Application of Calcium Hydroxide Concentration and Immersion Duration Towards Tomato Sweets Quality

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Abstract. Tomatoes flesh texture is tender, leading to mussy texture when cooked and immersed in sugar solution during the sweets processing. Therefore, this research used calcium hydroxide (Ca(OH)2) to aid the proper texture formation of tomatoes sweets during processing. The aim of this research was to observe the proper concentration of Ca(OH)2 and duration of immersion according to the quality and sensorial properties of tomatoes sweets. The experimental design used was Completely Randomized Design with two factors, i.e. Ca(OH)2 concentrations (5, 10, and 15 % (w/v)) and immersion duration (2, 6, 12, and 24 hours). Each treatment was done in three replications. Moisture content, vitamin C, total acid, texture and sensorial parameter test was evaluated. The research results showed significant difference between the Ca(OH)2 and immersion duration treatments. Moisture content and texture score increased along with the addition of Ca(OH)2 concentration and immersion duration, but it had negative correlation with vitamin C and total acid content. The tomatoes sweets treated with 15% Ca(OH)2 and immersion duration of 2 hours was the most preferred by panelists. The best treatment of tomatoes sweets from the sensory perspective contained 46.64% moisture content, 52.99 mg/100g vitamin C, 1.26% total acid, and 2.3 kg/cm2 texture score.

1. Introduction

Tomatoes (Solanum lycopersicum) is one of the most beneficial vegetables consumed as food ingredients or fresh. It is rich in nutrition especially vitamins and minerals, as well as a huge source of lycopene, 28 to 133 mg•kg−1, which acts as antioxidant [1]. Furthermore, the benefit of consuming this vegetable includes prevents degenerative diseases, attributed and associated with its rich flavonoids, phenolic acid, vitamin C and E [2]. However, this vegetable requires proper handling in the harvest time to postharvest treatments due to its short shelf life and it is categorized as perishable food due to high moisture content. Overall tomatoes production in Indonesia was 962.845 metric ton in 2017, and 24.520 metric ton specifically in Bali Province [3]. To add the value and to increase the farmers income, tomatoes could be processed into several products which may extend the shelf-life e.g. tomato ketchup, “dodol”, and sweets [4,5].

Sweets and candies are known as confections or craft products and defined as foods in which generally attributed and associated with sweetness taste with sugar as the main ingredient. It is commonly understood that candy is physically rather small compared to sweets [6]. Fruit candies, according to Cappa et al [7] should contain minimum 45 g/100g of fruits, with addition of sugar as much as 55g/100g and due to association to gel-like texture, candies may contain pectin as gelling agent as
well as organic acid. In addition, Susanto and Saneto [8] mentioned that these products were usually added with fruits flavor and used as snacks which could be grouped into three categories, i.e. dry sweets, wet sweets and wet sweets with sugar liquid. However, there was no basic standard in this category, therefore, the confectionary manufacture might differ in the characterization and categorization of sweets and candies types.

Tomatoes sweets offer functional food properties that may benefit the health. The basic principle of sweets processing is to soak the ingredients/fruit in sugar water for some time to obtain a certain level of sweetness [9]. Furthermore, to increase firmness of produce or processed fruits derivatives, calcium plays a fundamental role. Several studies had been conducted to maintain fruits and vegetables cell wall structure implementing calcium. Commonly, calcium solution is used prior to processing to maintain whole or fresh-cut fruits freshness and extend shelf-life, such as in mango [10], apple[11], mushrooms [12] and ready to eat spinach [13] during the storage. In addition, calcium incorporation on processed fruits was also studied due to its ability to improve physical characteristic of papaya syrup and it demonstrated promising result as it is able to enhance mechanical properties and nutritive content [14].

