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Effects of Drying Processes on the Vitamin C Content of Fruits and Vegetables

Deborah Cecil*, Basheer Khan**, Rachel Cecil***, Sharick Singh ****, Daniel Cecil*****

*(Department of Mechanical Engineering, University of Guyana, Turkeyen Campus
Email: deborah.cecil@uog.edu.gy dcecil2012@yahoo.com)
** (Department of Mechanical Engineering, University of Guyana, Turkeyen Campus
Email:kbasheer899@gmail.com)
*** (Department of Chemistry, University of Guyana, Turkeyen Campus
Email:annacecil485@gmail.com)
**** (Department of Mechanical Engineering, University of Guyana, Turkeyen Campus
Email : shamarsingh@yahoo.com)
***** (Department of Civil & Environmental Engineering, University of Guyana, Turkeyen Campus
Email : danielcecil1110@gmail.com)

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Abstract:

This study evaluates the effectiveness of various drying methods on the retention of Vitamin C in selected fruits and vegetables. These foods include *Musa* x *paradisiaca* (Plantain), *Spondiasdulcis* (Golden Apple), and *Cucurbita pepo* (Pumpkin), which are prevalent in the Guyanese diet. The focus was on assessing the impact of Indirect Solar Drying (under film), Direct Sunlight, and a Dehydrator (at 50^{o}C) on Vitamin C content. The analysis revealed that indirect solar drying (under film) most consistently preserved the highest levels of Vitamin C across the Plantain and Pumpkin samples. Emphasis was also made on the relationship between Vitamin C retention and moisture content of the samples used. These findings suggest that optimizing drying methods is crucial for preserving nutritional quality, particularly Vitamin C retention, in dried fruits and vegetables. It was established in this research work that the method of drying has a significant impact on the nutritional quality of dried fruits and vegetables, specifically their Vitamin C content. Indirect Solar Drying -Under Film proved to be the most effective in retaining Vitamin C, making it a superior method compared to direct sunlight and dehydrator method of drying.

Keywords **—Solar Drying, Dehydrator, Vitamin C.**

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I. INTRODUCTION

Vitamin C is essential in ensuring the human body is healthy and functioning to optimum levels through the formation of cartilage, muscle, blood vessels and bones collagen [1]. Due to its water solubility, it is needed in daily amounts from the diet for consistent healthy skin, gums and wound healing abilities in the body. Humans are dependent on their diet to meet their daily vitamin C needs because they do not possess the ability to synthesize this vitamin. It is observed that numerous animal genera are capable of synthesizing the vitamin because of the natural presence of the L-gulolactone oxidase enzyme. Nevertheless, due to the lack of this enzyme in humans, Vitamin C must be sourced from the diet as elaborated by [1].Consumers have been seeking healthy diet options through fruits and vegetables to meet their dietary needs. However, due to the high water content of these foods, microbial food spoilage is eminent [2]. Most of these foods contain approximately 80% water, which contributes to major deterioration in their shelf-life. Therefore, the dehydration of fruits and vegetables is deemed a solution of merit. Dehydration reduces the moisture content which

improves self-life [3]. Additionally, it reduces food waste and costs in packaging and storage; which adds to the pillars of food security.

Due to exposure to relatively high temperatures during conventional dehydration processes, the nutritional quality of the dried fruits and vegetables may be affected. As a result, there is a need to determine the most suitable method of dehydration to preserve the nutritive content. The measure of Vitamin C retention can serve as determinant/ index of food quality due to its temperature sensitivity,which was elaboratedby [3]. Vitamin C degradation can occur due to exposure to light, oxygen, and heat, which are all conditions met during dehydration processes. Therefore, it is essential that the most appropriate method of dehydration is determined.

Common methods used to dehydrate fruits and vegetables include the use of indirect solar drying (under film), direct sunlight, and a dehydrator. This study aims to determine which of these methods are most successful in retaining the Vitamin C content of *Musa* x *paradisiaca* (Plantain), *Spondiasdulcis* (Golden Apple), and *Cucurbita pepo* (Pumpkin). These are considered as common nutrient dense foods in Guyana.

