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Effect of final drying condition on qualities of freeze dry dragon fruit (*Hylocercus undatus*)

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Abstract

The effects of freeze drying conditions on qualiies of dragon fruit (*Hylocercus undatus*) were investigated. The fruit samples, sliced with peel at 1 cm. thickeness, were used. In this experiment, the freezing and vacuum drying were performed in the single chamber. The operation cycle included rapid freezing on plate freezer which equiped with air blasted (air velocity 1.38 m/sec.) at -40 °C until core product temperature reaching -10 °C. Followed by two step drying at working pressure of 40 Pa. The seconary drying temperature was controlled at 30, 40 and 50 °C. The qualities of freeze-dried samples including rehydration, apparent density shrinkage, color value and texture (hardness and crispness) of the freezed-dried samples were evaluated. The result showed that incresing drying temperature significantly incresed product cripness and rehydration ratio while significantly induced changing in the color of the rehydrated product.

Keywords: Dragon fruit (*Hylocercus undatus)*, Freeze drying, Rehydration, Texture.

1. Introduction

Drying is one of the most common food preservation process (Huang, 2010). Every drying technique has its own advantages and disadvantages.

The high temperature and long drying time associated with conventional hot air drying often causes heat damage and adversely affects texture, color, flavor and nutritional value of products (Tein, 1998). Which is the cause of low quality products. Then freeze drying can be applied to circumvent heat damage because it is using low temperature and pressure. Freeze dried foods are high quality characteristics such as low bulk density, high porosity, superior test and aroma retention including better rehydration properties, when compared to products made using other drying processes (Chokri, 1997; Simatos, 1974; Ratti, 2001).

Dragon fruit (Hylocereus undatus) or pitaya, have been grown in Vietnam for at least 100 years, following its introduction by the French (Hoa,2016).

Generally, the dragon fruit grown in tropical lowland. The dragon fruit weighs about 150-600 grams, with a medium sweet taste and low calories (Kamol lak, 2014).

This property makes dried dragon fruit slices an excellent candidate for developing an oil free, healthy snack food. The nutritional value can be well preserved and highest crispness can be generated by the freeze drying process.

The objectives of this study were to investigate the effects of final drying condition on moisture content, water activity, color, density, rehydration of freeze dry dragon fruit.

2. Materials and Methods

2.1 Materials.

Dragon fruit (Hylocercus undatus) grown in Pak Chong, Nakhon Ratchasima province, Thailand. The fruit were washed and sliced with peel to 1 cm. thickness, then cut into 4 sections. The fruit pulp had average total soluble solid of 9-11°brix and initial moisture content of 86.5-87.5 %(w.b).

2.2 Drying experiment.

The dragon fruit slices were dried by freeze dryer (I.T.C (1993) CO.,LTD, Thailand). The shecmatic diagram of the equipment was shown in fig. 1. This equipment is designed to freeze and vacuum dry the product within a single chamber. The refrigeration system is designed for direct freezing, combining an air blast freezing system (-40°C) and contact plate freezer (R-507: non-CFC). This can quickly freeze the product. After freezing, the direct heating system for product in drying process and utilizes heat to be rejected from the refrigeration system in melting ice from the moisture trapping chamber (Ice Condenser). Drying process can be adjust the step of drying and reduce the pressure to 13.3 Pa.

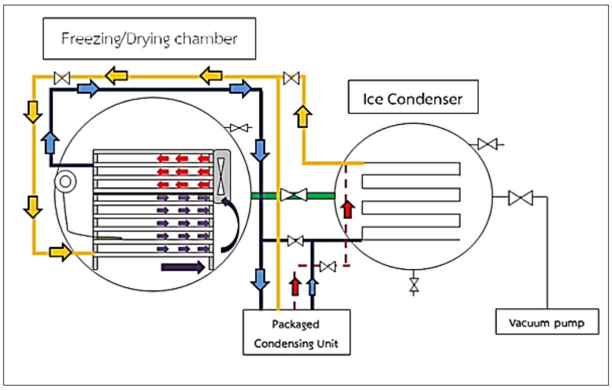


Figure 1 The shecmatic diagram of the equipment.

The dragon fruit sliced were dried by different drying methods until the final water activity was less than 0.6. Dragon fruit slices thick 1 cm., put in a 34x48 cm. aluminum tray, arranged single layer in a full tray and inserted probe at the core samples . These methods were described below.