Therefore, in this study calcium was used as additive in tomatoes-based sweets. Calcium hydroxide (Ca(OH)₂) can be used due to its ability to reinforce the surface fruits tissues in order to maintain the fruits intact during the heating process [15,16]. Ca(OH)₂ is a Generally Recognized as Safe (GRAS) food additive according to US-FDA and it is an EU approved additives and E number based on UK Food Standard Agency which commonly known as slaked lime or INS 526 as firming agent and acidity regulator [17,18]. The solution contains Ca²⁺ ion reacts with pectic compounds in the fruit tissues forms Ca – pectate, a pectin fiber in which might inhibit hydrolysis of pectic compounds which leads to intact the fruit firmness [12]. In this research, the purpose of using calcium hydroxide was to enhance the firmness of tomatoes sweets. Therefore, the calcium hydroxide treatments and immersion duration variation were expected to be effective to improve the quality of tomatoes sweets based on moisture content, vitamin C, total acid, texture, and sensorial properties. The aim of this research was to observe the proper concentration of Ca(OH)₂ and duration of immersion according to the quality and sensorial properties of tomatoes sweets.

2. Materials and Methods

2.1 Materials
Fresh tomatoes were obtained from local market in Tabanan Municipal, Bali, Indonesia. The tomatoes were graded and selected based on physical appearance i.e. fresh red color and free from physical defects, immediately brought to AIAT Food Laboratory and processed in the same day. Food grade calcium hydroxide (Ca(OH)₂) was obtained from Brata-Chemical, Indonesia. Other chemicals used in this experiment and analysis were reagent grade e.g. potassium iodide and iodine crystal purchased from Merck (Darmstadt, Germany), NaOH 0,1 N (Himedia, India), Phenolphthalein indicator (Has Chemical, Indonesia). Several equipment used in the processing of tomatoes sweets included oven drier (Memmert, GmBH, Germany), stoves, bowl, analytical balance, and other basic cooking equipment. In addition, the tools for analyzing moisture content, vitamin C, and total acid consisted of blenders, analytic scales, oven, burette, pipette, Erlenmeyer flask, and Whatman filter paper 1. Hand penetrometer (DGSI, Germany) was used to measure texture firmness.

2.2 Methods

2.2.1 Experimental Design
The research used Completely Randomized Design with 2 factors. The first factor was Calcium hydroxide concentration 5%, 10%, and 15%, the second factor was the duration of immersion variation 2, 6, 12 and 24 hours. All treatments were done in 3 replications. Several analysis was conducted to evaluate the quality of tomatoes sweets, e.g. moisture content and total acid, following the method of AOAC [19], and vitamin C (SNI 01-2891-1992) [20]. Objective texture analysis using hand –
penetrometer by measuring the firmness of the material against the force, expressed as kg/cm² [21]. Sensory analysis and ranking test by method of Soekarto [22].

2.2.2 Processing of tomatoes sweets
The processing of tomatoes for the sweets following the method from Buntaran et al. with slight modification [9]. In brief, the seedless tomatoes was soaked with Ca(OH)₂ according to the treatments followed by washing the treated tomatoes cleanly and then arrange the tomatoes in a pan/ skillet/ cauldron and sprinkle sugar on top (2 parts tomatoes: 1 part sugar). To reduce the moisture content, the tomatoes dough was let stand overnight and then followed by cooking the tomatoes with low temperature heat. The properly shaped sweets were dried at 50°C in an oven dryer.

2.3 Quality test evaluation
Moisture content analysis was following the direct measure method employing oven drier according to AOAC [19]. The temperature employed was 105°C for 15 minutes, drying was repeated until constant weight was obtained (error weight was ≤ 0,0003 grams). Vitamin C analysis following the standard method from Badan Standardisasi Nasional Indonesia using redox iodine titration method [20]. Determination of vitamin C content was done by mashing sample of 25 g homogeneously and then filtered. 25 ml filtrate and 2 ml of starch drawn and was titrated with iodine 0,01 N until blue discoloration was constantly appeared. Total acid measurement was conducted based on AOAC [19] by preparing 25 gram of sample followed by boiling for 1 hour and titrated using 0,1 NaOH PP indicator until the colour change was observed.

