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DEVELOPMENT OF AN OSMOTICALLY DEHYDRATED CHRISTOPHENE CANDIED PRODUCT

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ABSTRACT: Christophene (*Sechium edule*) was osmotically dehydrated to produce a candied product. The christophene was blanched in hot water for 5 min followed by steam blanching for 5 min and then subjected to osmotic dehydration in various sugar solutions prepared to 30°Brix and increased daily for 3 days to 45°Brix, 60°Brix and 70°Brix. Final drying was at 68°C for 4 hours. Preliminary results indicated that products from 100% sucrose had a dull appearance with a coat of sugar while products in 100% glucose/fructose were sticky. In further work, peeled and un-peeled christophene cubes were soaked in 75% sucrose with 25% glucose/ fructose and un-peeled christophene to 50% sucrose with 50% glucose/fructose and 25% sucrose with 75% glucose/fructose. A product from 75% sucrose with 25% glucose/fructose had the best overall acceptability (liked slightly to moderately), lowest moisture content (10.5-15.2%) and had low microbial count (< 10 cfu g -1) after 21 days of storage at 19±1°C.

INTRODUCTION

Christophene or chayote *(Sechium edule*, Swartz) is a highly perishable and seasonal vegetable (Littman, 1981). The vegetable contains about 98% water, which limits its shelf-life. Osmotic dehydration partially removes water from fruits or vegetables immersed in a hypertonic solution (Rastogi et al., 1999). Water loss is accompanied by simultaneous diffusion of solute into the food. Osmosis is the molecular movement of certain components in a solution through a semi-permeable membrane to another solution that has a lesser concentration of the particular molecules (Raoult-Wack *et al.*, 1989). Drying is one of the oldest methods of food preservation (Desrosier and Desrosier, 1977). Candying is a method of preserving fruits and vegetables, thus making them available during the off season. Candied christophene can be used as fruit substitutes in the baking industry and as an alternative to the otherwise bland and unpopular vegetable. Our objectives were to reduce the moisture level of christophene and to create value-added products by employing the principles of osmotic dehydration. The effects of varying sucrose/glucose-fructose combination with and without peel on the physico-chemical and sensory attributes of the candied product were investigated.

MATERIALS AND METHODS

Processing

Christophene (*Sechium edule*) Swartz of the dark green type were purchased from the wholesale market, Port-of-Spain. Each experimental batch consisted of 15 kg. Over-mature christophene were not selected, due to the tough texture which required longer blanching time in the production of the candied product. Fig. 1 outlines the steps in the candying of christophene. Christophene were washed in water, cut into halves and the cores removed. The vegetable, either peeled or un-peeled was sliced (2 cm x 2 cm). The vegetable was blanched in hot water for 5 min and steamed for 5 min. Blanching was done to increase the permeability of cell membranes. The weight of the vegetable was taken before and after blanching.

In the first stage of experimental work, using peeled christophene, 3 types of syrups for osmotic dehydration of the vegetable were used: 100% sucrose (PT_1); 50% sucrose with 50% glucose/fructose (PT_2) and 100% fructose (PT_3). On day 1, the blanched christophene cubes were added to each type of syrup at 30°Brix and the total soluble solids as °Brix was increased on day 2 to 45°Brix, day 3 to 60°Brix and day 4 to 70°Brix. To the syrups, 0.01% citric acid was added with 0.04% green colouring and 5 g of liquid lemon flavouring.

