Sucrose Concentration and Vitamin C in Pickled Guavas

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Abstract

The concentration of vitamin C in fresh guava was compared to that of pickled guava with different concentrations of sugar in the pickling solution. The vitamin C level was measured using redox titration with an iodate solution. The results indicate that while there is variability in vitamin C concentration in fresh guavas, more than 50% of vitamin C degrades over time in pickled guavas without sugar, and pickling guavas with sugar according to the Thai traditional method helps preserve the vitamin C level to a slight degree.

Keywords: guava, ascorbic acid, sucrose, pickling

I. INTRODUCTION

Pickled fruits are very common in Thailand as the pickling process helps aid fruit preservation. The Thai traditional pickling method involves pickling fruits in a solution containing sugar, salt and vinegar. As shown in Figure 1, there is a variety of fruits, such as mangoes, grapes, tamarind, Marian plums, and guavas, that are preserved through the method of pickling in Thailand[1].

However, little research has been done about the effect of pickling fruits on nutrition content. Thus, there is a need for more understanding of the pickling process and its effects. Here, the effect of the concentration of table sugar ($C_{12}H_{22}O_{11}$) used in pickling guavas affects its vitamin C, or ascorbic acid ($C_6H_8O_6$), content.

Figure 1: Thailand's pickled fruits sold in a market[1].

While different fruits have different nutritional content, all fruits that are commonly pickled in Thailand contain vitamin C. Thus, vitamin C level was chosen for investigation in this research. Guavas were chosen for this study as guavas are rich in vitamin C content compared to many other fruits[2]. The average concentration of vitamin C in guava has been measured to range from 50 to 300 mg per 100 g of fruit[3].

The level of vitamin C degradation during pickling, as a function of sugar concentration in the pickling solution, is investigated here. Multiple factors, including time, light exposure, pH, and storage temperature have been shown to affect the degradation of vitamin C through its oxidation process: the higher the concentration of dissolved oxygen in the solution, the higher the rate of degradation[4,5].

Previous research has shown that the activation energy for the degradation reaction of vitamin C in strawberries was higher with the addition of sugar than when prepared without sugar. Higher activation energy reduces the degradation rate[4]. The addition of sugar can effectively slow down the rate of degradation of vitamin C in strawberries. The same is likely to be true for pickled guavas.

On other research, Perla et. al. demonstrate a negative relationship between natural sugar content

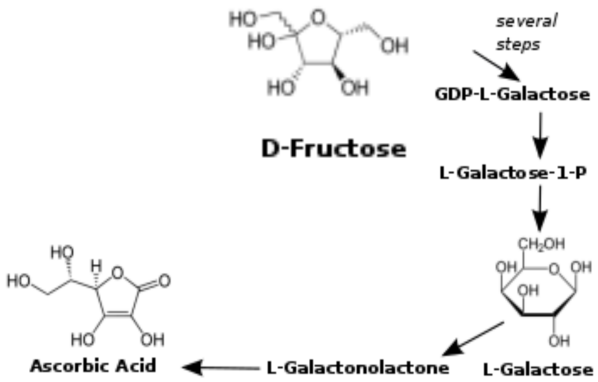

Figure 2: Synthesis of Ascorbic Acid From D-Glucose[7].

in citric fruits and vitamin C levels[6]. This is supported by Naidu's paper that describes how ascorbic acid is synthesized from D-glucose and D-galactose, shown in figure 2[7].

As little research has been done on the effects of sugar on vitamin C content in Thai pickled fruits, it would be helpful to investigate whether the concentration of sucrose during the pickling process has an effect on the preservation of vitamin C. This study will attempt to determine whether the amount of sugar used in the traditional Thai pickling method of guavas impacts vitamin C content, helping producers maximize the nutritional quality when producing pickled guavas in Thailand.