2.4 Texture analysis
Texture analysis for final product of tomato sweets was using hand penetrometer by measuring the level of hardness of the material against a given load which expressed in unit of the value of kg/cm² [21]. Measurements was made by placing hand-penetrometer needle on the surface of the material in a perpendicular instrument, then press the penetrometer slowly until it penetrates the flesh of the fruit. The measurement value from the needle that was showing the results.

2.5 Sensory analysis
Sensorial analysis was ranking test to determine the most liked and hedonic test towards color, aroma, texture, taste and overall [22]. Ranking test was done by selected panelists asked to determine the rank of the most liked product and then followed by scoring interpretation. The Panelists employed in sensory testing were 15 trained panelists. The scale used in the preference test consists of 1 = very dislike; 2 = dislike; 3 = ordinary / neutral; 4 = like; and 5 = very like.

2.6 Data Analysis
Data were analyzed using Analysis of Variance (ANOVA) with SPSS 16 IBM software. If the analysis results of variance showed a significant effect (p <0.05) then continued with the Duncan's Multiple Range Test (MRT).

3. Result and Discussion

3.1 Quality evaluation of tomatoes sweets
The results of moisture texture, vitamin C, total acids and texture firmness analysis of the tomatoes sweets with Calcium Hydroxide (Ca(OH)₂) treatments presented in Table 1 – 4. Generally, the moisture content of the tomatoes sweets affected by the concentration of Ca(OH)₂ and the immersion duration variations. The higher the concentration of Ca(OH)₂ and the longer the immersion duration causes an increase in the water content of the sweets. The highest moisture content obtained from the concentration of 15% Ca(OH)₂ after 24-hours immersion duration, significantly higher then 12 hours of immersion (Table 1). Consequently, the lowest moisture content of the sweets showed in the 5% Ca(OH)₂ solution
in shortest time of immersion 2 hours, and significantly lower than the same concentration with 24 hours of immersion duration.

Table 1. The effects of Ca(OH)$_2$ concentration and immersion duration on moisture content (% dw) of the tomatoes sweets

| Ca(OH)$_2$ concentration % (w/v) | Immersion duration |
|----------------------------------|--------------------|
|                                  | 2 hours            |
|                                  | 6 hours            |
|                                  | 12 hours           |
|                                  | 24 hours           |
| 5%                               | 14.81 ± 0.99 a     |
|                                  | 15.97 ± 1.53 a     |
|                                  | 21.66 ± 2.52 b     |
|                                  | 21.9 ± 1.28 b      |
| 10%                              | 22.65 ± 2.31 a     |
|                                  | 34.29 ± 3.26 b     |
|                                  | 46.55 ± 1.27 c     |
|                                  | 46.59 ± 2.21 c     |
| 15%                              | 46.64 ± 1.66 a     |
|                                  | 47.82 ± 1.88 a     |
|                                  | 59.37 ± 1.28 b     |
|                                  | 62.14 ± 1.51 ab    |

CV (%) = 5.22

Notes: The number followed by the same letter in the same row and column shows no significant difference in Duncan's test level of 5%. Small letters are read the horizontal direction (lines) and capital letters are read vertical directions (columns)

In this study all treatments illustrated gradual loss of moisture content. This might be associated to the chemical process, the higher Ca(OH)$_2$ concentration in the mixture leads to increase the calcium bonds with pectin, and as a result it strengthen the tissue structure of the fruits cell wall [23]. Thus, the reaction may inhibit the evaporation of the water in the fruits cell during the drying process of the sweets. This result is in accordance with the research of Haryanti et al, [24] that utilized 1.5% Ca(OH)$_2$ on french fries with more than 1% higher moisture content compared to untreated samples/ control. Another study by Asiah and Handayani confirming this condition implements Calcium hydroxide on vacuum fried pineapple product resulting higher moisture content and reduces mass shrinkage with 0.5% w/v Ca(OH)$_2$ in 30 minutes soaking duration [25].

