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Research on improving the acceptability of freeze-dried "Sap" coconut meat's sensory properties by sweeteners

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Abstract

The aim of this research is to initially evaluate the nutritional value of "Sap" coconut meat and develop a suitable formula to produce freeze-dried coconut product with high sensory properties. The effects of sweeteners (white sugar, rock sugar, maltodextrin) at concentrations (35%, 40%, 45%) on product quality including sensory properties (color, aroma and taste, texture) and hardness were studied. Then, the product was also investigated for the effects of citric acid ratios (0.5%, 1%, 1.5%, 2%, 2.5%) on the acceptable on sensory and lightness of the product. "Sap" coconut meat has a fairly high fat content and a relatively low sweetness with a total sugar content of 1.6%. The results of sensory evaluation and analysis of some physical criteria showed that the concentration of rock sugar at a concentration of 35% combined with 2% citric acid created a product with good sensory value and appropriate moisture. and good structure. The product also ensures food safety according to Vietnamese standards.

Keywords: coconut, sensory, quality, nutrition

Full length article **Corresponding Author*, e-mail: lethinhuthao@tgu.edu.vn Doi # https://doi.org/10.62877/64-IJCBS-24-25-19-64

1. Introduction

Freeze-dried fruits and vegetables are a variety of food produced through the process of eliminating water from the food by sublimating water vapor [1]. Sublimation refers to the transformation of a substance directly from its solid state to its gaseous state. At typical temperatures, the water content in food exists in a liquid state. In order to undergo sublimation, it is necessary for them to undergo the process of solidification through freezing. Thus, freeze-drying is also referred to as freeze-drying. When water is heated under vacuum circumstances, it undergoes sublimation, transitioning directly from a solid state (ice) to a gaseous state. After undergoing dehumidification, this process aids in preserving the product's initial form, hue, taste, and nutritional content [2]. Recent research has demonstrated that freeze-dried products effectively retain the majority of their nutrients and bioactive components. This method of drying is considered a modern approach [3, 4].

"Sap" coconut, a famous variety in Southern provinces (Vietnam), often referred to as solid coconut or cream coconut, is an alternative name for this particular type of coconut. The characteristics of this fruit include a thick and viscous flesh that resembles jelly, with a sticky texture and a soft, fatty flavor that distinguishes it from regular coconuts [5]. The "Sap" coconut is a highly valuable fruit due to its diverse applications in food technology, including ice cream manufacture, confectionery production, cosmetics, and pharmaceutical production [6]. "Sap" coconut is renowned not just for its delectable flavor but also for its substantial nutritional value, which assists in providing essential nutrients to the body, enhancing the user's overall well-being. This particular variety of coconut offers a substantial amount of essential nutrients for the body. Furthermore, it possesses other benefits such as enhancing cardiovascular well-being, promoting digestive health, and aiding in the treatment of ailments like skin rashes and joint discomfort [7]. The range of products derived from "Sap" coconut in Vietnam is currently restricted, primarily consisting of semi-finished goods. This is mainly due to shortcomings in the preservation, processing, and diversification stages, which fail to fully meet the demands of the production industry. Hence, there is a crucial requirement for conducting research on the processing techniques to enhance product variety and extend the shelf life of "Sap" coconut, which also could increase the income for farmers as well as develop new product. To enhance the quality and process a range of "Sap" coconut products, it is imperative to devise suitable formulae and processing protocols that optimize sensory and nutritional attributes. The execution of the subject matter will result in the generation of novel commodities, enhancing the economic efficacy of "Sap" coconut trees, augmenting the income of farmers, and fostering sustainable development of the local socio-economy.

2. Materials and methods

2.1 Sample selection and preparation

The "Sap" coconut is purchased from the Hoa Tan Coconut Cooperative located in Tien Giang. Southern Salt Corporation use salt. The Mien Tay Chemical Company (Can Tho) supplied citric acid and maltodextrin for food applications. The production of white sugar is carried out by Bien Hoa Sugar Corporation.

