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Process for Preparing Pre-fried and Frozen Sweetpotato French-fry Type Products

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ABSTRACT

Three processes for producing pre-fried and frozen sweetpotato French-fry type products were investigated. The best process was obtained by blanching sweetpotato strips in 0.5% of disodium acid pyrophosphate (SAPP) solution for 1-2 min, followed by partially frying in hot oil at 176°C for 20 sec. These sweetpotato strips were partially dehydrated with hot air oven at 176°C for 4 min, packaged in LDPE bags, and then stored at –20°C. Chemical, physical and sensory properties of a sweetpotato French-fry type product were also determined. Analysis included measurements of yields, moisture loss during process, moisture content, reducing sugar, oil content, vitamin C, color, texture and sensory panel scores for color, odor, flavor and texture. The best process produced a pre-fried sweetpotato product contained reducing sugar and oil content of about 2-3% and 7-10% respectively. The pre-fried products had a good stability in frozen storage for one year period and were acceptable in the sensory scores for color, odor, flavor and texture.

Key words : sweetpotato, french-fry, pre-fried, frozen

INTRODUCTION

Sweetpotatoes *(Ipomoea batatas L)* have been grown for domestic consumption in Thailand for many years. Commercial plantations are very few. Home and cottage-scale processing units have supplied products to local markets on a daily basis. These processed products such as boiled sweetpotato in heavy syrup etc. must be consumed within one to two days, due to short shelf-life. Calories contribution by sweetpotato in the diet is quite small because people consume sweetpotato as dessert and snackfood product.

Since 1987 the Government of Thailand has had a National Policy Plan (1987-1991) to promote commercial production through activities led by the Department of Agriculture and Department of Agriculture Extension. In this regard, food industry is required extensive research to develop an appropriate technology for processing a product with a longer shelf-life and to meet consumer preferences.

One prospective product is the frozen French-fry product. Recently, the rate of French-fries consumption from white potatoes have increased rapidly in fast-food shops. If a similar product prepared from sweetpotatoes are available, it might be acceptable to a larger number of consumers and would be a value-added product from sweetpotatoes.

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The sweetpotato French-fry type product was judged of good quality and acceptability by consumer panels. (Walter and Hoover, 1986) Since roots are harvested seasonally and storage costs are high, roots should be processed into a finished product.

The objectives of this study were to provide an improved process to produce a pre-fried and frozen French-fry type product from sweetpotato having a low oil content, and the moisture content about 30 to 32% and to evaluate chemical, physical and sensory changes of the sweetpotato French-fry type product from various processes.

MATERIALS AND METHODS

Raw materials

Approximately 250 kg sweetpotatoes (Kaset cultivar) were obtained from a producer in Suphan Buri province. The roots were kept for one week at 30°C and 65% relative humidity before processing into strips and frozen.

Processing conditions

Roots were processed into two sizes of the French-fry type strips. The roots were washed, hand-peeled, rinsed and sliced into so-called shoestring strips with an average length about 9-10 cm and cross-sectional side dimension of 6 mm × 6 mm and 8 mm × 8 mm with vegetable slicer (Robot Coupe, France). Small or uneven strips were discarded to improve product uniformity. These sweetpotato strips were then processed into a French-fry type following the flowchart in Figure 1. Three processes were done for producing the frozen French-fry type product. The deep fat fryer used in this study was NSF Testing Laboratory having a capacity of 15 kg of frying oil.

All strips were packaged in low density polyethylene bags and stored in a freezer at –20°C. After one week and one year storage time, they were thawed and analyzed for yields, weight loss, physical and chemical properties. They were fried in palm oil at 176°C at different periods (Table 1) for sensory panel test.

Chemical analyses

The analyses were performed on samples of products handled and processed under various processing treatments. All chemical analyses were performed in duplication. Dry matter was determined by weighing duplicated samples before and after drying in oven at 102 ± 3°C for 2 hr. Oil content of fried strips was determined by Soxhlet Extraction with petroleum ether for 16 hr, followed by evaporation of the solvent and weighing the residues. Reducing sugar was determined using Fehling's solution described by Lane and Eynon (AOAC. 1990). Ascorbic acid was determined using 2, 6-Dichloroindophenol titration method (AOAC, 1990).

