ESTABLISHMENT OF A PROCESSING PROCEDURE FOR MANUFACTURING DRIED DRAGON FRUIT

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ABSTRACT

In recent years, consumption of dragon fruits became an issue because of the dramatic increase in domestic production and the production in other countries. So it becomes urgent to develop new products, which can utilize the abundant amount of fresh dragon fruit, and provides a sustainable output for the domestic production. In the present study, we preliminarily developed a processing procedure to manufacture dried dragon fruit. The objectives of the study were (1) to determine if it is advantageous to do osmotic dehydration (OD) before hot air drying, (2) to find out a suitable submerging time if OD was necessary, and (3) to evaluate stability of the product during storage with or without using sodium bisulfite. The results showed that application of OD with a solution of 50% sucrose and 1.5% citric acid led to 6.58% higher in product yield, 8.08% lower in volume contraction, and 3 hours shorter in subsequent hot-air drying. The use of sodium bisulfite by submersion of sample in 0.5 % solution before processing was necessary to prevent the growth of mold and maintain sensorial quality (especially color) of the dried product. The processing procedure developed from this study can be implemented in industry.

Keywords: *dried dragon fruits, drying, osmotic dehydration, drying curves.*

TÓM TẮT

Những năm gần đây việc tiêu thụ trái thanh long gặp nhiều khó khăn vì tốc độ tăng diện tích trồng trọt nhanh trong nước cũng như ở các nước khác. Việc chế biến thanh long trở nên cấp thiết để tận dụng nguồn trái thanh long tươi dư thừa không phù hợp tiêu thụ tươi, và góp phần tạo đầu ra ổn định hơn cho ngành trồng trái thanh long trong nước. Trong nghiên cứu này, quy trình chế biến thanh long sấy khô được bước đầu thiết lập. Mục tiêu của nghiên cứu này nhằm (1) xác định liệu có cần thiết nên thực hiện bước tách nước thẩm thấu trước sấy khí nóng, (2) nếu cần thì tìm thời gian ngâm thẩm thấu thích hợp, và (3) đánh giá độ ổn định của sản phẩm trong quá trình bảo quản có và không có dùng sodium bisulfite. Các kết quả cho thấy việc có dùng bước tách nước thẩm thấu với dung dịch đường 50% và 1,5% acid citric làm tăng tỷ lệ thu hồi lên 6,58%, giảm sự co rút sản phẩm 8,08% và giảm được 3 h thời gian sấy khí nóng sau đó. Việc dùng sodium bisulfite là cần thiết bằng cách nhúng nguyên liệu vào dung dịch bisulfite 0,5% trước khi chế biến để ngăn sự phát triển của nấm mốc và duy trì chất lượng cảm quan (đặc biệt là màu) của sản phẩm sấy. Quy trình phát triển từ nghiên cứu này có thể được áp dụng vào thực tế.

Từ khóa: *thanh long, sấy, tách nước thẩm thấu, đường cong sấy.*

INTRODUCTION

Dragon fruit trees became one of the popular fruit-bearing trees in Vietnam. Part of dragon fruits are consumed fresh domestically. The other part is for exportation to China, Japan, EU, and other countries. In recent years, the exportation market is not stable and that the price of dragon fruit becomes very low, especially during the harvesting seasons. Processing of dragon fruits into long-shelf life products help reach the consumers better during off-seasons, make more outputs for the fruit, serve the increasing need of new products of consumers, and as well increase the economical of dragon fruits. To process dried dragon fruit, solar drying is not suitable because dragon fruit contains a high content of water (Moo-Huchin et al., 2014). Furthermore, the solar drying time would be very long which facilitate spoilage of the product. Hot air (tray) drying is suitable to be applied in plantation areas in Vietnam and in other developing countries. Submersion of the fruit into a high osmotic pressure solution for a period of time (which is also osmotic dehydration) helps release a part of water from the fruit into the solution and the subsequent hot-air drying can be shorten (Duangmal and Khachonsakmetee, 2009; Germer et al., 2010).

The goal of this study was to preliminarily establish a procedure to produce a dried dragon product. To obtain that goal, experiments were carried out to (1) evaluate the necessity of osmotic dehydration (OD) before hot-air drying, (2) find out suitable submerging time in term of processing efficiency and product quality, and (3) evaluate the changes of product quality with and without using sodium bisulfite during processing during one month of storage.