2.2 Freeze-dried "Sap" coconut meat process and sensory evaluation

Select "Sap" coconut meat that has an appropriate thickness, is undamaged. By manipulating the raw material, the result can achieve a consistent size and shape, hence enhancing its sensory appeal. The process involves immersing "Sap" coconut in hot water at a temperature of 90-95^{o}C for a duration of 15 seconds for preventing browning reaction. Furthermore, the blanching water is supplemented with salt and lemon juice to mitigate the occurrence of browning. To enhance the sweetness and sensory appeal of the product, it is recommended to soaking it in a sugar solution containing three distinct forms of sugar: white granulated sugar, rock sugar, and maltodextrin. The concentration of the sugar solution should be between 35% and 45%. While the coconut pieces are being soaked, agitate them to ensure that the raw material is uniformly exposed to the sugar solution. The duration for soaking is three hours. Position the "Sap" coconut pieces on the drying tray, ensuring they are evenly spaced, then place the tray with the coconut in the freezer to solidify. Subsequently, the wax-coated coconut undergoes a drying process using a freeze drier (YK-118-T, Taiwan) until the moisture content of the product is reduced to less than 5%. The obtained product was further analysis about sensory value. Before sensory evaluation, the panelists were trained. This study involved a total of 50 participants who were voluntarily recruited by freeze-dried coconut sampling on the Tien Giang University campus. They were all consumers of freeze-dried products and of over 18 years old. Participants provided informed consent when participating in this study and were not remunerated for their time. Conducting sensory analysis to assess the attributes of the product, including its color, taste, and overall structure. Utilizing a preferred scoring system based on a standardized scale of 6 levels (ranging from 0 to 5), with 5 being the maximum score for an indicator for most like.

The physicochemical indicators were assessed using the AOAC [8] method.

2.3. Data analysis

The experiments were conducted randomly with three replications, and the average value was taken. The experiments were structured based on the premise of using the optimal result from the previous experiment as the basis for the following trial. The process of collecting data and applying statistical techniques was carried out utilizing the Statgraphics XV.I statistics program.

3. Results and discussion

3.1 Nutrition values of "Sap" coconut meat

The quality of a product is significantly influenced by the raw materials used. Therefore, it is essential to establish certain indicators for assessing the beginning components. The raw materials of "Sap" coconuts undergo initial processing, and the coconut meat is extracted for chemical analysis of its indicators. Table 1 displays the findings of the nutrition value of raw material. The "Sap" coconut meat has a significantly high moisture content, reaching 64.5%. Simultaneously, the lipid content is 24.7%. The high lipid content of coconut meat makes it prone to quality changes, resulting in a limited shelf life. Therefore, it is crucial to identify preservation or processing methods to effectively utilize this precious raw material source [9]. The findings also indicate that the "Sap" coconut meat has relatively low levels of total sugar and reducing sugar. Therefore, it is essential to incorporate a suitable quantity of sugar throughout the product manufacturing process to enhance the sensory appeal of the product.

Table 1. Nutritional profile of "Sap" coconut meat

Content	Value
Total sugar	1.60%
Reducing sugar	ND
Moisture content	64.5%
Protein	2.52%
Ash	0.64%
Lipid	24.7%

*ND: Not detected

3.2 Effect of types and concentration of sugar on sensory properties of freeze-dried "Sap" coconut meat

3.2.1 Color property

As mentioned in section 3.1, in order to increase the sensory value of the product, "Sap" coconut was soaked in a solution containing three different types of sugar: white sugar, rock sugar, maltodextrin with concentrations of 35%, 40%, 45% for 3 hours. The product was freeze-dried, and the results showed that the type and concentration of sweetener strongly affected the sensory score of the color of the product after drying (Table 2).

For sweeteners, when using white sugar, the product has a yellow-brown color, not white, so the average score for sensory evaluation of color is low, 3.14. For rock sugar and maltodextrin, the product does not change color when dried. The average score for sensory evaluation of color is 4.15-4.16, there is no statistically significant difference between the two samples. The difference in color may be due to the influence of color change reactions. The color change rate of

white sugar is higher than that of rock sugar, and maltodextrin is the type of sugar that changes color the least during product processing [10]. The higher the concentration of sweetener, the more it affects the color of the product. However, depending on the type of sugar, the level of influence of the concentration is also different. For white sugar and rock sugar, the higher the concentration, the lower the sensory evaluation score of the product. For maltodextrin, on the contrary, the higher the concentration, the whiter the color, the higher the sensory evaluation score of the color.