In the second stage of the investigation, using both peeled and un-peeled christophene, 4 types of syrups were prepared as follows: 75% sucrose with 25% glucose/fructose (without peel); 75% sucrose with 25% glucose/fructose (with peel); 50% sucrose with 50% glucose/fructose (with peel); and 25% sucrose with 75% glucose/fructose (with peel). On day 1, the blanched christophene was added to each syrup at 30°Brix, and the total soluble solids as °Brix increased on day 2 to 45°Brix, day 3 to 60°Brix and day 4 to 70°Brix. Pearson Square method was used to calculate the required amount of sucrose and glucose/fructose required to attain the required ratio and Brix level. A 1:1 ratio of vegetable to syrup was used with 0.01% citric acid. On day 5, samples were drained of syrup and rinsed quickly with sterile water to remove excess surface sugar and allowed to drain for 3 minutes. Each treatment was weighed and dried in a dehydrator at 68°C for 4 hours. Moisture loss, % was monitored every hour. The candied products were cooled quickly and packaged in polyethylene bags (2 cm x 6 cm) and sealed and stored at 19±1°C. During storage, the products were analysed for pH, texture, colour, microbial and sensory quality.

Physico-chemical analyses

Moisture (%) of fresh christophene, osmotically dehydrated christophene before and after mechanical dehydration was determined by AOAC (1980). Colour was measured on the fresh christophene, osmotically dehydrated christophene and the dehydrated product on a Minolta Chroma Meter and expressed as L, a, b values. An average of three readings was taken for each sample and the average determined. Texture measurements of three samples in triplicate were measured on a Koehler Digital Penetrometer (Koehler Instruments Company Ltd, Bohemia, USA). The depth of penetration of the product by a 2.5 g needle after 5 sec was recorded as 0.01 mm. pH was recorded for the fresh christophene, blanched christophene, dehydrated christophene and stored products from 4 treatments of the second stage of experimental work. pH ws measured on an Orion model 520 A pH meter.

Sensory evaluation. In the first stage of experimental work, untrained panelists (28) in each session ranked the products from the 3 syrup treatments (100% sucrose; 50 % sucrose with 50% glucose/fructose and 100% fructose) on a scale from 1-3 (1- most preferred; 2- moderately preferred; 3-least preferred) for colour, texture, taste and overall acceptability. The sensory evaluation was conducted in 2 sessions. In the second stage of processing, the products from the four treatments (75% sucrose with 25% glucose/fructose (without peel): 75% sucrose with 25% glucose/fructose (with peel); 50% sucrose with 50% glucose/fructose (with peel); and 25% sucrose with 75% glucose/fructose (with peel) were given scores for colour, taste, texture and overall acceptability on a 9 –point Hedonic scale (9-liked extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither liked nor disliked; 4-dislike slightly; 3-dislike moderately; 2-dislike very much; 1-disliked extremely) as described by Watts et al. (1970). Panelists were asked to suggest a desirable colour and flavour to be added in the second stage of processing. Sensory evaluation was performed by a 50 member of untrained panelists comprising of staff and students of the University of the West Indies.

Microbial evaluation. On storage, the candied products from the four treatments in the second stage of processing were examined for microbial quality. Microbial analysis was conducted on day 8, day 13, and day 20 after processing of the candied dehydrated product. Serial dilutions (10^{-1} –10^{-5}) of each treatment were prepared and total plate count enumerated on Plate Count Agar (PCA) and yeast and moulds on Potato Dextrose Agar (PDA). The PCA plates were incubated at 35°C and PDA plates at 25°C for 48 hours. The number of microorganisms was enumerated as cfu $^{g-1}$.

Statistical analysis. SPSS Statistical Packages for Social Sciences, Version 8 (Stanford University) was used to analyse the data using analysis of variance (ANOVA) to determine the effects of treatments on sensory parameters of taste, texture, pH and overall acceptability. Friedman's test was used for ranking of colour, texture, taste and overall acceptabilty of treatments from the first stage of experimental work. Analysis of variance at 5% level of significance investigated the effects of the four (4) treatments in the second stage of experimental work on moisture, physico-chemical and sensory quality of the products.