To examine their contribution to the human diet, it should be noted that Plantains (ripe) generally contain 18.4mg/100g, Golden Apples (unripened) contain 52mg/100g, while Pumpkins contain 9mg/100g of Vitamin C [4].The daily requirement for adult males and females is 90mg and 75mg respectively; children ages 4-8 years require 45mg. It can therefore be said that the foods chosen for analysis will contribute greatly to the Guyanese diet and especially so using the most efficient method of drying [5].

II. OVERVIEW OF VITAMIN C

All Vitamin C, known chemically as L-ascorbic acid (L-AA), “represents a class of compounds exhibiting biological activity similar to L-AA” [3]. It plays a paramount role in human health, being water-soluble and contributing to numerous physiological functions. Vitamin C acts as an antioxidant and participates in enzymatic and hormonal processes, as such, it is crucial for tissue growth and repair. Its antioxidant abilities allow it to efficiently scavenge free radicals. This results in the shielding of cells from oxidative damage which is known to prevent cancer. By minimizing oxidative stress, Vitamin C also plays a vital role in modulating inflammation and reducing tissue damage associated with immune responses [6]. Numerous plant and animal species possess the ability to naturally synthesize Vitamin C through the uronic acid pathway; however, humans lack the gulonolactone oxidase enzyme necessary for this process due to a genetic mutation [3]. As a result, dietary intake of Vitamin C is essential for maintaining optimal health. Without an adequate supply, individuals may develop scurvy, a condition characterized by connective tissue damage, muscle weakness, and other symptoms. To meet dietary requirements, individuals are advised to consume Vitamin C-rich foods such as fruits and vegetables. Citrus fruits, berries, and certain vegetables like broccoli and peppers are particularly rich sources [3].

In the event that foods are drained of their Vitamin C content during processing, regulatory bodies such as the United States Food and Drug Administration (USFDA) categorize ascorbic acid as a Generally Recognized as Safe (GRAS) food additive when used within specified limits. However, excessive supplementation can develop adverse effects, including gastrointestinal disturbances and kidney stone formation, particularly at doses exceeding 2-3 grams per day [3].

III. METHODS OF DRYING

1) ***Solar Drying- Direct and Indirect (Under Film):*** A solar dryer is designed to capture solar energy and circulate in such a way to produce a drying effect. This method is commonly used for the drying of fruits and vegetables. Direct, and indirect solar dryers make up the two types of dryers. They further elaborated on the design and purpose of the dryers and described that direct solar drying is leaving the samples on a flat tray in an open field. In the interest of this study, an indirect solar dryer was used. This dryer consists of a box that has an insulated interior and a film cover that is a glass like structure of polyethylene. Indirect solar dryers use an

insulated box with a black interior surface and a glass cover. Cold air enters from a lower inlet, gets warmed by sunlight which dehydrates the substance inside. Hot, moist air exits from an upper outlet due to density differences, facilitating ventilation and drying of the samples [7]. Please see Fig. 1 below for further details.

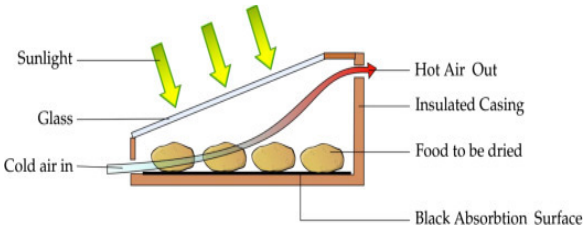

Fig.1Working Principle of a Solar Dryer

2) *Dehydrator*: Dehydrators specialize in removing moisture without burning or "cooking" the sample. It is also commonly used to dry fruits and vegetables. Dehydrators achieve this by circulating air at relatively low temperatures with a fan. The fan draws air through the bottom or back of the machine and circulates it across the food that is flatly a laid on equidistant trays [8]. See Fig. 2 which describes the principles of this technology.