Table 2. Effect of type and concentration of sweetener on sensory evaluation score of color

Type of sweetener	Concentration (%)			Mean
	35	40	45	
White sugar	3.24^{b}	3.15^{ab}	3.03^{a}	3.14^{A}
Rock sugar	4.27^{d}	4.15^{cd}	4.03^{c}	4.15^{B}
Maltodextrin	4.09^{c}	4.15^{cd}	4.24^{d}	4.16^{B}
Mean	3.87^{B}	3.81^{AB}	$3,77^{B}$	
F (Type)	**	F (concentration): **	F (interaction): **	
CV (%)	CV (type): 7,07	CV (concentration): 0,84	CV (interaction): 11.09	

*Note: Values in the same column/row with different letters indicate statistically significant differences, **: significant difference at 1% level.*

The type and concentration of sweeteners are correlated with each other, affecting the sensory evaluation score of the product's color. When using white sugar at concentrations of 35%, 40%, 45%, the dried product has a yellow-brown color, so the sensory evaluation score of the color is low, from 3.03 to 3.24. It can be concluded that in this study, white sugar is not suitable for use. When using rock sugar, the product has a high sensory evaluation score at concentrations of 35% and 40%. The sensory evaluation score of the color of these two samples has no statistically significant difference (4.27 and 4.15). The rate of color change due to browning reactions depends on the structure of the sugar molecule and the processing conditions [11]. Maltodextrin sugar shows good ability to retain product color, so it is evaluated with high sensory scores when soaked at higher concentrations. Sensory evaluation scores for color of samples using maltodextrin sugar at ratios of 35%, 40%, 45% gradually increased from 4.09 to 4.24. The results can also be concluded that when using different types of sugar, the products have different colors. In the same type of sweetener but used at different concentrations, the products also have different colors. In which, “Sap” coconut soaked with rock sugar and maltodextrin has beautiful colors, similar to each other.

3.2.2 Taste of product

Taste is one of the important factors in evaluating the quality of a product [11]. The research results also showed that the taste of the product changes when using different types of sugar at different concentrations (Table 3).

Table 3. Effect of type and concentration of sweetener on sensory assessment scores of taste

Type of sweetener	Concentration (%)			Mean
	35	40	45	
White sugar	3.79^{c}	3.45^{b}	3.18^{ab}	3.47^{B}
Rock sugar	4.27^{e}	4.12^{de}	3.88^{cd}	4.09^{C}
Maltodextrin	3.18^{ab}	3.09^{a}	3.18^{ab}	3.15^{A}
Mean	3.74^{B}	3.55^{AB}	3.41^{A}	
F (Type)	**	F (concentration): **	F (interaction):**	
CV (%)	CV (type): 9.19	CV (concentration): 2.65	CV (interaction): 9.41	

*Note: Values in the same column/row with different letters indicate statistically significant differences, **: significant difference at 1% level.*

When using white sugar, the product has a good taste but is not suitable, so the average sensory score for taste is 3.47. For maltodextrin, the product has a sugary smell than coconut smell, a bland taste, less sweet, so the average sensory score for taste is the lowest, 3.15. As for rock sugar, the product has a light coconut smell, a moderate sweetness suitable for the product, so the average sensory score is high, 4.09. The sensory evaluation results also show that, at a sugar concentration of 35%, the samples still have a coconut aroma, so the average sensory score is high, 3.74. When using sugar at a higher concentration, the product has a light coconut smell, a sweet taste or is not suitable, so the average sensory score is low, 3.55. When the sugar concentration reaches 45%, the sugar smell overwhelms the coconut smell and the product tastes too sweet, so the lowest average sensory score is 3.41. The type and concentration of sweeteners are correlated to each other and affect the sensory evaluation score of the product's taste. When using white granulated sugar soaked at different concentrations, the product does not have a suitable taste, so the sensory evaluation score is low, averaging from 3.18 to 3.79. In which, the sample at a concentration of 35% has the highest sensory evaluation

score of 3.79. For the rock sugar sample, the product has the best taste evaluation when soaked at a concentration of 35% (4.27). This sample is rated the highest and is statistically different from the remaining samples due to its light, harmonious sweetness. For maltodextrin, the sensory score is low, from 3.09 to 3.18, because it does not create sweetness for the product. The sweetness of maltodextrin is rated at about 5% when compared to sucrose [12]. The above results show that soaking with sweeteners at high or low concentrations affects the taste of the product. In particular, the sample soaked with rock sugar at a concentration of 35% has the highest sensory score for taste.