RESULTS AND DISCUSSION

First stage of Processing

There were no ($P>0.05$) differences in 'L' 'a' 'b' values based on syrup treatments (PT_1 - 'L' 43.6, 'a' - 1.6, 'b' 8.4 ; PT_2 - 'L' 42.8, 'a' -1.5, 'b' - 8.7; PT_3 -'L' 43.4, 'a'- 1.5, 'b' - 9.0), however there were changes ($P<0.01$) in 'a' values of the products on storage (Table 1)

Sensory. No differences ($P>0.05$) in preference for colour, appearance and taste of candied products due to syrup treatments but differences ($P<0.05$) in texture and overall acceptability (Table 2). Although, there were no differences in texture and overall acceptability between candied products PT_2 and PT_3, based on the overall mean attribute scores (colour, appearance, taste, texture and overall acceptability) for candied products, PT_2 was ranked first (Table 3) from the first stage of the experiment and thus, was selected for further study. The product in 100% sucrose had a dull appearance. Responses (out of 36) by panelists indicated the following recommendation for colour : green (14) yellow (8), natural (7), red (6) and other (1). Lime was the most desired flavour (12), followed by cinnamon (8), orange and ginger (7). Based on the highest response, the colour green and lime flavour were introduced in formulations in the 2^{nd} stage of processing.

Second Stage of Processing

Fresh christophene had a high moisture content of 93.8%. The moisture was reduced in the osmotically dehydrated product (Table 4). The total moisture losses (%) on osmotic dehydration of fresh christophene to final candied products were: T_1- 83.3; T_2-76.6;T_3-65.70; T_4-63.10.The effect of syrup treatments on moisture loss of the product was significant ($P<0.05$). The presence of the peel in T_2 acted as a barrier to % moisture loss as compared to T_1. Treatments T_3 and T_4 had less moisture loss during osmotic dehydration than treatments T_1 and T_2, thus indicating that a higher percentage of sucrose to glucose/fructose was necessary to remove a higher % of moisture, which is the underlying principle of osmotic dehydration. Table 4 shows that in the final products T_1 and T_2 had the lowest moisture content of 10.4 and 15.2 % respectively with the low microbial count of <10 cfu g^{-1} on storage at 20°C for 21 days.

Physico-chemical analysis

There were no changes ($P>0.05$) in colour, texture and pH due to syrup treatments and storage. The average tristimulus values for the candied product were: "L' – 30.32±SD 2.6, 'a' - 10.83±SD 4.7, 'b' – 12.9±SD 4.2. Texture ranged from 15.1- 48.1 mm / 5 sec (SD 8.5-28.2). The pH of the fresh christophene was 6.01, blanchedchristophene 5.30 and candied product of 3.72-4.40 (SD: 0.03-0.28).

Microbial

Treatment T_1 with 75% sucrose with 25% glucose/fructose had the lowest microbial count which decreased on storage at 18-20°C for 20 days. T_2 , which was left un-peeled had a higher microbial load than T_1 even though the syrup treatment was the same. The peel of T_2 may have harboured microoraganisms, and acted as a barrier to water loss and sugar absorption. The higher microbial numbers of T_3 and T_4 and which increased on storage could be linked to the lower % sucrose syrup and higher moisture content of the product. Microbial spoilage does not occur in dried fruits which contain less than 18-25 % moisture (Somogyi and Luh, 1986).

Sensory evaluation

There were differences ($P<0.05$) in colour and texture of candied product, but no differences ($P>0.05$) in taste and overall acceptability due to syrup treatments (Table 5). Treatment T_1 was the most liked candied product for its colour (6.86), texture (7.08) with an overall acceptability of being liked slightly to liked moderately (6.6).

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Harvest christophene

↓

Store

↓

Wash

↓

Peel/do not peel

↓

Slice

↓

Weigh

↓

Blanch and Steam

1 st stage	2nd stage
100% sucrose	75% sucrose with 25% glucose/fructose
50% sucrose with 50% glucose/fructose	50% sucrose with 50% glucose/fructose
100% glucose/fructose	25% sucrose with 75% glucose/fructose