Physical measurements

Yields, weight losses and size of pre-fried sweetpotato strips were determined.

Color CIELAB L* a* b* C* and h were determined from reflectance measurement with a ACS Spectro-sensor II (Applied Color System, inc. Princeton, NJ 08543). Four rows of strips were placed side by side in 5 cm × 4 cm cell. Color data were determined with daylight illuminant in duplicate.

Shear measurements were made using an Instron Universal Testing Machine. (Model 1140). Samples of 15 g pre-fried product and 2.5 g finish-fried product were placed perpendicular to the blades of a Kramer shear cell with a slotted bottom and kg shearing force measured. The cross-head speed was set at 200 mm/min. The shear force for each treatment was determined 5 times.

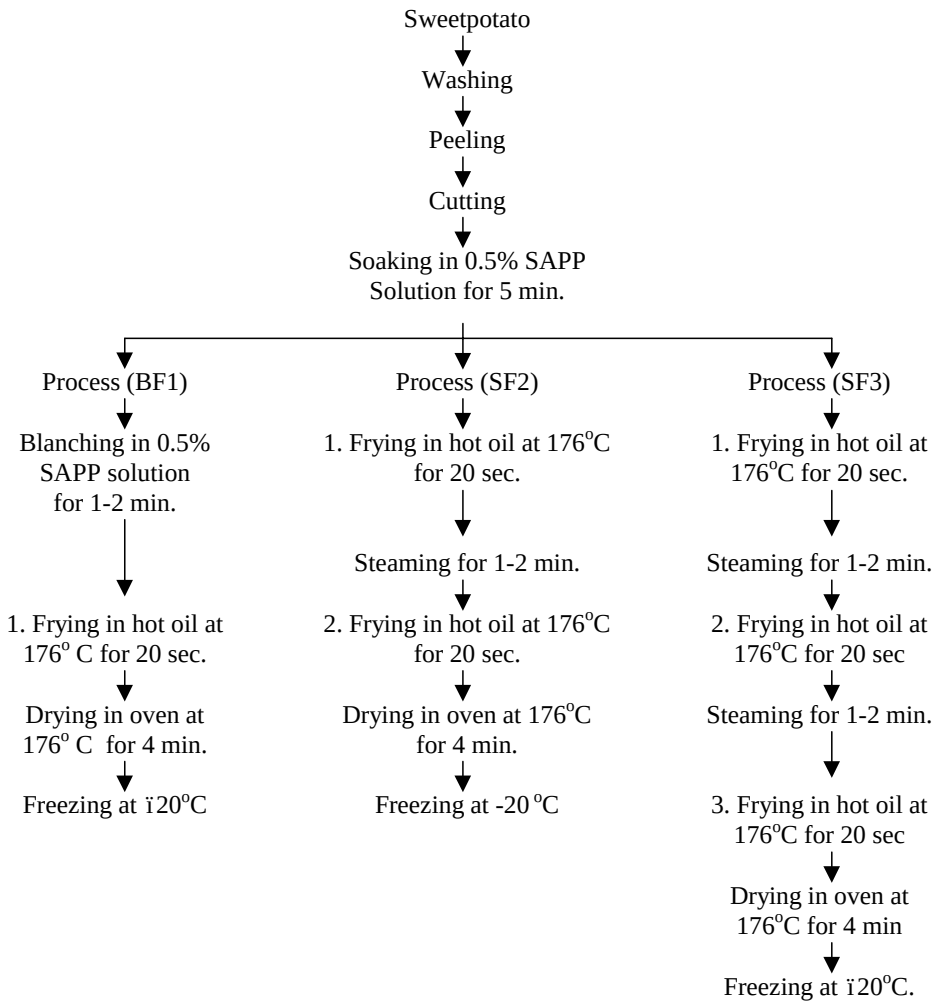

Figure 1 Process of preparing of French-fry type products from sweetpotato.