(a.) (b.)

Figure 2 The arrangement of samples in Kryo "D" Freezer machine (a.)Measurement of core temperature samples (b.)

The Freezing Shelf temp at -40°C in air blast freezer with Semi-contact plate freezer until the sample temperature was -10°C (The material temperature was detected by probe.). The system was into primary drying, by operating the pressure at 40 Pa. and then shelf temperature is heated to -5°C. When the secondary drying, shelf temperature increases to 30, 40 and 50°C. Until the core temperature of sample is different from shelf temp 1°C., the freeze drying process is completed.

2.3 Moisture content (AOAC, 2000).

Moisture content was determined by the hot air oven method. Samples before and after drying were dried in the oven at 105°C until a constant weight was achieved. Weighing was performed using a digital balance, and then moisture content (dry basis) was obtained as following formula:

$$\%\ \text{moisture content (w.b.)} = \frac{(W_1\text{-}W_2)}{W_1} \times 100 \qquad (1)$$

W1 = Weight of the dragon before drying (g.)

W2 = Weight of the dragon after drying (g.)

2.4 Water activity (aw.).

Take a sample of dragon fruit after drying to about 3 g., cut into small pieces. To measure the water activity of the product after drying. By measuring water activity from the NOVASINA model Lab Swift-aw.

2.5 Density.

The mass of dragon fruit samples was measured using an electronic balance with an accuracy of 10^{-2} g. Then put sample into a cylinder container with 1 L. of black sesame seeds, scraping the surface smooth of black sesame seeds and weigh the total of black sesame seeds with samples are in the container. The experiment was replicated nine times of each sample. The appearance density was expressed by the equation (2):

$$\rho = \frac{m}{v} \qquad (2)$$

Where ρ (g/cm^3) is appearance density, m (g.) the mass of dragon fruit samples and V (cm^3) the volume of dragon fruit samples.

2.6 Texture analysis.

Texture properties of the dried samples were measured using a texture Analyzer (Stable micro systems, TA. HD. Plus, UK) with a 2 mm. diameter cylinder probe. The probe was passed through the sample at a test, pre-test and post-test speed of 0.2, 1 and 10 mm/s, respectively. The test is 6 duplicates each divided 2 parts include the pulp and peel of freeze dried dragon fruit, both parts repeat the 3 replications. The hardness is the amount of maximum force required to break the sample (newton) and crispness counts the number of peaks (peak).

2.7 Color.

The fresh or dried samples were placed at center of box for evalulated color with a height of 20 cm. The samples were taken a photos at an angle of 90° from the vertical. Then, the color of sample were evaluated by

Photoshop CS5 Portable, random 5 points for 1 piece of white pulp. Color values were expressed as:

L* = (whiteness/darkness)

a* = (red/green)

b* = (yellow/blue)

The total color difference (ΔE) was calculated in equation (3). (Phoungchadang, 2011).

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (3)$$

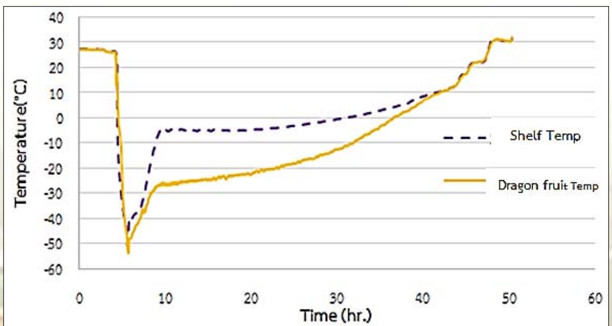
2.8 Rehydration.

The rehydration potential of dried dragon fruit chips was evaluated by immersing 10 g samples in water at 25°C and weigh every 10 minutes until the weight is constant. Then weight is calculated according to the formula (water absorbed (g.) divided by the dry sample weight (g.)) was expressed as the rehydration ratio. Plot graph between rehydrationratio with time.