3.2.3 Overall structure of product

The type and concentration of sweeteners both affect the sensory evaluation score of the product's structure (Table 4). White sugar at different concentrations after drying, the product is flexible and has a phenomenon of sugar recrystallization on the surface [13], which is not suitable for consumers' taste. Meanwhile, the sensory evaluation score of maltodextrins gradually decreases at concentrations from 35% to 45%. As the concentration of maltodextrin increases, the phenomenon of sugar recrystallization inside the coconut increases, making the sample harder. For rock sugar, the product has a better structure than other types of sugar due to different crystallization rates [14]. However, at high concentrations, rock sugar makes the product structure flexible. According to the evaluation results of the sensory council, at a concentration of 35% rock sugar, the product has the highest sensory value, with a moderate structure.

Table 4. Effect of type and concentration of sweetener on sensory assessment scores of texture

Type of sweetener	Concentration (%)			Mean
	35	40	45	
White sugar	3.15^{a}	3.06^{a}	3.00^{a}	3.07^{A}
Rock sugar	4.18^{e}	4.06^{de}	3.85^{cd}	4.03^{B}
Maltodextrin	3.79^{c}	3.39^{b}	3.09^{a}	3.42^{B}
Mean	3.71^{C}	3.50^{B}	3.31^{A}	
F (Type)	**	F (concentration): **		F (interaction): *
CV (%)	CV (type): 6.74	CV (concentration): 3.35		CV (interaction): 10.01

*Note: Values in the same column/row with different letters indicate statistically significant differences, **: significant difference at 1% level.*

3.2.4 Hardness and moisture content

White sugar at different concentrations after drying the product is soft, the hardness gradually decreases with the concentration of added sugar, the low average hardness is 1294 g force, not suitable for consumer taste (Table 5). Meanwhile, when using maltodextrin sugar, the product after drying has a structure that is too hard, the high hardness is from 5511 - 7557 g force. The results are also consistent with the results of sensory evaluation of the product's structure. As the concentration of maltodextrin sugar increases, the phenomenon of recrystallization of sugar inside the coconut increases, making the sample harder. For rock sugar, the product has a better structure than other types of sugar. However, using rock sugar at a high concentration of rock sugar makes the product structure soft, the hardness gradually decreases. According to the above results, when using rock sugar at a concentration of 35%, the product has a moderate structure.

Table 5. Effect of type and concentration of sweetener on product hardness

Type of sweetener	Concentration (%)			Mean
	35	40	45	
White sugar	1520^{c}	1231^{b}	1132^{a}	1294^{A}
Rock sugar	4864^{f}	4053^{e}	2847^{d}	3921^{B}
Maltodextrin	5511^{g}	6636^{h}	7557^{i}	6568^{C}
Mean	3965^{B}	3973^{B}	3845^{A}	
F (Type)	*	F (concentration): *		F (interaction): *
CV (%)	CV (type): 40.05	CV (concentration): 1.30		CV (interaction): 55.42

*Note: Values in the same column/row with different letters indicate statistically significant differences, **: significant difference at 1% level.*

Moisture is defined as the free water content in food, which is the percentage of water contained in the product compared to the dry weight of the product. The results of the survey on the influence of the type and concentration of sweetener on the moisture content of the product after drying are shown in Table 6. When using white sugar, the product has high moisture content, long drying time, and an average moisture content of 4.61%. For rock sugar, the product after drying has an average moisture content of 3.60%. As for the product using maltodextrin, after drying, the moisture content is low, 2.69%. The type and concentration of sweetener both affect the moisture content of the product after drying. For white

sugar soaked at concentrations of 35%, 40%, 45%, after drying, the product has a high moisture content of 4.20-4.91%. The moisture content of the product after drying when soaked with rock sugar at a concentration of 35% was 3.30%, at a concentration of 40% and 45%, the moisture content was not different, 3.69% and 3.79% respectively. In particular, for maltodextrin, the moisture content after drying of the samples was low, from 2.52-2.90%. When evaluating the structure, it was found that the product when using maltodextrin had a structure that was too hard, so it was not suitable for use. As for white sugar, the product after drying had a flexible structure, which was not suitable. Through the above results, the type and concentration that should be used is rock sugar with a concentration of 35%.

