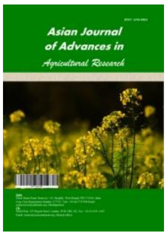

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The Effect of $Ca(OH)_2$ and Sugar on Characteristics of Long Beans Sweet

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Long beans are one type of vegetable that is quite popular in the community and has the potential to be developed. Although this type of vegetable gets damaged easily, its shell life is extended by drying which is achieved by adding $Ca(OH)_2$ and soaking it in sucrose for about 12-24 hours. The solution helps to strengthen its texture before processing. This research aims to determine the effect of $Ca(OH)_2$ and sugar treatment on the appearance of sweet long beans. Furthermore, it is designed as factorial experimental research with a completely randomized value consisting of two factors namely $Ca(OH)_2$ (1%, 2%, 3%), and sugar solution (50%, 60%, 70%). The variables observed in sweet of long beans were reducing sugar, total moisture content, ash content, acidity, color test, yield test, and organoleptic test. Conclusively, the treatment using 1% of calcium hydroxide and 50% sugar concentration produced good characteristics with reduced sugar of 0.64 mg/100gr, moisture content of 8.53%, ash content of 2.17%, the acidity of 4.10, brightness level (L*) of 39.96, and a yield of 21.13%. Hence, it gives the best appearance, taste, texture, and overall acceptance on sweet of long beans.

Keywords: Long bean; sugar treatment; calcium hydroxide; sweets; product innovation.

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1. INTRODUCTION

Long beans have great economic importance, and it is often consumed fresh as a salad or processed into several dishes. In addition, it is considered a good source of vitamins and minerals, as well as highly rich in vegetable protein, with the following nutritional contents namely 70.00% carbohydrates, 17.30% protein, 1.50% fat, and 12.20% water. Furthermore, it contains vitamin c, folate, magnesium, manganese, and fiber which are good for human health [1,2] because they control cholesterol and blood sugar levels of the body [3,4].

The disadvantage of long beans is that they are quickly damaged due to microbial contamination, yellowing, and wilting. Nevertheless, processing into confectionery products helps to increase its shell life which is achieved by drying. These dried sweet beans are obtained with the addition of sugar and dried by sunlight or an oven [5]. Subsequently, the texture becomes harder as the moisture content reduces [6]. Generally, dry candy has a lower moisture content than wet sweets, which is about 20% [7], but to overcome the barrier in making sweets from vegetables, it is necessary to soak it in a $Ca(OH)_2$ lime solution [8]. This implied that calcium helps to maintain the texture of the fruit or vegetable [9]. Therefore, fruit needs to be treated with $Ca2^+$ severally before or after harvesting to increase fruit firmness or slow down its softening [10]. According to Arrington and DeVetter [11] and Huang et al. [12], the application of $Ca2^+$ affects fruit firmness. For example, calcium forms Ca-pectate with vegetable pectin, which causes increased rigidity [13,14].

Moreover, Sugar serves as the major ingredient for making sweets which are often used for flavoring, caramelizing, and forming a brownish color [15]. Wipf et al. [16] explained that in the production of dried sweets, glucose and sucrose are added and soaked for about 12-24 hours, this process improves the taste, aroma, and texture. At present, the relationship between the production sweet of long beans, granulated sugar, and $Ca(OH)_2$ has not been provided. Therefore, this research is aimed to study various processed long beans as well as determine the characteristics of candied long beans by soaking the $Ca(OH)_2$ and Sugar Solution.

2. MATERIALS AND METHODS

The research was a factorial completely randomized design consisting of two factors, namely the concentration of $Ca(OH)_2$ solution 1%, 2%, and 3% as well as the concentration of sugar solution 50%, 60%, and 70%. Each treatment was repeated three times to obtain 27 experimental units. The materials used go through a sorting process to obtain the best results and the long beans included are aged 30-40 days from the flowering process obtained in Jembrana District, Mendoyo District, and Filtering Village. Also, the following was added, F1 hybrid species, sugar, $Ca(OH)_2$, water, citric acid, parchment paper, filter paper, tissue, Nelson's reagent, arsenic molybdate solution, and plastic standing pouch. The tools used were scales, gas stove, plastic basin, knife, cutting board, baking sheet, stainless pan, wooden spoon, measuring cup, thermometer, UV-V spectrophotometry, clamp handle, oven, petri dish, desiccator, Erlenmeyer, and paper. filter, pH meter, color reader, analytical balance, blender, measuring flask, beaker, test tube, and aluminum foil.