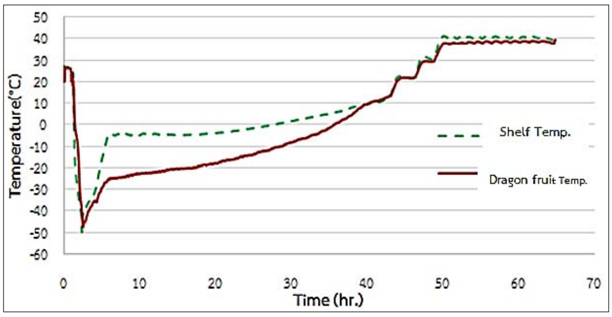
3. Results and Discussion

3.1 Effect of freeze drying conditions on Dehydration rate of dragon fruit chips.

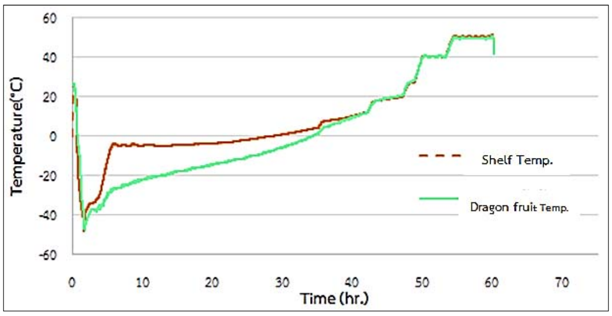
Drying curves shown in Fig. 2 indicate the drying time for seconary drying temperature at 30°C was the shortest (50 h). Followed by the secondary drying conditions at 40°C takes about 55 hours, while the drying time of seconary drying temperature at 50°C was the longest (60 h). Therefore, drying temperature at 30°C is the fastest drying because the temperature of sample in the secondary drying to determine the freeze drying process. The temperature and time of freeze drying affect to qualities of dragon fruit chips.



(a.)



(b.)



(c.)

Figure 3 The relationship between the temperature of the dragon fruit and the drying time for seconary drying temperature at 30°C (a.), 40°C (b.) and 50°C (c.).

3.2 Effect of freeze drying conditions on quality of dragon fruit chips.

The moisture content and water activity of the dragon fruit chips shown in table 1, it was found that, after drying the dragon fruit chips, the moisture content was noticeably decreased. By secondary drying at 30°C, the highest percentage of moisture content and water activity value was 9.87% wet basis and 0.222 respectively, compared with the secondary drying at 40 and 50°C, there was a significant difference at the 95% confidence level, followed by secondary drying at 40°C with a percentage of moisture content 8.55% dry basis and water activity value was 0.204. The secondary drying at 50°C had the lowest of moisture content was 8.53% wet basis and water activety value was 0.172. This is due to the increased drying temperature and time.

The results of apparent density test dragon fruit after freeze drying shows in table 1, it was found that at the secondary drying conditions of 30, 40, 50°C, the densities after drying were decreased from before drying(0.98 g/cm3). The values were 0.16, 0.19, 0.08 g/cm3, respectively. At the secondary drying temperature 30°C, the lowest density and secondary drying temperature 50°C, the density was highest.

Table 1 Effect of freeze drying conditions on quality of dragon fruit chips.

Secondary drying temperatures	(M.C.%$_{w.b}$)	water activity	Apparent density (g/cm^3)
30°C	9.87b±0.26	0.222a±0.001	0.16ab±0.06
40°C	8.55a±0.26	0.204b±0.002	0.19b±0.122
50°C	8.53a±0.07	0.172c±0.001	0.08a±0.03

^{abc}Different letters in the same column within the same section indicate a significant difference (p≤0.05). The values shown in the table are mean ± standard deviation.

Table 2. Effect of freeze drying conditions on texture properties.

Secondary drying temperatures	Textural properties			
	Pulp		Peel	
	Hardness (N)	Crispness (Peak)	Hardness (N)	Crispness (Peak)
30°C	9.29^b±4.63	2.78^a±3.67	6.83^a±2.09	2.44^a±2.24
40°C	3.96^a±2.84	10.78^b±6.22	6.04^a±1.20	3.78^a±3.35
50°C	4.33^a±2.02	10.56^b±3.91	5.54^a±2.66	11.56^b±9.21

^{ab}Different letters in the same column within the same section indicate a significant difference (p≤0.05). The values shown in the table are mean ± standard deviation.

Table 3. Effect of freeze drying conditions on color.