The three types of sugar used are white sugar, rock sugar, and maltodextrin, all of which affect the color, structure, and flavor of the product. In terms of color, rock sugar and maltodextrin produce products with good color. In terms of structure, rock sugar has the best structure. In terms of flavor, rock sugar has the most suitable flavor. Thus, rock sugar is the suitable type of sugar to produce products with good sensory value. In the samples processed at concentrations of 35%, 40%, and 45% of rock sugar, the sample with a concentration of 35% produces the best product in terms of color, flavor, and structure. This concentration is fixed for further studies.

Table 6. Effect of type and concentration of sweetener on product moisture content

Type of sweetener	Concentration (%)			Mean
	35	40	45	
White sugar	4.20^{f}	4.72^{g}	4.91^{h}	4.61^{C}
Rock sugar	3.30^{d}	3.69^{e}	3.79^{e}	3.60^{B}
Maltodextrin	2.52^{a}	2.67^{b}	2.90^{c}	2.69^{A}
Mean	3.34^{A}	3.69^{B}	3.87^{B}	
F (Type)	**	F (concentration): **		F (interaction): **
CV (%)	CV (type): 15.97	CV (concentration): 2.11		CV (interaction): 19.8

*Note: Values in the same column/row with different letters indicate statistically significant differences, **: significant difference at 1% level.*

3.3 Effect of citric acid ratio on product sensory value

Citric acid is one of the compounds that can maintain the color of freeze-dried products [15]. Regarding color, when the citric acid ratio increases, the sensory value of the color of the samples also increases gradually from 3.81 to 4.29, the brightness index (L*) also changes, ranging from 69.6 to 75.6 (Table 7).

Table 7. Statistical results of sensory evaluation indicators of products and color index according to the ratio of added citric acid

Sample code	Citric acid concentration (%)	Sensory score			L* value (brightness)
		Color	Taste	Overall structure	
D1	0.5	3.81^{a}	3.95^{a}	3.86^{a}	69.6^{a}
D2	1.0	3.91^{ab}	3.95^{a}	4.00^{ab}	71.3^{a}
D3	1.5	4.05^{b}	4.09^{a}	4.05^{ab}	72.0^{ab}
D4	2.0	4.29^{c}	4.24^{b}	4.19^{b}	75.6^{c}
D5	2.5	4.29^{c}	3.95^{a}	4.05^{ab}	74.3^{bc}
		**	*	**	**
CV (%)		3.30	2.44	1.57	

*Note: Values in the same column with different letters indicate statistically significant differences, **: significant difference at 1% level.*

Samples D1, D2, D3 have no obvious difference, the L* index of the samples is 69.6, 71.3 and 72.0. Samples using 2% and 2.5% have the highest popularity of 4.29 and have similar colors of 75.6 and 74.3 respectively. Regarding taste, the higher the citric acid ratio, the more it affects the taste of the product. The sample using 2.5% has the highest citric acid ratio, the product has a slightly sour taste, the sensory score is 3.95. The sample using 2% citric acid has the highest sensory score of 4.24. Through the evaluation of sensory indicators and color indicators, the sensory description table (Table 8), it is found that the brightness of the product increases gradually with the citric acid addition ratio. The selected product after drying has a beautiful bright color (Figure 1), and has lipid, protein, total sugar, and total ash contents of 54.1%, 4.79%, 18.6%, and 1.97%, respectively.

Table 8. Sensory description of products when changing the citric acid ratio

Sample	Description
D1	The product is white, has a light coconut scent, sweet taste, and a slightly soft texture.
D2	The product is white, has a light coconut scent, sweet taste, and a hard, spongy structure.
D3	The product is bright white, has a light coconut scent, sweet taste, and a hard, spongy structure.
D4	The product is bright white, has a light coconut scent, sweet taste, and a hard, spongy structure.
D5	The product is bright white, has a light coconut scent, a slightly sour taste, and a hard, spongy structure.