The research data were analyzed by using the analysis of variance (ANOVA) method and are categorized into two namely objective and subjective data. For the objective data, a Least Significant Difference Test is conducted at a level of 5% to find out different pairs. While Duncan's Test was conducted for the subjective data, to analyze Reducing sugar content by spectrophotometer using the Nelson-Somogyi method. Afterward, the water content, ash content, pH, color test, analysis of color using a color reader with L*a*b* coordinate, and Yield test by comparing the final weight of the material with the initial weight were performed. Consequently, the subjective observation was carried out by organoleptic assessment and the number of panelists used was 25 people.

3. RESULTS AND DISCUSSION

3.1 Reduced Sugar

Based on the results of the study, the sugar concentration had a very significant effect, while the concentration of $Ca(OH)_2$ and its interactions had no significant effect on the reducing sugar of sweets long beans (Fig. 1). The concentration of $Ca(OH)_2$ to form a hardener on the cell wall of the material is a result of soaking the fruit in lime solution which causes a bond between pectin and $Ca(OH)_2$. According to Suriati [17], the change was due to the formation of a reaction between the content of $Ca2^+$ ions in lime which binds to the carboxyl group of pectin. Therefore, the sugar added during the soaking process is partially broken down into glucose and fructose. Also, Verma et al. [18] explained that the immersion of the sugar solution will cause the release of water from the fruit which alternates with the sugar solution entering the fruit. This property shows that the more sugar added, the higher the sugar content produced. Hence, this is in correlation with the opinion of Eom et al. [19], that a high sugar solution will cause the total sugar level to increase thereby causing a significant difference in reducing sugars.

3.2 Moisture Content

The concentration of $Ca(OH)_2$ had a significant effect on the moisture content of sweets long beans, while the sugar content and its interactions had no significant effect. Moreover, the differences in the value of moisture content based on the immersion of $Ca(OH)_2$ solution are due to the presence of calcium compounds that penetrate the long bean tissue, thereby, making it stronger [20]. In addition, the sugar concentration showed no significant effect because the ability to bind with water is a property that causes sugar to reduce the moisture content of the added food [21]. Hence, the results of this study are in line with research by Reichembach and Petkowicz [5], that the more sugar added, the lower the moisture content.