Secondary drying temperatures	Before drying			After drying			ΔE
	L*	a*	b*	L*	a*	b*	
30°C	92.27	4.07	-12.04	94.03	2.63	-8.47	6.23^a±3.37
40°C	92.27	4.07	-12.04	94.35	1.86	-7.07	6.30^a±4.23
50°C	90.65	3.94	-12.71	93.80	2.25	-8.00	6.72^a±3.38

^{a}Different letters in the same column within the same section indicate a significant difference (p≤0.05). The values shown in the table are mean ± standard deviation.

Texture is one of the most important criteria for consideration of consumer acceptance of snack chip (Huang, 2010). Table 2 gives results of texture tests. The pulp of freeze dried dragon fruit was at 40°C. Has the lowest hardness and highest crispness. The values were 3.96 newton and 10.78 Peak, respectively, which was not significantly different with the secondary drying conditions of 50°C. However, in the peel of freeze dried dragon fruit, the secondary drying conditions of 50°C were hardness less than the secondary drying conditions of 40°C, which was 5.54 newton and highest crispness was 11.56, which was significantly different at the 95% confidence level.

Table 3 shows the results of the color tests. There was no significant difference in color between secondary drying temperatures. Analysis of the color difference of before and after freeze dried dragon fruit showed that the samples after drying the sample is lighter color than before drying. The secondary drying conditions at 30°C had the lowest ΔE value of 6.23 due to the low temperature used for drying. Followed by secondary drying at 40 and 50°C. The values were 6.30 and 6.72, respectively.

Figure 4 Dragon fruit before and after freeze drying before freeze drying (a.) after freeze drying (b.).

3.3 Effect of freeze drying conditions on rehydration ratio of dragon fruit chips.

Figure 4 shows the relationship between the rehydration ratio of the dragon fruit freeze dried and rehydration time. In the first 10 minutes of the three drying conditions, the high rehydration ratio was gradually reduced to a constant value. Secondary drying conditions at 50°C had the highest rehydration ratio of 2.57, followed by secondary drying at 40 and 30°C, about 2.53 and 2.21, respectively.

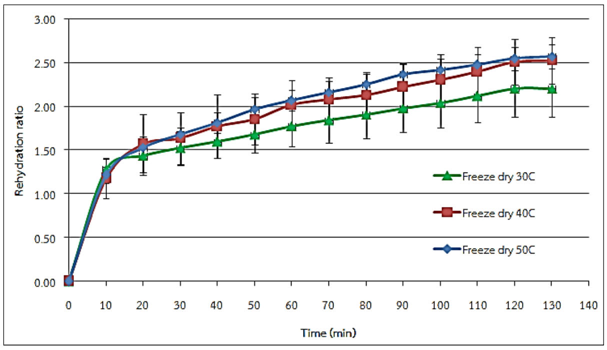


Figure 5 The relationship between the rehydration ratio and rehydration time of the dragon fruit freeze dried for seconary drying temperature at 30°C, 40°C and 50°C.

4. Conclusions

Based on experimental tests reported in this paper the texture and quality of dragon fruit freeze dried at the three secondary drying conditions. The drying time for secondary drying conditions was 30°C. It takes the shortest time (about 50 hours), while the drying time at the secondary drying conditions is 50°C It takes a longest time (about 60 hours), which is secondary drying 30°C, the highest percentage of moisture content after drying was 10.95% dry basis and The secondary drying at 50°C had the lowest of moisture content dry basis and water activity value Which is 9.33 % dry basis and 0.172 respectively. When analyzing the rehydration, the secondary drying at 50°C had the highest rehydration ratio. The color of the dragon fruit samples before and after freeze drying in each secondary drying condition showed that the the sample is lighter color than before drying. The secondary drying conditions at 30°C had the lowest ΔE value of 6.23 followed by secondary drying of 40 and 50°C, respectively, shows that when used in the drying temperature increase will make up the difference in higher color. From the texture test, it was found that the pulp of freeze dried dragon fruit was at 40°C. Has the lowest hardness and highest crispness but in the peel of freeze dried dragon fruit at 50°C, the hardness was less than the secondary drying conditions of 40°C and highest crispness. The density at 30°C had the lowest density and at temperature 50°C has the highest texture density. Thus, freeze drying is suitable for industrial production to add value to dragon fruit. By drying at a secondary temperature of 50°C, the product is good characterized appearance and high quality, especially texture which is the key criteria studied.

5. Acknowledgements

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