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Effect of Blanching and Drying on Quality of Dried Papaya Fruit

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Abstract.
Papaya, a juicy and tasty fruit, belonging to family Caricaceae is scientifically known as *Carica papaya* Linn. Phytochemically, it contains enzymes (Papain), lycopene, carotenoids, alkaloids, monoterpenoids, flavonoids, mineral and vitamins. The pulp of papaya (*Carica papaya* L.) has a pleasant aroma and taste, which are important qualities for sensorial acceptance. After ripening, the papaya fruit softens immediately. Perishable nature and flat odor of papaya limit its commercial processing. Drying is a relatively simple process in which water activity in food is reduced, minimizing or inhibiting the chemical and enzymatic reactions and microbial growth that are responsible for its deterioration. Therefore, objective of this study focused on the effect of blanching temperature and time; heat pump drying temperature and storage condition to β-caroten (mg/100), vitamin C (mg/100g), color (sensory score) of the dried papaya *(Carica papaya)*. Results showed that papaya *(Carica papaya)* should be blanched in hot water 95°C at 10 seconds in the present of Calcium lactate 0.2% and then beeing dried by heat pump dryer at 50°C until 12% moisture. The final dried papaya was shelf-stable for a period of 12 weeks at ambient temperature without any appreciable adverse changes in physico-chemical as well as sensory quality characteristics of the dried products.

Keywords: *Papaya, blanching, drying,* β-caroten, *vitamin C*

I. INTRODUCTION

Papaya is a fruit of the papaya tree or also known as *Carica papaya*. It is a first rate source of vitamins A and C. It contains in small quantity thiamine, riboflavin, calcium, iron, potassium, magnesium and sodium.[1] Unripe papaya is a good source of carbohydrates, vitamins and proteins, and the content decreases as it ripens. Very ripe papaya is not a good source of protein because unripe papaya contains more protein. The vitamin C content of the hard ripe and very ripe pawpaw was found to be fairly high. Papaya at different stages is a good source of vitamin A and mineral elements (Ca, Mg, Na and K). Unripe pawpaw contains the highest amount of all the non-nutritive elements (saponin, alkaloid, tannin, flavonoid and phenol) analyzed which are beneficial to the body.[2] The fruit by products are also good sources of bioactive compounds such as β-carotene, lycopene, anthocyanins and flavonoids when compared to fruit pulps.[3] These bioactive components are responsible for the pharmacological properties of this auspicious plant and demonstrate its importance in daily intake and alimentation. Papaya is considered as nutraceutical fruit due to its multifaceted medicinal properties.[4] Papaya acts as an antioxidant, antimicrobial, anticarminative, anticancer, and has hepato-protective, immunological, and other therapeutic attributes. The seed and pulp of papaya have bacteriostatic effects against several enteropathogens, such as *Bacillus subtilus* and *E. coli*.[5]

Papaya is used for its fruits, and it is very familiar among people because they used them as their breakfast and also as an ingredient in jellies, preserves, or cooked in various ways. The juice makes a popular beverage, young leaves, shoots and fruits cooked as vegetable.[6] In cosmetic industries, the application of plants and plant extracts are widely used and various of purpose such as moisturizing, whitening, tanning, color cosmetic, sunscreens, radical-scavenging, anti-oxidant, immune stimulant, washing, preservatives, ands thickeners.[7]

In literature, various pretreatments have been used which include sulfuring or sulfite dip, salt solution, blanching, chilling, and freezing, blanching, dipping and sulfiting, sucrose, blanching and sulfiting, dipping in 0.5% ascorbic acid solution; 0.3% l-cysteine solution; 0.1% 4-hexyl resorcinol solution; 0.5% sodium meta bisulfite solution; mixed solution of 0.05% 4-hexyl resorcinol and 0.5% sodium meta bisulfite; blanching in hot water at 85°C, steam, water and oil blanching, EPSA (2% ethyl oleat + 4% potassium carbonate + 1% ascorbic acid + 1% citric acid) or EPSM (2% ethyl oleat + 4% potassium carbonate + 2% sodium metabisulfite), ascorbic acid, lemon juice, salt solution, honey dip and 0.1% KMS (Potassium Meta bisulfite), 0.2% KMS, and 0.3% KMS.[8, 9, 10, 11, 12, 13]