↓

Add citric acid, flavouring and colour

↓

Day 1, Boil syrup for 10 min: Submerge in 30°Brix

↓

Day 2, Measure °Brix and increase to 45°Brix

↓

Day3, Measure °Brix and increase to 60°Brix

↓

Day4, Measure °Brix, and increase to 70°Brix

↓

Drain and rinse excess surface sugar

↓

Dry at 68°C for 4 hrs

↓

Package

↓

Store, 19±1°C

Figure 1. Production of an osmotically dehydrated candied christophene

Table 1. Effect of Storage on Colour of Candied Product (first stage of processing)

Treatments	Colour					
	'L'		'a'		'b'	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
PT_1	43.6	5.90	-1.60	0.53	8.40	1.00
PT_2	42.8	0.07	-1.50	0.75	8.70	2.40
PT_3	43.4	0.56	-1.50	0.56	9.00	1.10
Not significant, P>0.05						
Storage						
Day 1	42.0	2.30	-2.00	0.10	8.16	1.40
Day 13	44.5	2.80	-1.14	0.14	9.36	1.10
Significance	P>0.05, n.s.		P<0.01, significant		P>0.05, n.s.	

n.s.- not significant: S.D. standard deviation

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

Table 2. Effect of Syrup Treatment on Texture and Overall Acceptability of Candied Product.

Treatment	Texture		Overall Acceptability	
	Mean	S.D.	Mean	S.D.
PT_1	2.46a	0.74	2.46a	0.79
PT_2	1.85b	0.70	1.75b	0.64
PT_3	1.71b	0.80	1.78b	0.83

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

1- most preferred; 3- least preferred

Table 3. Sensory Score and Rank of Candied Product (First stage of processing).

Treatment	Total Mean Score	Rank
PT1	2.31	3
PT2	1.50	1
PT3	1.79	2

PT_1-100% sucrose (without peel); PT_2- 50% sucrose with 50% glucose/fructose (without peel); PT_3-100% fructose (without peel)

Total mean score – average of scores of colour, appearance, taste, tecture and overall acceptability

most preferred; 3- least preferred

Table 4. Changes in Moisture Content (%) on Osmotic Dehydration of Christophene.

Treatment	% Moisture loss	% Moisture
Fresh christophene	-	93.8
Candied before dehydration, % loss from fresh christophene		
T_1	70.1	23.7
T_2	70.3	23.5
T_3	53.7	39.9
T_4	55.9	37.9
Final product, % loss on dehydration of candied product		
T_1	13.3	10.4
T_2	8.3	15.2
T_3	11.9	28.0
T_4	7.2	30.7

T_1-75% sucrose with 25% glucose / fructose (without peel)
T_2- 75% sucrose with 25% glucose / fructose (with peel)
T_3- 50% sucrose with 50 % glucose/fructose (with peel)
T_4-25% sucrose with 75% glucose/fructose (with peel)

Table 5. Effects of Syrup Treatments on Sensory Attributes of Products (second stage of processing)

Treatments	Sensory attributes							
	Colour		Texture		Taste		Overall acceptability	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
T_1	6.86	1.42	7.08	1.35	6.66	1.93	6.60	1.86
T_2	6.06	1.79	6.26	1.73	6.04	1.62	6.00	1.44
T_3	6.28	1.75	6.18	1.40	5.94	1.82	5.70	1.60
T_4	5.80	1.90	6.04	1.67	6.18	1.80	5.90	1.78
Average mean	6.24	1.79	6.39	1.55	6.18	1.80	6.11	1.68
Significance	$P<0.05$.		$P<0.05$		$P>0.05$		$P>0.05$	

Hedonic score- 9-like extremely; 8-like very much; 7-like moderately; 6-like slightly; 5-neither like nor dislike; 4-dislike slightly; 3-dislike moderatley; 2-dislike very much; 1- dislike extremely
T_1-75% sucrose with 25% glucose / fructose (without peel)
T_2- 75% sucrose with 25% glucose / fructose (with peel)
T_3- 50% sucrose with 50 % glucose/fructose (with peel)
T_4-25% sucrose with 75% glucose/fructose (with peel)