MATERIALS AND METHODS

Materials

Dragon fruits for experiments were purchased at a local market. Other materials and chemicals for the study included refined sugar (Bien Hoa Sugar Company, Vietnam), acid citric, and sodium bisulfite (China).

Experimental processing procedure

The experimental procedure is shown in Figure 1.

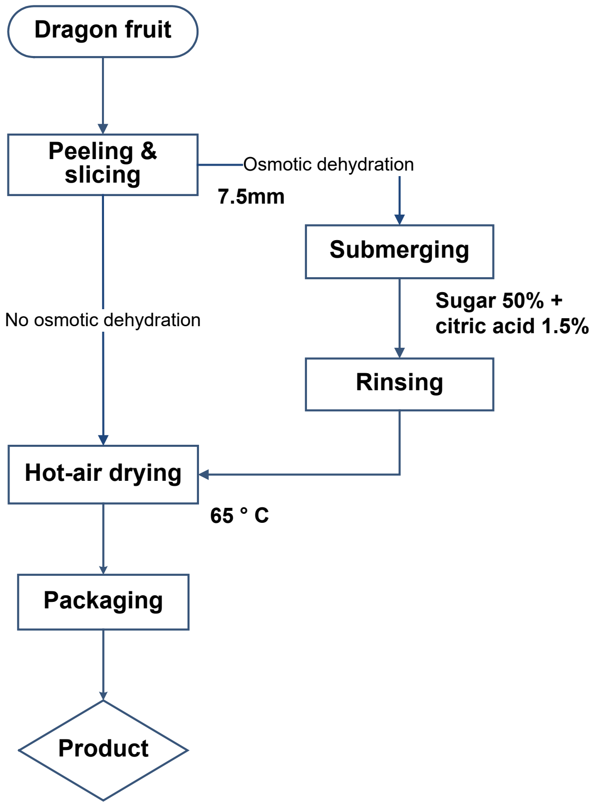

Figure 1. Experimental procedure for processing dried dragon fruit with and without osmotic dehydration

Experiments

Effects of processing dragon fruits with and without osmotic dehydration on processing efficiency and production quality

Dragon fruits were peeled and sliced into circular slices that 0.75 cm thick. These pieces were either dried directly using a hot-air (tray) dryer or submerged into an osmotic solution (sucrose 50% and citric acid 1.5%) with the weight ratio of fruit: solution at 1:2 for three hours before hot-air drying. The hot-air drying was set at 65°C. The products were evaluated on (1) physical properties before and after OD, (2) time for subsequent hot-air drying to reach 14% of moisture content, (3) yield or the weight of product compared to the weight of dragon fruit pieces before drying, (4) volume contraction of the dried product, and (5) sensorial quality of the products.

Effects of osmotic submerging time on processing efficiency and sensorial quality of product

Samples were processed according to the procedure shown in Figure 1. The osmotic submerging time was experimented with 2, 3, 4 and 5 hours. The osmotic solution contained 50% sucrose and 1.5% citric acid. After OD the samples were dried using the hot-air dryer until the samples reached 14% moisture content. The products were evaluated on moisture content, water activity, volume contraction, recovery yield and sensorial properties.

Evaluation of dried dragon fruit quality after one month of storage

Processing of dried dragon fruit was carried out with and without submerging in 0.5% sodium bisulfite solution for five minutes before OD and hot-air drying (Figure 1). The osmotic submerging time was according to the result of the previous experiment. After one month of storage in PE package at room conditions, samples were taken to measure color, total plate counts, total yeasts counts, total mold counts, *Coliforms* and for sensory evaluation.

Physicochemical analyses

Moisture content was determined using drying at 105 °C until a constant weight. Brix degree (indicating dissolved solids) was measured using an Atago Hand Refracttometer 0 – 32 on the juice obtained from grinding and compressing the fruit/ fruit samples.

Thickness of dragon fruit slices before and after processing was measured using the method of replacement of toluene solvent. Volume contraction (%) after a treatment was determined as $(V_{after\ treatment} * 100) / V_{before\ treatment}$.

Color of the material and the products was determined using a Konica Minolta color instrument and the results were illustrated through values of L*, a*, and b*.

For sensorial evaluation in experiments 1 and 2, preference test toward color, taste, structure and general like using a hedonic 9 point scale was applied with a panel of 25 members. For experiment 3, Dou-Trio test with twelve members was applied to check whether sensorial properties of the dried product changed significantly after one month of storage.