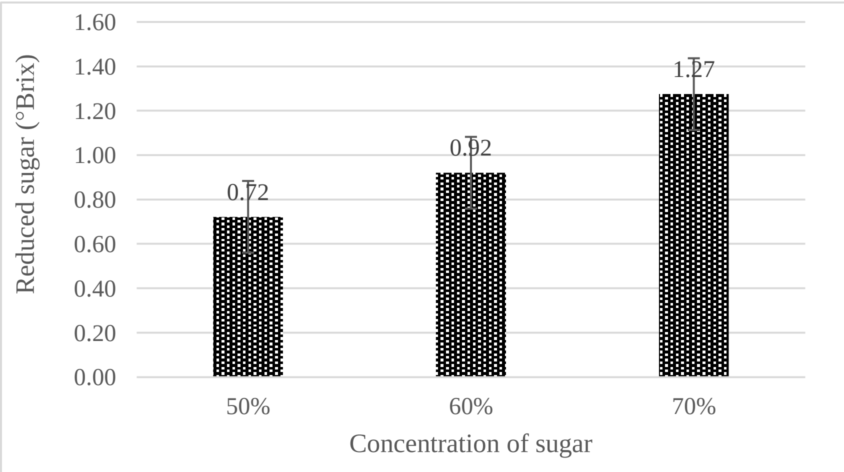

Fig. 1. Reduced sugar (°Brix) sweets long beans

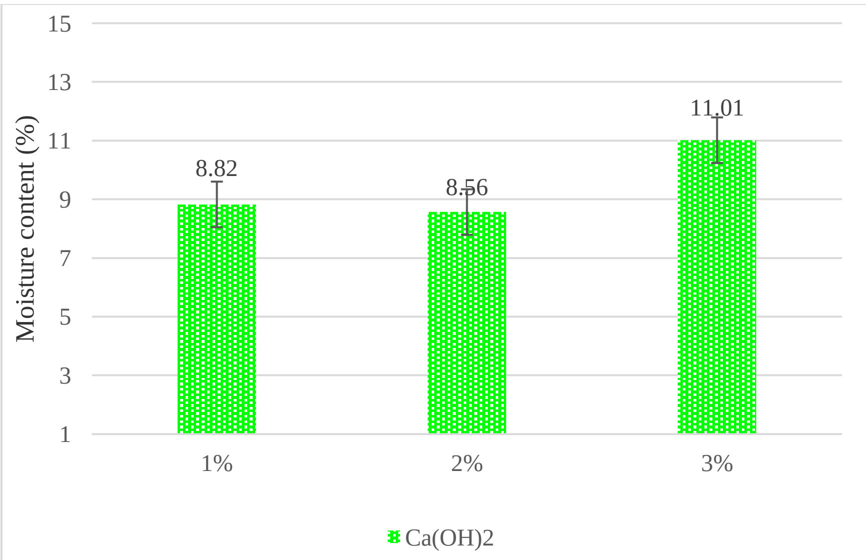

Fig. 2. Moisture content (%) long bean sweets

3.3 Ash Content

The results showed that the concentration of $Ca(OH)_2$, sugar, and their interactions showed no significant effect on the ash content of sweets long beans. Ash content is one of the quality variables in dried sweets. Trisnawati et al. [8], state that the ash content of dried sweet fruit is at a maximum of 2%. Sangeeta and Hathan [22] define it as an inorganic substance leftover from the combustion of organic material. Therefore, the determination of ash content is closely related to the mineral content contained in a material. Consequently, the higher the minerals contained in the food, the higher the ash content [2].

3.4 Acidity

The results showed that the concentration of $Ca(OH)_2$, sugar, and their interactions showed no significant effect on the acidity of sweet long beans. Guo et al. [23] and Pátkai [24] explained that the degree of acidity of food is influenced by the acids found in natural foodstuffs thereby determining the level of H+ ions released. Singh et al. [25] stated that sugar is used as a food preservation technique in situations where there is relatively high sugar content in line with increasing acid levels.

3.5 Color L*

The results showed that the concentration of $Ca(OH)_2$, sugar, and their interactions showed no significant effect on the color (L*) of sweet long beans. Sugar concentration causes the color of sweet long beans to be darker which is a result of the Maillard reaction. Furthermore, Suriati et al. [26] stated that the browning reaction of foodstuffs containing carbohydrates is a result of the effect of heat on reducing sugar. About Pu and Sun [27], drying using a fairly high temperature for a long-time causes damage to carbohydrates, which leads to a non-enzymatic browning reaction (Maillard reaction). In addition, the Maillard reaction occurs because of the reaction between the amino groups of proteins and the carboxyl groups of reducing sugars which produces a brown material and oxidation of vitamin C. In line with Suriati et al. [9] vitamin C (ascorbic acid) is a reducing compound and can also act as a precursor for the formation of non-enzymatic brown color.