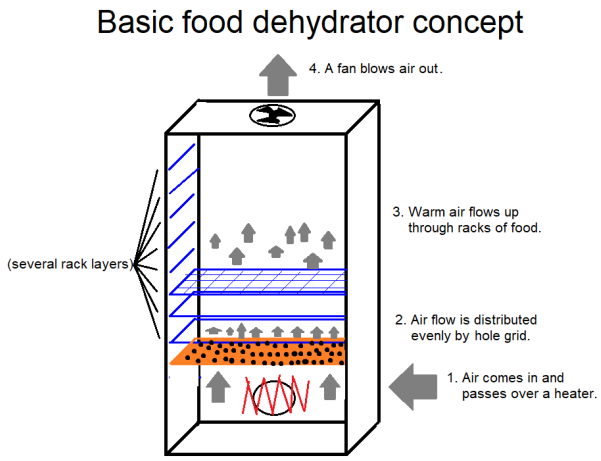

Fig. 2 Principles of Food Dehydrator

IV. RESULTS

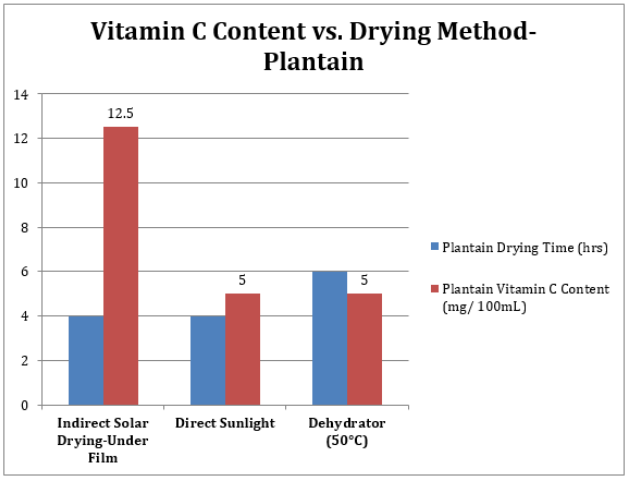

Fig. 3 Vitamin C Retention of Plantain after Drying Under Film, Direct Sunlight, and by Dehydrator

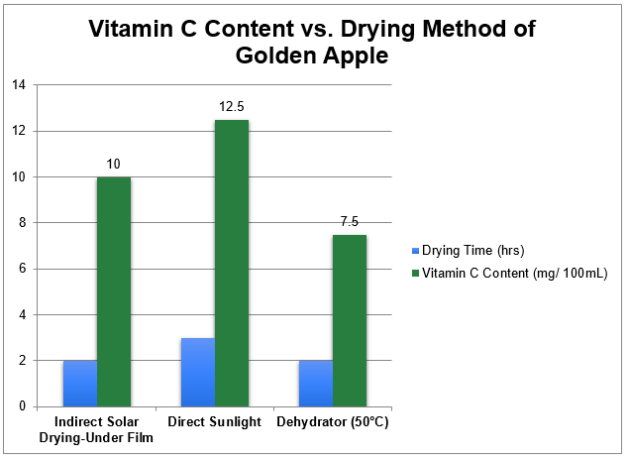

Fig. 4 Vitamin C Retention of Golden Apple after Drying Under Film, Direct Sunlight, and by Dehydrator

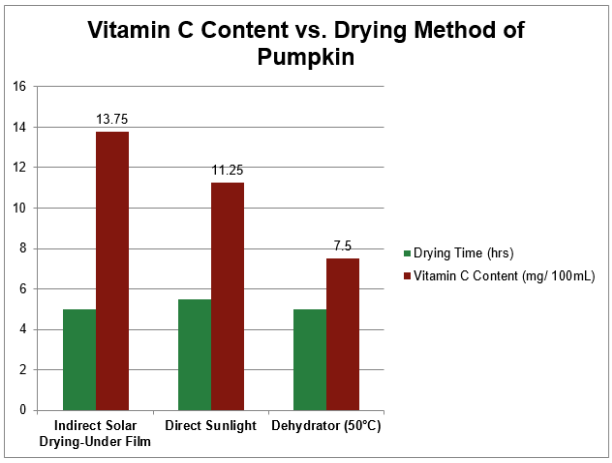

Fig. 5 Vitamin C Retention of Pumpkin after Drying Under Film, Direct Sunlight, and by Dehydrator