Microbial evaluation was carried out by a third party, Hai Dang Analytical Service Company in District 1, Ho Chi Minh City, Vietnam.

Statistical analysis

All experiments were carried out in triplicate and all analyses were performed at least twice. Calculation, tabulating and graphing of data were carried out using Microsoft Excel 2007 (Microsoft, USA). Statistical analysis was performed by using JMP software version 10.0 (SAS Institute Inc, USA). The difference was considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Effects of osmotic dehydration on processing efficiency and production quality

Physicochemical properties of dragon fruit before and after OD are shown in Table 1.

Table 1. Physicochemical properties of dragon fruit before and after osmotic dehydration

Parameters	After slicing	After OD
Production yield (%)[(a)]	65.76± 2.96	54.05± 2.38
Moisture content (%)	88.94± 1.06	78.92± 1.08
Water activity	0.980± 0.013	0.960± 0.009
Brix °	8.92± 0.54	18.52± 0.45
pH	4.43± 0.15	4.25± 0.12
Volume contraction (%)[(c)]	-	9.03± 0.26

Data are average ± SD of three independent repeats

[(a)] *compared to beginning fruit weight (before peeling and slicing)*

[(c)] *volume contraction compared with slices before osmotic dehydration*

A significant weight of peel was removed. As shown in the table, the production yield decreased after OD which means that the amount of materials migrating from the osmotic solution into the fruit was smaller than the amount of materials released from the fruit into the solution. Due to concentration difference, sucrose was expected to penetrate into the fruit. Because of that, the Brix degree increased significantly (Table 1). Water released from the fruits and as shown in Table 1, the moisture content and the weight decreased. The pH of the fruit decreased, which could be due to the migration of citric acid into the fruit. Water activity decreased as the result of increase in dissolved solids. After being further dried with the hot-air dryer, the physicochemical properties in dragon fruits continued to change as shown in Table 2.

Table 2. Physicochemical properties of dried dragon fruit slices obtained from hot-air drying after with and without previous osmotic dehydration

Parameters	Without OD	With OD
Product yield (%) [(a)]	18.89± 0.77	25.47± 1.05
Moisture (%)	14.38± 0.63	14.26± 0.58
Water activity	0.470± 0.027	0.462± 0.016
Volume contraction (%) [(b)]	82.53± 2.69	74.45± 2.74
Drying time (h)	12	9

Data are average ± SD of three independent repeats

[(a)] *compared to the weight of fruit pulp slices before processing.*

[(b)] *compared to the volume of fruit pulp slices before processing.*

After drying up to 14% moisture, using OD resulted in 25.47 ± 1.05 % product yield which was significantly higher than the yield (18.89 ± 0.77 %) when no OD was used. Not only the yield was higher, the hot-air drying time of the former was also three hours shorter than the later (9h vs. 12h). de Medeiros et al. (2016) also observed that pretreatment of mango with OD resulted in shorter subsequent hot air drying. In our study, the other observed advantage with using OD was the lower volume contraction of the product. Water activity of the two products was not significantly different. The moisture reduction curves during hot-air drying are shown in Figure 2 and images of the two products are given in Figure 3. OD reduced subsequent drying time because part of water was removed during OD (Pallas et al., 2013).

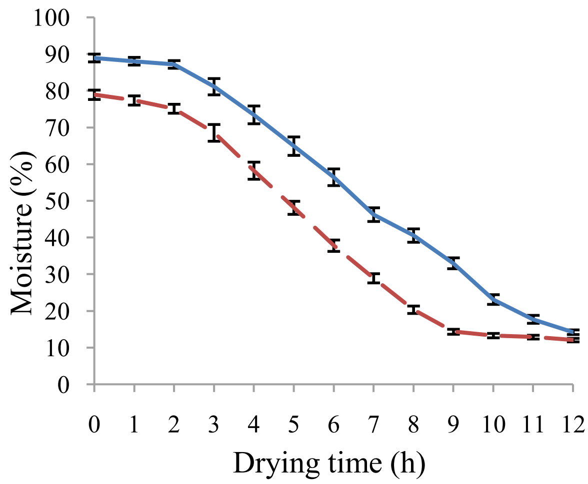

Figure 2. Moisture reduction curves during hot-air drying at 65°C of dragon fruit slices without (——) and with (– –) previous osmotic dehydration