II. METHODS

Pickling methods

Seven different sucrose concentrations, ranging from 0.0 to 53.1 ± 0.6 mg sucrose/g water, were prepared by adding different amounts of sucrose to 350-mL of distilled water. The ratio of the other pickling ingredients was done according to the traditional Thai pickling method: the sodium chloride and vinegar concentration were kept constant by adding 17g of NaCl and 14 ml commercial vinegar (5% ethanoic acid) to each of the solutions.

Five guavas of similar size were purchased from the same vendor. Each guava was cut into ten slices of 25.0 ± 0.5 grams each. Each slice was pickled with each of the seven solutions prepared in a 70-mL sealed glass container, as described in table 1. Three slices of each guava were tested to determine the initial concentration of vitamin C before pickling.

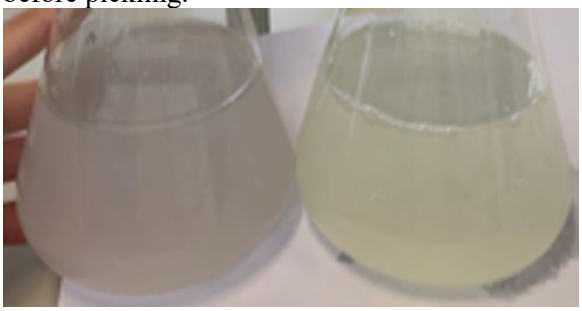

Figure 3: Titration color of vitamin C in guavas. The right flask shows the original color of the solution while the left flask shows the end-point color of the solution after titration.

Five containers of pickled guavas were prepared for each of the seven concentrations. The containers were wrapped with aluminum foil to minimize the degradation of vitamin C due to light exposure. The guavas were then left in the containers for 7 days at an average temperature of 30 ± 5°C.

Titration for vitamin C content in guavas

To determine the vitamin C content in guavas, a titration method using an iodate solution was performed according to a verified standard procedure[8]. The initial vitamin C content in guavas was titrated using a solution of 25 ± 0.5 grams of guavas blended in 25 mL of distilled water. 25 mL of the blended solution was then used for each titration. The color of the solution before and after reaching the end point of the titration is shown in Figure 3. The titration was repeated for three trials using the three slices of the same fresh guava to determine the average vitamin C content in each of the fresh guavas, along with the uncertainty in the titration method.

After the 7-day pickling period, each slice of pickled guava was removed from its container and blended in a blender with 25 mL of distilled water. 25 mL of each blended solution was then titrated to determine the vitamin C content. The percentage of vitamin C remaining for each condition was then calculated.

To determine the statistical difference in vitamin C concentration between the 7 trials of guavas pickled without sugar and the 28 trials of guavas pickled with varying amounts of sugar, an ANOVA Tukey test was performed.

III. RESULTS AND DISCUSSION

Results show that there is variability of vitamin C content within fresh guavas. Table 1 shows that each of the 5 guavas tested has a different initial vitamin C concentration when fresh. While Guavas 4 and 5 show vitamin C levels close to the reported average vitamin C concentration in guava of 50 to 300 mg/100g[3], the rest are well below. This may be because areas with lower growing temperatures tend to produce higher vitamin C levels in fruit, but hot tropical areas like Thailand tend to produce fruit with lower levels of vitamin C[9]. This result indicates that researchers studying vitamin C should directly measure the level of vitamin C in the fruit they are studying, rather than assuming that their fruit matches published levels, as vitamin C levels vary with fruit type, size and conditions of growth.

Average Concentration of Vitamin C in Fresh Guavas (±2 mg Vitamin C/ 100 grams of Guava)				
Guava 1	Guava 2	Guava 3	Guava 4	Guava 5
27	28	36	42	46

Table 1: Average vitamin C concentration of the five different fresh guavas.

The results of the titrations of the pickled guavas show that there is a significant degradation of vitamin C over time when pickling guavas with no sugar, as shown in Table 2. The degradation could be due to the pickling with vinegar and salt, but it could also be due to the gradual degradation of vitamin C over time[5].

