumers. Sometimes, the color becomes a determining factor of food quality, so that certain food additives are used to maintain food color. According to Winarno (1997), the result of caramelize reaction, dark color as a result of the Maillard reaction and food dyes addition, as well as product oxidation process, are some causes of color changes in food. The processing of jumbo raisin from bilimbi uses sugar to inhibit microbial growth and also to keep its color. Jumbo raisin is not only immersed in sugar
solution but also going through the drying process. The reaction which causes color changes in the dried food product in caramelization and Maillard reaction.

According to Winarno (1997), in the drying process, the organic acid of the ingredients will react to reducing sugar and leads to color change, more specifically into brown color (browning). This reaction is begun with sucrose hydrolysis where sucrose is split into inert sugar (glucose and fructose). Browning reaction occurs after the splitting and dehydration process, and there will be polymerization which produces some organic acids that react to reducing sugar. Based on the research result, the color of jumbo raisin from bilimbi is brown. The organoleptic test result shows that different sugar addition does not bring different acceptance on bilimbi raisin color, where panelists assessment on the color of jumbo raisin for all treatment is the same, that is 2 (dislike).

c. Aroma

One of the quality parameters used in organoleptic testing is the aroma or flavor which can be perceived by a sense of smell and its typical aroma is acceptable (Kusumawati et al., 2000). Food aroma can be one important way to stimulate the appetite. Before eating food, consumers are used to smelling its aroma first to judge its quality. Therefore, the aroma is the most important factor in determining consumers’ acceptance of a certain product. The aroma of the food product is caused by the formation of a volatile compound, as a result of an enzymatic reaction or non-enzymatic reaction, that can be perceived by our sense of smell (Zuhrina, 2011).

According to Zuhrina (2011), the concentration of aroma components in the vapor phase in our mouth defines the aroma produced. The organoleptic result shows that different sugar addition gives a different aroma perception of bilimbi raisin. The more sugar amount is added, the panelists like the aroma more. The aroma of bilimbi will decrease if more sugar is added. Besides, adding different sugar concentrations will bring a different aroma to bilimbi raisin. Panelists score 2 (dislike) for jumbo raisin from bilimbi with the addition of 50% sugar, and score 3 (like) for jumbo raisin from bilimbi with the addition of 75% and 100% sugar.

CONCLUSIONS

Based on the processing result of jumbo raisin from bilimbi with different sugar addition, it can be concluded that the treatment formulations that were used are with different sugar addition of 50%, 75% and 100%. The best result of water content is found in the 100% sugar addition with an average of 10.64%, and the highest vitamin C content is found in the 50% sugar addition (with an average of 7.77 mg/100 g). The highest acceptance of the panelists on the preference test is found in the 75% and 100% sugar addition with the same final value, those are 3 (like) from the taste aspect, 2 (dislike) from the color aspect and 3 (like) from aroma/flavor aspect.

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