The basic types of drying methods which may be used in the drying of fruits include sun and solar drying, atmospheric drying including batch (kiln, tower, and cabinet dryers) and continuous (tunnels, belt, belt-trough, fluidized bed, explosion puff, foam mat, drum, and microwave heated) methods and sub-atmospheric dehydration (vacuum, belt/drum and freeze dryers). Recently the scope has been expanded to include use of low-temperature and low-energy methods like osmotic dehydration. Since drying is a process involving transient heat and mass transfer, the choice of the method to be used depends on various factors which should be taken into account. These factors include raw material and its properties, desired physical form and characteristics of the product, necessary operating conditions, and operation costs.[14]

Pre-treatments have been standardized for the preparation of intermediate moisture products from papaya viz. osmotically dried slices and candy.[15] Process temperature (30, 40 and 50 °C), syrup concentration (50, 60 and 70° Brix) and process time (4, 5 and 6 h) for osmotic dehydration of papaya (*Carica papaya*) cubes were optimized for the maximum water loss and optimum sugar gain by using response surface methodology.[16] Calcium impregnation is used as a pretreatment in the processing of papaya in syrup. The effect of process temperature (30 and 45°C), calcium source (calcium gluconate and calcium lactate), calcium concentration (0.5 and 1.5% w/w), and pH (4.2 and 6) were studied.[17] An experiment was conducted to determine the drying rate, moisture content of osmo-dried papaya slice.[18] A research studied the effect of different microwave power levels, heating time, intermittent time and slice thickness on the drying kinetics of papaya slices. The influence towards the color appearance, the papaya microwave intermittent drying characteristics and the tendency of water loss were obtained.[19] A study evaluated the sensory quality and the stability of papaya dehydrated by convective drying.[20]

Papaya industrialization is an alternative that makes it possible to minimize these losses and to use the fruits that are out of standard for commercialization. The application of appropriate technologies to preserve papaya nutritional properties is one of the ways to supply the population with healthy and nutritious processed foods. Therefore, objective of this study focused on the effect of blanching temperature and time; heat pump drying temperature and storage condition to β-caroten (mg/100g), vitamin C (mg/100g), color (sensory score) of the dried papaya *(Carica papaya)*.

II. MATERIALS AND METHOD

2.1 Material

We collected papaya *(Carica papaya)* in Bac Lieu province, Vietnam. They must be cultivated following VietGAP to ensure food safety. After collecting, they must be conveyed to laboratory within 4 hours for experiments. They were washed under tap water to remove foreign matters. The samples were then washed with Perasan to avoid contamination. After removing the superficial green portion, the fruits were subsequently blanched and dried. Besides papaya *(Carica papaya)* we also used another material during the research such as Calcium lactate. Lab utensils and equipments included digital weight balance, cooker, heat pump dryer.

Figure 1. Papaya *(Carica papaya)*

2.2 Researching procedure

2.2.1 Effect of blanching temperature and time to β-caroten (mg/100g), vitamin C (mg/100g) and color (sensory score) in the dried papaya (Carica papaya)

Raw papaya *(Carica papaya)* were blanched in water solution with 0.2% Calcium lactate at different temperature and time (100^{o}C, 5 second; 95^{o}C, 10 seconds; 90^{o}C, 15 seconds; 85^{o}C, 20 seconds). Then they were dried by heat pump at 50^{o}C until 12% moisture. All samples were analyzed β-caroten (mg/100g), vitamin C (mg/100g), color (sensory score) to validate the appropriate blanching condition.

2.2.2 Effect of drying temperature by heat pump to β-caroten (mg/100g), vitamin C (mg/100g) and color (sensory score) in the dried papaya (Carica papaya)

Raw papaya *(Carica papaya)* was blanched in water solution with 0.2% Calcium lactate at 95^{o}C in 10 seconds. Then these samples would be dried under heat pump dryer at different temperature (30^{o}C, 35^{o}C, 40^{o}C, 45^{o}C, 50^{o}C, 55^{o}C) until 12% moisture. All samples were analyzed β-caroten (mg/100g), vitamin C (mg/100g), color (sensory score) to validate the appropriate drying temperature.