Table 2. The effects of Ca(OH)$_2$ concentration and immersion duration on Vitamin C (mg/100 g) of tomatoes sweets

| Ca(OH)$_2$ concentration % (w/v) | Immersion duration |
|----------------------------------|--------------------|
|                                  | 2 hours            |
|                                  | 6 hours            |
|                                  | 12 hours           |
|                                  | 24 hour            |
| 5%                               | 62.37 ± 2.62 c     |
|                                  | 52.49 ± 2.49 b     |
|                                  | 51.14 ± 1.56 b     |
|                                  | 52.99 ± 0.77 a     |
| 10%                              | 51.94 ± 1.74 c     |
|                                  | 53.51 ± 1.64 c     |
|                                  | 53.02 ± 2.84 b     |
|                                  | 42.81 ± 1.85 a     |
| 15%                              | 52.99 ± 1.79 a     |
|                                  | 49.48 ± 2.86 ab    |
|                                  | 44.24 ± 3.00 b     |
|                                  | 36.25 ± 1.78 ab    |

CV (%) = 4.56

Notes: The number followed by the same letter in the same row and column shows no significant difference in Duncan's test level of 5%. Small letters are read the horizontal direction (lines) and capital letters are read vertical directions (columns)

Vitamin C content of the tomatoes sweets effected by the Ca(OH)$_2$ concentration (Table 2). The higher Ca(OH)$_2$ concentration coupled with the extended duration of immersion lead to the degradation of Vitamin C content. The lowest levels of Vitamin C were in the treatment of Ca(OH)$_2$ concentration of 15% with a 24-hour soaking duration. This phenomenon is a common issue with vitamin C, since it is the type of vitamins which are prone to hydrolysis during the processing of materials and categorized as vitamins which is highly soluble in water [26,27]. In addition, during the process, ascorbic acid oxidizes to dehydroascorbic acid, DHAA hydrolysed to 2,3 diketogulonic acid. The temperature affect and increase oxidation and thus the Vitamin C intact during process [28].
### Table 3. The effects of Ca(OH)$_2$ concentration and immersion duration on total acids (%) of tomatoes sweets

| Ca(OH)$_2$ concentration % (w/v) | Immersion duration |
|-------------------------------|------------------|
|                               | 2 hours       | 6 hours       | 12 hours      | 24 hours      |
| 5%                            | 0.76 ± 0.55 a  | 0.77 ± 0.13 a | 0.65 ± 0.13 a | 0.65 ± 0.16 a |
| 10%                           | 1.16 ± 0.18 c  | 0.97 ± 0.13 b | 2.87 ± 0.11 ab| 0.68 ± 0.13 a |
| 15%                           | 1.26 ± 0.08 c  | 0.99 ± 0.15 b | 0.82 ± 0.15 ab| 0.64 ± 0.10 a |

CV (%) = 15.29

Notes: The number followed by the same letter in the same row and column shows no significant difference in Duncan’s test level of 5%. Small letters are read the horizontal direction (lines) and capital letters are read vertical directions (columns).

Texture firmness is one of the most crucial aspects for the consumer acceptability. The greater the load needed to tear the sample, the higher the level of hardness of the tomato sweets. The highest average of the texture firmness of tomatoes sweets is 3.57 kg/cm$^2$ obtained from 10% Ca(OH)$_2$ concentration treatment with 6 hours immersion duration (Table 4). This sweets gain the firmness due to the pectic compound forms Ca-Pectate in the tissue of the fruits [29].