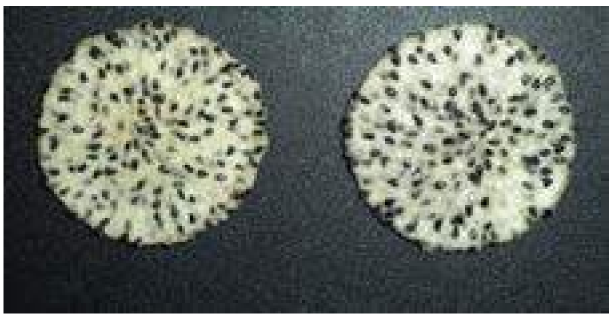

Figure 3. Dried dragon fruit slices without (left) and with (right) osmotic dehydration

The product obtained from processing with using OD looked fuller and smoother than the one without using OD (Figure 3). Part of the surface of the product without using OD was brown while the other product was white in the entire surface. Such observations were confirmed with sensorial test results (Table 3). The product with using OD was preferred in all attributes and had higher general preference. The taste of the MD product was more intense due to absorbed sugar and citric acid. The non MD product has a rather rough structure and plainer taste. OD of apricot before hot-air drying also resulted in a dried product of better color and appearance compared to without using OD (Raj et al., 2015).

Table 3. Sensorial scores of attributes of the dried dragon slices obtained from processing with and without osmotic dehydration

Attributes	Without OD	With OD
Color	5.08[a]	6.88[b]
Taste	4.56[a]	7.28[b]
Structure	3.84[a]	7.36[b]
General score	5.04[a]	7.36[b]

Data are average scores of 25 panelists. Values on the same row do not share a common superscript for a significant difference. Higher scores indicate higher preference (like level).

Effects of osmotic submerging time on processing efficiency and product sensorial quality

Physicochemical properties of dragon fruit slices after varying osmotic submersion time are shown in Table 4.

Table 4. Physicochemical properties of dragon fruit slices after varying osmotic submersion time

Parameters	Osmotic submersion time (h)			
	2	3	4	5
° Brix	17.00 ± 0.32	18.50 ± 0.47	18.50 ± 0.30	18.50 ± 0.21
pH	4.31 ± 0.12	4.24 ± 0.11	4.22 ± 0.15	4.25 ± 0.13
Moisture (%)	79.66 ± 1.28	78.88 ± 1.10	78.79 ± 1.15	78.81 ± 1.12
Water activity	0.96± 0.005	0.95± 0.007	0.95± 0.009	0.95± 0.009
Volume contraction (%)[(a)]	7.89 ± 0.22	8.95 ± 0.21	9.01 ± 0.27	9.09 ± 0.16

Data are average ± SD of three independent repeated experiments.

[(a)] *compared to fruit slices before OD.*

The rate of migration of sucrose into the fruit was illustrated by the increase in Brix degree. In the fruit slices, this value doubled to 17.00 ± 0.32 after two hours from 8.90 ± 0.48. After three hours, the Brix degree did not increase and moisture contained did not decrease significantly anymore (Table 4). The subsequent hot-air drying time could not be shortened anymore when the time for OD was longer than three hours (Figure 4).

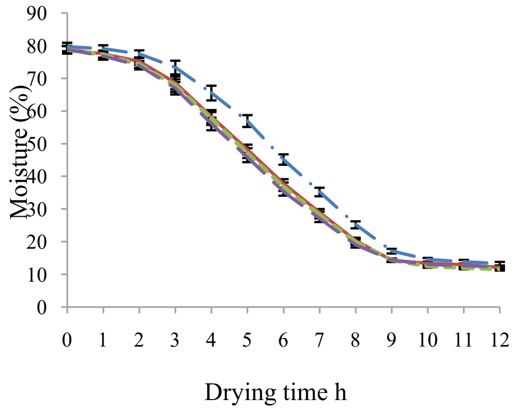

Figure 4. Moisture reduction curves during hot-air at 65 °C drying after 2 (▬ · ·), 3 (▬▬), 4 (▬ ▬ ▬) and 5 (▬ ▬) hours of osmotic submersion.

Sensory evaluation using a hedonic 9 point scale also showed the same trend; preference (like level) for three attributes (color, taste, structure) and for general score increased with osmotic submersion time from 0 to 2 and 3h and did not increase significantly anymore (data not shown) when submerging time was increased further to 4 and 5 h.