Sensory evaluation

Sensory evaluations were performed on all finish-fried products. For panel evaluation, the frozen strips were fried at 176°C for 50-150 seconds. The finish-fried products were presented to 10 members of research staff of Institute of Food Research and Product Development. Panels were served coded samples on white plate and were asked to evaluate color, odor, flavor, texture and overall acceptability. Sensory scores were judged with a score range from 1 to 9 on the following scoring system. 1 dislike extremely, 2 dislike very much, 3 dislike moderately, 4 dislike slightly, 5 neither like nor dislike, 6 like slightly, 7 like moderately, 8 like very much, 9 like extremely.

Statistical analyses

The data collected were analyzed by the analysis of variance (ANOVA) using the statistically analysis system (Duncan's Multiples range test).

RESULTS AND DISCUSSION

Process for pre-fried product

Sweetpotato pre-fried products were prepared from various processing treatments. The first process (BF1) comprised only one partial frying steps, under controlled time and temperature conditions, the second process (SF2) had two partial frying steps, the third process (SF3) had three partial frying steps after steaming or blanching step (Figure 1). There were differences in products for dry matter, oil content, reducing sugar, vitamin C, yield, size, weight loss, shear force measurements. These data are presented in Table 1-3. The data from this study indicated that processing treatments affected these properties differently. The overall effect was to reduce the weight of sweetpotato French-fry type product from about 30% to about 47% of the weight of the original strips, and to cause a concentration of solid on the surface for improved surface texture.

Chemical compositional analysis

The data of the composition of pre-fried prodcuts indicated that both samples of pre-fried products produced by steaming and frying in oil 2 and 3 times were higher in reducing sugar than the blanched sample (Table 1). Blanching process used in this study extracted more sugar from the samples. Blanching the sweetpotato strips caused decrease

Table 1 Effect of various processing treatments on dry matter, fat, reducing sugar, vitamin C of sweetpotato French-fry type products.

Processing treatments	Dry matter (g/100 g)	Fat (g/100 g)	Reducing sugar (g/100g)	Reducing sugar (g/100 g d.b)	Vitamin C (mg/100 g d.b)
Fresh sweetpotato	30.34	-	6.31	20.79	63.75
Pre-fried product					
BF 1-66	44.35	9.82	2.10	4.73	50.90
SF 2-66	49.36	13.98	6.00	12.15	40.06
SF 3-66	59.46	18.22	5.30	8.91	30.75
BF 1-88	42.12	7.54	2.14	5.08	52.14
SF 2-88	48.89	11.08	6.10	12.47	36.32
SF 3-88	56.62	14.48	5.60	9.89	29.00
Finish-fried product			Frying time (sec)		
BF1-F66	72.72	26.16	90		9.15
SF2-F66	75.91	24.26	60		8.30
SF3-F66	81.22	25.37	50		6.13
BF1-F88	72.47	31.34	150		10.42
SF2-F88	73.78	24.88	120		8.26
SF3-F88	81.88	23.22	105		6.90

d.b - dry weight basis

Table 2 Effect of various processing treatments on frying time, cross sectional size, yield and weight loss, of pre-fried sweetpotato French-fry type product.

Processing treatments	Size (mm)	Yield (n = 4) (g/100 g w.b.)	Yield (n = 4) (g/100 g d.b.)	Weight loss (n=4) (g/100 g w.b)
Pre-fried product				
BF1-66	5.5 × 5.5	69.26	28.81	30.73
SF2-66	4.5 × 5.5	55.94	29.21	44.06
SF3-66	4.0 × 4.0	52.73	32.99	47.27
BF1-88	7.6 × 7.6	67.44	26.38	32.56
SF2-88	7.4 × 7.2	62.27	29.77	37.73
SF3-88	6.4 × 6.2	58.50	33.12	41.50

w.b. - wet weight basis, d.b - dry weight basis

Table 3 Effect of various processing treatments on color values and shear measurements of sweetpotato French-fry type product.