### Table 4. The effects of Ca(OH)$_2$ concentration and immersion duration on texture firmness (kg/cm$^2$) of tomatoes sweets

| Ca(OH)$_2$ concentration % (w/v) | Immersion duration |
|-------------------------------|------------------|
|                               | 2 hours       | 6 hours       | 12 hours      | 24 hours      |
| 5%                            | 1.80 ± 0.10 a  | 2.50 ± 0.26 b | 2.57 ± 0.25 b | 3.10 ± 0.17 c |
| 10%                           | 3.33 ± 0.15 c  | 3.57 ± 0.15 c | 2.87 ± 0.15 b | 2.10 ± 0.36 a |
| 15%                           | 2.30 ± 0.26 a  | 2.50 ± 0.10 ab| 3.03 ± 0.42 b | 2.63 ± 0.38 ab|

CV (%) = 8.31

Notes: The number followed by the same letter in the same row and column shows no significant difference in Duncan’s test level of 5%. Small letters are read the horizontal direction (lines) and capital letters are read vertical directions (columns).

According to Afifah [30], immersion of fruit treatment in a calcium solution might strengthen the texture of the fruit so that it produces tomatoes sweets with a hard texture. This is due to the calcium compound in the solution absorbed by the fruit tissue. In addition, according to the content of pectic substances contained in the fruit tissue reacts with the calcium solution to form calcium lactate which strengthens the fruit tissue. Calcium solution is an electrolyte containing cations that might be able to react with pectin molecules and result in Ca- Pectinate formation which is insoluble in water. The dissociated Ca$^{2+}$ in the calcium solution reacted with carboxyl groups in pectin lead to the formation of Ca-pectinate. The longer the immersion duration, the more Ca ions reacted with pectin. Processing sweets using calcium hydroxide solution with a concentration of 5-10% produces sweets with a harder texture with better taste [31].
3.2 Sensory analysis

The results of analysis of variance in sensory parameters test of the tomatoes sweets were significantly different (p < 0.01) on color, taste, and overall acceptance (Table 5). The treatment of 15% Ca(OH)\textsubscript{2} concentration with 2 hours immersion duration obtained the highest score in the color test 4.00 (like), highest taste score among other treatments 3.80 (neutral to like), and overall acceptance by the panelist of 3.67 (neutral to like). Based on this result there is a tendency for the longer immersion duration and lower concentration in the calcium solution resulting in faded color appearance which leads to a decrease in the sensorial test score, especially in color aspect. This result is inline with other research that was observing the sensory parameter of pineapple crisp cooked by vacuum frying equipment in which the color of pineapple crisp was found brighter in the samples that was treated with higher concentration of calcium hydroxide disregarded the length duration of cooking [25].

Tabel 5. Sensorial properties test of the tomatoes sweets treated with several Ca(OH)\textsubscript{2} concentration and immersion duration

| Treatments | Color   | Aroma   | Texture | Taste   | Overall  |
|------------|---------|---------|---------|---------|----------|
| 1          | 3.80 ± 0.86 de | 3.80 ± 0.22 a | 3.67 ± 1.05 a | 3.20 ± 0.94 | 3.33 ± 1.05 bc |
| 2          | 3.00 ± 0.17 bc | 3.13 ± 0.17 a | 2.87 ± 0.22 a | 3.00 ± 0.85 abc | 2.87 ± 0.83 ab |
| 3          | 3.60 ± 0.16 cde | 2.93 ± 0.88 a | 2.80 ± 0.86 a | 3.53 ± 0.74 cd | 3.33 ± 0.19 bc |
| 4          | 3.73 ± 0.88 de | 3.33 ± 0.62 a | 2.80 ± 0.86 a | 3.40 ± 0.74 bcd | 3.33 ± 0.62 bc |
| 5          | 3.47 ± 1.06 cde | 3.07 ± 0.80 a | 3.27 ± 0.88 a | 3.73 ± 0.80 d | 3.47 ± 0.83 bc |
| 6          | 3.20 ± 0.86 bcd | 3.27 ± 0.80 a | 3.27 ± 1.16 a | 3.40 ± 0.99 bcd | 3.27 ± 0.59 bc |
| 7          | 2.67 ± 0.98 b | 3.07 ± 1.03 a | 2.53 ± 0.99 a | 2.80 ± 0.94 ab | 2.27 ± 0.96 a |
| 8          | 1.93 ± 1.03 a | 3.53 ± 1.00 a | 2.93 ± 1.33 a | 2.73 ± 0.88 ab | 2.40 ± 0.74 a |
| 9          | 4.00 ± 0.85 e | 3.20 ± 0.68 a | 3.27 ± 1.03 a | 3.80 ± 0.56 d | 3.67 ± 0.62 c |
| 10         | 3.00 ± 1.00 bc | 2.73 ± 0.80 a | 2.73 ± 1.16 a | 2.87 ± 0.74 abc | 2.80 ± 0.77 ab |
| 11         | 3.00 ± 0.93 bc | 3.20 ± 0.56 a | 2.40 ± 0.31 a | 2.67 ± 1.05 a | 2.47 ± 0.92 a |
| 12         | 3.87 ± 0.19 de | 3.20 ± 1.01 a | 3.00 ± 1.07 a | 3.87 ± 0.52 d | 3.33 ± 0.90 bc |