2.2.3 Effect of storage condition to vitamin C (mg/100g) in the dried papaya (Carica papaya)

After completion of drying treatment, the dried papaya *(Carica papaya)* was subjected to storage. They were kept in PET/AL/PE (zipper top), PET/AL/PE (vaccum) bag at different 4^{o}C, 28^{o}C. The vitamin C (mg/100g) will be analyzed in 3 weeks interval for 12 weeks.

2.3 Physico-chemical and sensory analysis

Vitamin C and β-carotene contents of dried fruit samples were determined by titration method of Osborne and Voogt (1978) and spectrophotometric method based on Ultraviolent (UV) inactivation respectively as described by Onwuka (2005).[21, 22] Color (sensory score) of papaya (*Carica papaya)* was assessed by a group of panelist. They were required to evaluate the odour, colour, taste, sweetness and overall acceptance using the 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

2.4 Statistical analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics Centurion XVI.

III. RESULT & DISCUSSION

3.1 Effect of blanching temperature and time to β-caroten (mg/100g), vitamin C (mg/100g), and color (sensory score) in the dried papaya *(Carica papaya)*

During the fruit drying process, changes in appearance and color may occur and compromise the product acceptance. These changes occur through the action of the polyphenol oxidases enzymes that are present in the fruits, leading to the formation of melanins (dark pigments) from the oxidation of phenols to o-quinones.[23]

Pretreatments are usually performed precede drying of fruits in order to minimize the adverse changes occurring during drying and subsequent storage. Pretreatments are recommended techniques used to enhance quality of dried fruits. This is because they prevent darkening of the cut fruit surface and cause the destruction of pathogens that could cause foodborne illness.[24]

Raw papaya *(Carica papaya)* was blanched in water solution with 0.2% Calcium lactate at different temperature and time (100^{o}C, 5 second; 95^{o}C, 10 seconds; 90^{o}C, 15 seconds; 85^{o}C, 20 seconds). Then they were dried by heat pump at 50^{o}C until 12% moisture. All samples were analyzed β-caroten (mg/100g), vitamin C (mg/100g), color (sensory score) to validate the appropriate blanching condition. Results were mentioned in table 1. From table 1, the papaya *(Carica papaya)* should be blanched at 95^{o}C in 15 seconds to maintain the most β-caroten (mg/100g), vitamin C (mg/100g) and sensory score in the dried *papaya (Carica papaya)* .

The effect of pretreatments and drying methods on some qualities of dried mango fruits was studied. The fruit slices were pretreated with three pretreatments – ascorbic acid dip at 31% w/v concentration, honey dip at 20% v v-1 concentration and steam blanching at a temperature of 120°C and dried using three drying methods (sun, solar and oven drying). In sun and solar drying the mango was dried for eight hours, while for oven drying six hours at an average temperature of 32°C, 41°C and 65°C respectively. The result showed that the pretreatment methods used did not have effect on the drying rate. The nutrient analysis showed that mango samples treated with honey solution had the highest retention of vitamin C (140.35 mg per 100 g) in sun drying method compared to ascorbic acid treated, steam blanched and control samples. Also, for β-carotene, honey treated samples had the highest value of 5921.90 µg per 100 g across the drying methods.[24]

Pre-treatments have been standardized for the preparation of intermediate moisture products from papaya viz. osmotically dried slices and candy. the pretreatment consisting of blanching of fruit slices for 1 minute with 0.2% citric acid followed by dipping in 0.2% KMS for 20 minutes was standardized. Osmotically dried papaya contained 5.6% moisture, 55^{o}Bx TSS, 0.26% acidity, 16.4mg/100g ascorbic acid and 1395.46 µg/100g carotenoids whereas candied papaya contained 16.13% moisture, 46.8oB TSS, 0.12 % acidity, 16.5mg/100g ascorbic acid and 1543 mg /100gm carotenoids content. A slight increase in moisture and reducing sugar took place whereas decrease in total sugar, ascorbic acid and carotenoids was noticed during storage. The developed products remained shelf-stable for 6 months at ambient temperature with minimum changes in their physico-chemical and sensory atributes.[14]