There is also large variability in the degradation of vitamin C between different guavas. This indicates that there were likely other relevant factors with initial differences between the guavas tested, such as the ripeness and enzyme levels, reducing levels of confidence in the conclusions.

	Pecent Remaining Vitamin C in 25 g Guava (± 19 %)				
	Guavas				
Time	1	2	3	4	5
7 days after pickling with 0 M sugar	54	39	17	55	29

Table 2: Percent vitamin C remaining in guavas after pickling in vinegar and salt solution with no sugar.

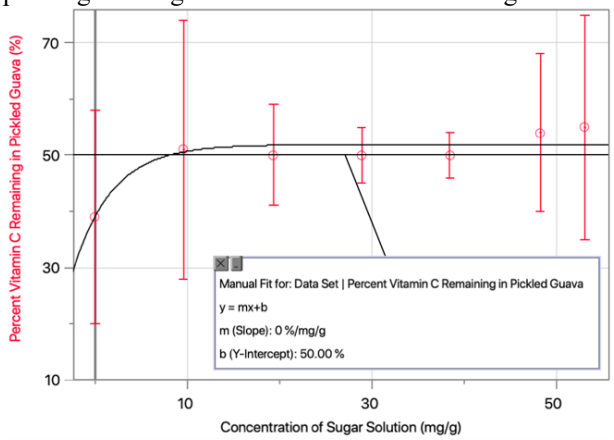

Figure 3: Relationship between the concentration of sugar and percent reduction in vitamin C content.

There is a noticeable difference in vitamin C concentration for guavas pickled with and without sugar. Figure 3 indicates that as the concentration of sugar increased from 0.0 to 53.1 mg sucrose/g water, the percent vitamin C remaining in pickled guava increased. It seems that the addition of sugar has reduced the degradation of vitamin C in pickled guava.

For the pickled guavas with sugar concentrations above 9.6 mg/g, a linear fit with a slope of 0 can be fitted to the data within uncertainty, indicating that for the concentrations tested, the amount of sugar had no effect on the final level of vitamin C in pickled guavas.

Statistical Test

An ANOVA statistical test was conducted between vitamin C concentration of guavas pickled without sugar and those with varying amounts of sugar. The Tukey HSD showed a $p < 0.01$ confidence level, indicating a significant difference between the percent remaining vitamin C in the 7 trials of pickled guava without sugar and the 28 trials where the guavas were pickled with the addition of sugar.

It further suggests that pickling guavas in sugar reduces the degradation of vitamin C.

No statistically significant differences were found for the vitamin C content of guavas that were pickled in different concentrations of sugar solutions. This may be due to the fact that the increase in activation energy (as described by Sapeia et al.) occurred with the very lowest level of sugar tested (9.6 mg/g), and thus no further decrease in degradation rate occurred for higher sugar concentrations.

The extended range of sugar concentration when pickling is a major limitation in this research. While figure 3 shows a sudden increase from 0 to 9.6 mg/g, the precise range in which increasing sugar had an increasing activation energy effect was not clearly identified. Also, table 3 shows that, on average, almost 50% of vitamin C concentration was lost for the 5 pickled guavas.

Further research should be conducted to determine if varying the concentration of vinegar and salt when pickling guavas can reduce the degradation of vitamin C. Research into the effects of pickling on the vitamin C content of other fruits and on the levels of other important nutritional factors is also recommended.

IV. CONCLUSION

There is high variability of vitamin C concentration in both fresh guavas and in the proportion of remaining vitamin C in guavas pickled without sugar. The concentration of vitamin C in guavas pickled with sugar is higher than that of guavas pickled without sugar. These results indicate that sugar reduces the rate of vitamin C degradation. The results also show that different concentrations of sugar in the pickling solution tested give a similar remaining proportion of vitamin C contents compared to the original guavas.

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