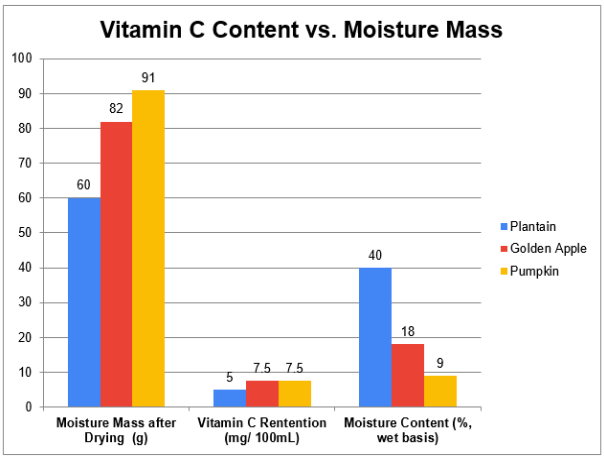

Fig. 6 Relationship between Water Retention and Vitamin C Content after Drying via a Dehydrator at 50 °C

V. ANALYSIS

Vitamin C degradation is influenced by numerous factors such as temperature, light exposure, pH, water retention, and oxidation. By varying the dehydration methods using fruits and vegetables, various relationships were made. In Fig. 3 and Fig. 5, the drying method of an Indirect Solar Dryer-Under Film allowed the Plantain and Pumpkin samples to retain the highest amount of Vitamin C content when compared to the drying of Golden Apple (Fig. 4).

When compared to drying via the Dehydrator at 50^0C, Golden Apple showed a 67 % increase in Vitamin C retention when dried in direct sunlight and a 33% increase when dried in an Indirect Solar Dryer- Under Film. Comparisons to dehydration of Pumpkin samples at 50 ^{0}C revealed an 83 % increase in Vitamin C retention when dried in an Indirect Solar Dryer- Under Film and a 61 % increase in Vitamin C retention when dried in direct sunlight. The same comparison was done with Plantain and showed a 150 % increase in Vitamin C retention when dried in an Indirect Solar Dryer-Under Film. This percentage difference was also the same for drying in direct sunlight. This vast difference in Vitamin C retention based on drying methods was described in Fig. 3. It should be noted that the drying times were very similar for direct sunlight drying and drying in an Indirect Solar Dryer Under Film. Additionally, samples were dried until they were similar in appearance of colour, texture and flexibility or brittleness.

The Indirect Solar Drying- Under Film produced the most consistent results in retaining the highest amount of Vitamin C in the Pumpkin and Plantain samples. This could infer that this method reduces the moisture loss of the samples and resultantly improve the Vitamin C retention when compared to the Dehydrator and Direct Sunlight Drying methods. This is made evident from the relationship presented in [9-10].When using the Dehydrator Method, the moisture content was calculated on a wet basis to determine the relationship between Vitamin C retention and Moisture Content. It was noted that the samples with the lower moisture content (higher mass after drying) was associated with an increase in Vitamin C degradation. This directly agreed with the findings of [9-10]. From Fig. 6, it is underscored that as the moisture content (wet basis decreased), the Vitamin C retention increased. Furthermore, the Golden Apple and Pumpkin samples retained more moisture after drying when compared to the Plantain samples. As such, the Golden Apple and Pumpkin samples had the highest Vitamin C retention (7.5mg/ 100mL) when compared to the Plantain samples (5.0 mg/ 100mL). This highlighted a 50% difference in Vitamin C retention based on moisture content.

VI. CONCLUSIONS

It was establishedin this research work that the method of drying has a significant impact on the nutritional quality of dried fruits and vegetables, specifically their Vitamin C content. Indirect Solar Drying -Under Film proved to be the most effective in retaining Vitamin C, making it a superior method compared to direct sunlight and dehydrator usage. These results highlight the potential of indirect solar drying to improve food preservation and contribute to better dietary outcomes by retaining essential nutrients. Additionally, this research's findings were consistent with literature that presented the relationship between moisture content and Vitamin C retention. As the moisture content (wet basis) of the samples decreased after drying, the rate of Vitamin C degradation increased. This study underscores the need for further exploration into various drying techniques to establish the best practices for preserving the nutritional integrity of food products.

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