In another study, calcium impregnation was used as a pretreatment in the processing of papaya in syrup. The effect of process temperature (30 and 45°C), calcium source (calcium gluconate and calcium lactate), calcium concentration (0.5 and 1.5% w/w), and pH (4.2 and 6) were studied. The mineral source affected significantly the calcium uptake and the fruit firmness.[17]

3.2 Effect of drying temperature by heat pump to β-caroten (mg/100g), vitamin C (mg/100g) and color (sensory score) in the dried papaya *(Carica papaya)*

Drying is one of the oldest methods for the preservation of food products and it is the process of removing water from food by circulating hot air through it to reduce the moisture content to a level which prohibits the growth of microorganisms. Drying of food materials has advantages such as control of product quality, achievement of hygienic conditions, and reduction of product loss.[25]

Table 1. Effect of blanching and time to β-caroten (mg/100g), vitamin C (mg/100g) and color (sensory score) in the dried papaya *(Carica papaya)*

Blanching	β-caroten (mg/100g)	Vitamin C (mg/100g)	Sensory score
100^{o}C, 5 seconds	154.21±0.01^b	7.69±0.01^b	6.44±0.03^c
95^{o}C, 10 seconds	160.75±0.00^a	9.35±0.02^a	7.34±0.00^a
90^{o}C, 15 seconds	152.11±0.02^c	6.38±0.01^c	7.08±0.02^b
85^{o}C, 20 seconds	148.33±0.00^d	5.27±0.01^d	6.03±0.02^d

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2. Effect of drying temperature by heat pump to β-caroten (mg/100g), vitamin C (mg/100g) and color (sensory score) in the dried papaya *(Carica papaya)*

Drying temperature	β-caroten (mg/100g)	Vitamin C (mg/100g)	Sensory score
30^{o}C	160.94±0.01^a	9.39±0.01^a	7.36±0.01^a
35^{o}C	160.92±0.00^a	9.39±0.03^a	7.35±0.00^a
40^{o}C	160.90±0.02^a	9.38±0.02^a	7.35±0.02^a
45^{o}C	160.84±0.02^a	9.36±0.01^a	7.35±0.01^{aa}
50^{o}C	**160.75±0.00^a**	**9.35±0.02^a**	**7.34±0.00^a**
55^{o}C	154.63±0.01^b	7.78±0.03^b	6.21±0.02^b

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3. Vitamin C (mg/100g) in dried papaya *(Carica papaya)* by the effect of packaging material and storage temperature

Storage time (week)	Dried papaya *(Carica papaya)* by the storage temperature (^{o}C) kept in PET/AL/PE (zipper top)		Dried papaya *(Carica papaya)* by the storage temperature (^{o}C) kept in PET/AL/PE (vaccum)	
	4 ^{o}C	28 ^{o}C	4 ^{o}C	28 ^{o}C
0	9.35±0.01^a	9.35±0.01^a	9.35±0.03^a	9.35±0.01^a
3	9.31±0.03^{ab}	9.29±0.03^{ab}	9.33±0.01^{ab}	9.30±0.02^{ab}
6	9.28±0.01^{ab}	9.20±0.01^b	9.28±0.02^b	9.24±0.03^b
9	9.22±0.02^b	9.16±0.03^{bc}	9.24±0.01^{bc}	9.19±0.02^{bc}
12	9.14±0.01^b	9.11±0.01^c	9.17±0.00^c	9.13±0.01^c

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Process temperature (30, 40 and 50 °C), syrup concentration (50, 60 and 70^o Brix) and process time (4, 5 and 6 h) for osmotic dehydration of papaya (*Carica papaya*) cubes were optimized for the maximum water loss and optimum sugar gain by using response surface methodology. The peeled and pre-processed papaya cubes of 1 cm size were immersed in sugar syrup at constant temperature water bath having syrup to papaya cubes ratio of 4:1 (w/w). The cubes were removed from bath at pre-decided time, rinsed with water and weighed. Initial moisture content of papaya samples were 87.5–88.5% (wb), which was reduced to 67.6–81.1% after osmotic dehydration in various experiments showing mass reduction, water loss and sugar gain in the range of 20.6–36.4, 23.2–44.5 and 2.5–8.1%, respectively. The weight reduction, water loss and sugar gain data were statistically analyzed and regression equation of second order were found the best fit for all the experimental data. Maximum water loss of 28% with optimum sugar gain of 4% was predicted for the 60^{o}Brix syrup concentration at 37 °C for syrup to fruit ratio as 4:1 in 4.25 h of osmotic dehydration.[16]