Changes of dried dragon fruit after one month of storage

Based on the results of previous experiments, OD was carried out with 3h of submersion in solution of 50% sucrose and 1.5% citric acid. An optional extra step, submersion in 0.5% sodium bisulfite, was introduced before OD. After OD, the sample was dried with the hot-air dryer at 65 °C to 14% moisture. The dried product was packed in PE bag and stored for one month in room conditions. When submersion in sodium *bisulfite was used, the microbial quality of the product met Vietnamese regulation on dried fruit for direct consumption (Table 5). In the case of not using sodium bisulfite, the total mold counts were higher than the limit set by the regulation.

Table 5. Microbial quality of dried dragon slices after one month of storage in PE bag at room conditions

Parameters	Unit	No sodium bisulfite	with sodium bisulfite	QĐ 46:2007 QĐ/BYT[(a)]
Total plate counts	CFU/g	5.0×10^2	6.0×10^1	10^4
Coliforms	CFU/g	Not detected (LOD = 10)	Not detected (LOD = 10)	10
Total yeast counts	CFU/g	1.0×10^1	Not detected (LOD = 10)	10^2
Total mold counts	CFU/g	5.5×10^2	Not detected (LOD = 10)	10^2

[(a)]Regulation of Vietnam Ministry of Health on dried fruits for direct consumption. LOD ~ limit of detection

Using sodium bisulfite also stabilized the color of the dried product (Figure 5). Whereas when sodium bisulfite was not applied, there were significant changes in L^* and a^* values (Figure 5). L^* represents lightness of sample, and that the decrease in L^* indicated a darker color of the samples. a^* and b^* range from green to red and blue to yellow, respectively. The sample without bisulfite became darker (lower L^* value), greener (lower a^* value) and tended to be more yellow after one month of storage.

A Duo-Trio sensorial test was carried out to check whether the panelists were able to distinguish the difference between newly-produced sample and sample after one month of storage. In case of no sodium bisulfite was used, twelve out of twelve panelists said the two samples were different, which indicated that two samples were significantly different. When sodium bisulfite was applied, only five of the twelve reported the newly-produced sample and the sample after one month of storage were different, which indicated that the two samples were not significantly different. Using sodium bisulfite did not only minimize the development of microorganisms (e.g., mold) but also maintained better sensorial quality of the dried dragon fruit slices.

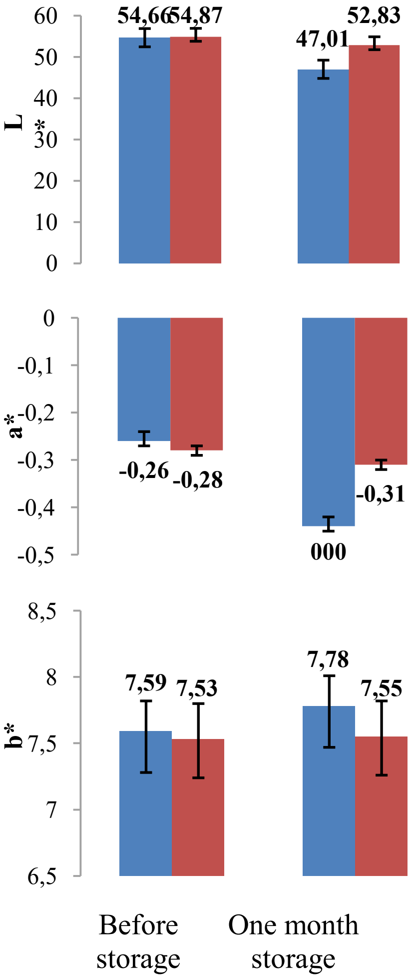

Figure 5. Changes of color parameters of dried dragon slices with (■) and without (■) using sodium bisulfite during processing after one month of storage in PE bag under room conditions.

CONCLUSIONS

For processing dried dragon fruit slices, application of OD with a solution of 50% sucrose and 1.5% citric acid led to 6.58% higher in product yield, 8.08% lower in volume contraction, and 3 hours shorter in subsequent hot-air drying. Three hours of osmotic submersion was more suitable than 2 hours in term of sensorial quality and product yield. Submersion with more than 3 hours did not increase product yield or sensorial quality. Submersion of dragon fruit slices in 0.5% sodium bisulfite solution before processing was necessary to prevent the growth of mold and maintain sensorial quality (especially color) of the dried product. There is a need to investigate the possibilities to reuse and/or utilize the used osmotic solution and to investigate the changes of product quality for a longer storage time.

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