Table 1. Ash content (%) sweets long beans

$Ca(OH)_2$	Sugar			Average
	50%	60%	70%	
1%	2.17	1.63	1.80	1.86
2%	1.94	1.52	1.74	1.73
3%	1.70	2.06	1.73	1.83
Average	1.97	1.73	1.75	

Table 2. Acidity sweets long beans

$Ca(OH)_2$	Sugar			Average
	50%	60%	70%	
1%	4.10	4.15	4.08	4.11
2%	4.09	4.07	4.09	4.08
3%	4.08	4.13	4.13	4.11
Average	4.09	4.11	4.10	

Table 3. Color (L*) sweets long beans

$Ca(OH)_2$	Sugar			Average
	50%	60%	70%	
1%	39.96	38.36	38.96	39.10
2%	40.32	36.89	35.81	37.67
3%	37.10	38.95	37.22	37.76
Average	39.13	38.07	37.33	

Table 4. Yield (%) sweets long beans

$Ca(OH)_2$	Sugar			Average
	50%	60%	70%	
1%	21.13	21.32	21.38	21.27
2%	21.32	21.27	21.27	21.29
3%	21.22	21.26	21.52	21.34
Average	21.22	21.28	21. 39	

Table 5. The sensory character of taste, texture, and overall acceptance

Treatment	Taste	Texture	Overall acceptance
$Ca(OH)_2$ 1% Gula 50%	3.67	3.00	3.27
$Ca(OH)_2$ 1% Gula 60%	2.93	2.93	3.13
$Ca(OH)_2$ 1% Gula 70%	3.40	2.67	3.13
$Ca(OH)_2$ 2% Gula 50%	3.27	2.93	3.20
$Ca(OH)_2$ 2% Gula 60%	3.53	2.93	3.07
$Ca(OH)_2$ 2% Gula 70%	3.47	3.13	3.27
$Ca(OH)_2$ 3% Gula 50%	2.60	2.67	2.87
$Ca(OH)_2$ 3% Gula 60%	2.93	3.07	3.07
$Ca(OH)_2$ 3% Gula 70%	2.27	2.73	2.67

3.6 Yield

The results showed that the concentration of $Ca(OH)_2$, sugar, and their interactions showed no significant effect on the color (L*) of sweet long beans. Ai et al. [20] stated that as the concentration of $Ca(OH)_2$ increases, more Ca^{2+} enters the material and binds with water causing the yield to increase which is a result of the mobilization of water from the fruit to the sugar solution and vice versa, thereby affecting the weight of the final product [28].

3.7 Sensory Character

The results showed that the $Ca(OH)_2$ concentration and sugar concentration showed a very significant effect on the sensory character of sweet long beans. The interaction of $Ca(OH)_2$ concentration and sugar concentration showed no significant effect on the sensory character of texture and the overall acceptance of sweets long beans. Also, the addition of high concentrations of $Ca(OH)_2$ and sugar when drying long beans have an effect on the taste, which causes the panelists to prefer low concentrations of sugar and $Ca(OH)_2$. This is in comparison to Silva et al. [29], that added sucrose in food often gives rise to flavor and causes a sweet taste. Sathiyaseelan et al. [30], stated that $Ca(OH)_2$ water can reduce oxalate compounds and provide a good texture (crispy), while Trisnawati et al. [8] state that immersion in $Ca(OH)_2$ water will give a harder texture. Consequently, the low concentration of $Ca(OH)_2$ was preferred because high $Ca(OH)_2$ often results in a texture that is too hard. The highest value was obtained at the concentration of $Ca(OH)_2$ 2%, sugar 70%, and the concentration of $Ca(OH)_2$ 1%, sugar 50%, which was 3.27 (acceptable value). Furthermore, the lowest average value was obtained at the concentration of $Ca(OH)_2$ 3%, sugar 70%, which was 2.67 (slightly disliked).

4. CONCLUSION

Treatment of sugar concentration has a very significant effect on reducing sugar and sensory variables. While the treatment of $Ca(OH)_2$ has a very significant effect on the water content. The interaction of $Ca(OH)_2$ concentration and sugar concentration showed no significant effect on the sensory character of texture and the overall acceptance of sweets long beans The treatment on 1% of $Ca(OH)_2$ and 50% sugar concentration produces the best characteristic with reducing sugar of 0.64 mg/100gr, moisture content of 8.53%, ash content of 2.17%, acidity of 4.10, brightness level (L*) of 39.96, and yield of 21.13%. Hence, it gives the best appearance on long beans, taste, texture, and overall acceptance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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