The experiment was conducted to determine the drying rate, moisture content of osmo-dried papaya slice. Drying of papaya slices in a hot air oven dryer takes only 660 minutes for drying from an initial moisture content of 89% (wb) to a final moisture content of 6.92, 4.84, 7.19 and 2.79% (db) of 55 oBrix and the final moisture content were recorded of 65 oBrix that 16.30, 4.12, 9.32 and 9.76% (db) for T1, T2, T3 and T4 samples. The drying temperature is the main factor controlling the rate of drying.[18] A research studied the effect of different microwave power levels, heating time, intermittent time and slice thickness on the drying kinetics of papaya slices. The influence towards the color appearance, the papaya microwave intermittent drying characteristics and the tendency of water loss were obtained. The results indicated that the drying rate of papaya during the microwave intermittent drying consistently declined with the change of microwave power levels.[19]

3.3 Effect of storage condition to vitamin C (mg/100g) in the dried papaya *(Carica papaya)*

Loss of nutrients, such as vitamin C and carotenoids, may occur during storage, thus reducing the nutritional value of dried fruit. Degradation of these nutrients depends on factors such as pH, oxygen exposure, presence of light, metals, enzymes, temperature and the drying methods used.[26, 27] In addition to the nutritional aspects, sensorial attributes must be evaluated in order to determine the quality of dried fruits. The aroma and flavor may be altered due to loss of volatiles during drying and storage of the dried fruits, leading to lower product acceptance.[28]

After completion of drying treatment, the dried papaya *(Carica papaya)* was subjected to storage. They were kept in PET/AL/PE (zipper top), PET/AL/PE (vaccum) bag at different 4^{o}C, 28^{o}C. The vitamin C (mg/100g) will be analyzed in 3 weeks interval for 12 weeks. Dried papaya *(Carica papaya)* should be stored under vacuum in PET/AL/PE bag at 4^{o}C to maintain vitamin C (mg/100g) for 12 weeks.

The drying operation reduces the moisture content of solids to a condition favorable for safe storage without deteriorations. The most significance reason for the popularity of dried products is that in dehydrated foods, microorganisms practically do not grow due to the presence of a minimum amount of water and thus they are immune to enzymatic reactions that could provoke alterations or spoilage in the food.[29, 30, 31]

Another study evaluated the sensory quality and the stability of papaya dehydrated by convective drying. Fresh and dried papaya were evaluated for color, moisture, pH, acidity, water activity, soluble solids, vitamin C, carotenoids, total extractable polyphenols (TEP) and antioxidant activity (ABTS). The sensorial acceptance of the dried papaya was evaluated using a structured nine-point hedonic scale. For the stability study, the analysis of moisture, pH, titratable acidity, water activity, total carotenoids and vitamin C were carried out every 30 days of storage until 120 days. During storage, the moisture content of dried papaya remained constant, but there were undesirable changes in color, increase of acidity and reduction of soluble solids. The degradation of total carotenoids and vitamin C followed the first order reaction, and the half-life time was 346 days for carotenoids, whereas for vitamin C it was only 29 days. In the sensory analysis, the dried papaya received grades between 5.0 and 6.0 for all evaluated attributes. Dried papaya is recommended to be consumed up to 30 days, since within this period a product with higher total carotenoids content, vitamin C and with satisfactory physicochemical and sensorial characteristics were obtained.[20]

IV. Conclusion

Papaya holds a broad spectrum of phytochemicals, including polysaccharides, vitamins, minerals, enzymes, proteins, glycosides, saponins, flavonoids, and phytosterols. Fruit dehydration is a way of supplying the population with healthy and nutritious foods. The shelf life of dried fruit can be defined by the evaluation of changes occurred in chemical characteristics during storage. The dried papaya samples revealed that they are rich in vitamin C and β-carotene (antioxidant) which makes them healthy and nourishing and also important ingredient in the food industry for the production of food supplements and other functional foods.

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