Notes: The number followed by the same letter in the same row and column shows no significant difference in Duncan’s test level of 5%. Small letters are read the horizontal direction (lines) and capital letters are read vertical directions (columns).

Treatment 1 = 5% Ca(OH)\textsubscript{2}: 2 hrs immersion duration; Treatment 2 = 5% Ca(OH)\textsubscript{2}: 6 hrs immersion duration; Treatment 3= 5% Ca(OH)\textsubscript{2}: 12 hrs immersion duration; Treatment 4 = 5% Ca(OH)\textsubscript{2}: 24 hrs immersion duration; Treatment 5 = 10% Ca(OH)\textsubscript{2}: 2 hrs immersion duration; Treatment 6 = 10% Ca(OH)\textsubscript{2}: 6 hrs immersion duration; Treatment 7= 10% Ca(OH)\textsubscript{2}: 12 hrs immersion duration; Treatment 8 = 10% Ca(OH)\textsubscript{2}: 24 hrs immersion duration; Treatment 9 = 15% Ca(OH)\textsubscript{2}: 2 hrs immersion duration; Treatment 10 = 15% Ca(OH)\textsubscript{2}: 6 hrs immersion duration; Treatment 11 = 15% Ca(OH)\textsubscript{2}: 12 hrs immersion duration; Treatment 12 = 15% Ca(OH)\textsubscript{2}: 24 hrs immersion duration;

Sensorial properties test is of the key variable as determination point of acceptability of product from the panelists and essential to quality control aspect [32]. The highest sensorial score was found in treatment 9 by hedonic testing. Furthermore, ranking test was done by sorting products according to panelist preferences and then the first rank is used as a benchmark to determine the best product. The results of the ranking test analysis showed that treatment 9 (15% Ca(OH)\textsubscript{2} with 2 hours immersion duration) was ranked 1st with the highest score 0.60 (Figure 1). This indicates that the panelists preference to the product of treatment 9 due to of the acceptance in terms of color, aroma, texture, taste, and overall was the best compared to other treatments.
Figure 1. Sensorial ranking test of tomatoes sweets with the treatment of concentration and immersion duration in Ca(OH)$_2$.

4. Conclusions
From this research, it can be inferred that, calcium hydroxide could be employed to retain the physical quality and sensorial properties of tomatoes sweets. Based on the sensorial ranking test, Ca(OH)$_2$ concentration of 15% with immersion duration for 2 hours was determined as the most optimum treatment and obtained the highest sensorial score from the panelist due to its color, aroma, taste, texture and overall aspects. The sweets treated with Ca(OH)$_2$ holds more water which offers better moisture content, as well as inhibition of evaporation during the drying process of the tomatoes sweets. Therefore, it results better firmness and maintain the texture of the final product of sweets during the drying process.

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