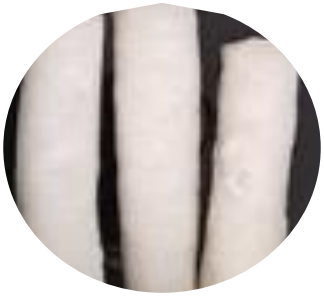

Figure 1. Freeze-dried "Sap" coconut meat

4. Conclusions

Through the process of researching, evaluating and surveying some technological parameters suitable for the freeze-dried "Sap" coconut processing process, the initial chemical composition of "Sap" coconut used as raw material to produce freeze-dried "Sap" coconut has been determined. At the same time, the study also showed that the mixing ratio for "Sap" coconut to meet the criteria of quality, efficiency, and sensory criteria is 35% rock sugar and 2% citric acid. The study has initially built a suitable mixing formula; however, the technological parameters need to be studied further to create a product that has value not only in terms of sensory but also in terms of nutrition.

References

[1] S. Shukla. (2011). Freeze drying process: A review. International journal of pharmaceutical sciences and research, 2(12): 3061.

[2] V. Valentina, R. A. Pratiwi, P. Hsiao, H. Tseng, J. Hsieh, C. Chen. (2016). Sensorial characterization of foods before and after freeze-drying. Sensorial Characterization of Foods Before and After Freeze-drying, 1(6): 1-5.

[3] S. Mun, D. J. McClements, J. Surh. (2011). Influence of maltodextrin addition on the freeze-dry stability of β-lactoglobulin-based emulsions with controlled electrostatic and/or steric interactions. Food Science and Biotechnology, 20: 1143-50.

[4] J. Chutrtong. (2015). Survival of probiotic bacteria in freeze-dry yogurt starter cultures storage at 4 and 30 degree celsius. Procedia-Social and Behavioral Sciences, 191: 2219-25.

[5] Công ty TNHH SX – TM & DV ABC Việt Nam. (2021). Thành phần dinh dưỡng và công dụng của quả dừa sáp. https://duasap.com.vn/thanh-phan-dinh-duong-va-cong-dung-cua-qua-dua-sap/#, accessed date: 27/8/2022.

[6] Lê Thị Cẩm Giang (2020). Dừa sáp và những công dụng của nó đối với sức khỏe. https://songkhoe.medplus.vn/dua-sap-va-nhung-cong-dung-cua-no-doi-voi-suc-khoe/, accessed date: 3/9/2022. .

[7] Tạp chí công thương (2022). Nghiên cứu chế biến một số sản phẩm từ quả dừa Sáp làm nguyên liệu phục vụ sản xuất các sản phẩm thực phẩm, mỹ phẩm. https://tapchicongthuong.vn/bai-viet/nghien-cuu-che-bien-mot-so-san-pham-tu-qua-dua-sap-lam-nguyen-lieu-phuc-vu-san-xuat-cac-san-pham-thuc-pham-my-pham-98405.htm, accessed date: 26/8/2022. .

[8] AOAC. Official methods of analysis of the Association of Official Analytical Chemists: Association of Official Analytical Chemists.; 2005.

[9] D. Wang, H. Xiao, X. Lyu, H. Chen, F. Wei. (2023). Lipid oxidation in food science and nutritional health: A comprehensive review. Oil Crop Science, 8(1): 35-44.

[10] M. D. P. Buera, J. Chirife, S. L. Resnik, R. D. Lozano. (1987). Nonenzymatic browning in liquid model systems of high water activity: Kinetics of color changes due to caramelization of various single sugars. Journal of Food Science, 52(4): 1059-62.

[11] B. Jiang, Y. Liu, B. Bhandari, W. Zhou. (2008). Impact of caramelization on the glass transition temperature of several caramelized sugars. Part I: chemical analyses. Journal of agricultural and food chemistry, 56(13): 5138-47.

[12] J. N. BeMiller. 19 - Carbohydrate and Noncarbohydrate Sweeteners. In: BeMiller JN, editor. Carbohydrate Chemistry for Food Scientists (Third Edition): AACC International Press; 2019. p. 371-99.

[13] A. Saleki-Gerhardt, G. Zografi. (1994). Non-isothermal and isothermal crystallization of sucrose from the amorphous state. Pharmaceutical Research, 11: 1166-73.

[14] T. S. E. Lim, K. F. Chia, L. M. Loo, S. Y. Wong. (2021). Rock sugar crystallization: The effect of mineral impurities. Sugar Tech, 23(6): 1432-9.

[15] A. Milani, M. Jouki, M. Rabbani. (2020). Production and characterization of freeze-dried banana slices pretreated with ascorbic acid and quince seed mucilage: Physical and functional properties. Food Science & Nutrition, 8(7): 3768-76.