Processing Treatments	CIELAB SYSTEM L*	a*	b*	C*	h	Shear force (Kg.)
Pre-fried product						
BF 1-66	75.38	-1.45	29.86	29.89	92.79	23.37
SF 2-66	68.60	-0.87	24.65	24.67	92.02	26.87
SF 3-66	67.80	-0.13	27.80	27.80	90.27	28.16
Finish-fried product						
BF1-F66	62.69	1.29	28.53	28.56	87.35	23.32
SF2-F66	59.87	1.22	29.64	29.66	87.65	22.66
SF3-F66	58.57	5.43	24.86	25.44	77.67	24.32
Pre-fried product						
BF1 -88	70.75	-1.24	30.56	30.58	92.32	23.32
SF2 -88	65.74	-1.28	25.65	25.68	92.86	25.12
SF3 -88	63.11	-2.30	24.69	24.80	95.33	26.82
Finish-fried product						
BF1-F88	62.35	-0.95	24.46	24.48	92.22	20.62
SF2-F88	60.15	3.21	25.46	25.66	82.82	22.50
SF3-F88	60.18	2.84	24.85	25.01	83.49	26.25

L* is the lightness a* is the red-green color component b* is the yellow-blue color component
C* is the chroma (saturation) = $(a^{*2} + b^{*2})^{1/2}$ h is the hue angle = arctan (b*/a*)

in dry matter because part of sugars and other water-soluble materials were extracted by the hot water. Pre-fried sweetpotato products of BF1 process had reducing sugar content of 2-3% and also had the lowest oil content in average 7-10 %. Vitamin C content in this product was higher compared to those of the other products (50.90-52.14 mg/100 g dry weight basis), which indicated high nutritious value for BF1 processing product.

Sensory evaluation

The sensory scores for sweetpotato French-fry type product odor, flavor showed no significant difference among types of processing treatments (Table 5 and 6). Panelists scored the odor and flavor of products between slightly like and moderately like. Most panelists score the odor and flavor of products in both sizes processed in BF1 as like moderately, due to the lower content of flavor and reducing sugar (2-3 %). It is likely that when a blanching or water extraction step is used, some of the flavor components will also be extracted. Blanching was effective in lowering the reducing sugar content of sweetpotato strips. The scores for sweetpotato French-fry type product color showed significant difference ($P< 0.05$) among types of process. Panelists scored the color of products between slightly like and very much like. The mean scores of sweetpotato French-fry type product of BF1 process was the highest in color, texture, overall acceptability among other products as shown in Table 5, 6. Toma et al (1986) reported that darker french fried product were produced from potatoes of lower specific gravity because of the higher reducing sugar content. The gray discoloration was thought to be caused by the reaction between o-dihydroxyphenols and iron III (Hoover, 1963) and discoloration is nonenzymatic browning, which results when reducing sugars condense with amino groups (Spark, 1969). The rate of this reaction increased at high temperatures attained in oil frying. The discoloration could be reduced if the o-dihydroxyphenol-Fe III and sugar-amino reaction were minimized.

The L*, a*, b*, C*, h color values are presented in Table 3. Three partial frying steps decreased L* value as indicating a change to a darker product. The L*, a*, b* color values were similar in all pre-fried products of SF2 and SF3 processes. The color of sweetpotato pre-fried products of BF1 process were lighter (higher L* value) than product of SF2 process and SF3 process (Table 4). Frying decreased L* and caused an increase in a* values as anticipated indicating a change to a darker, more red product.

Mean scores for texture and overall acceptability also showed trend toward a maximum at BF1 process. Mean scores for texture and overall acceptability of the best product were rated between moderately like and very much like. The quality of best product maintained crispiness on the exterior, moist mealy interior and golden yellow in color. Product of twice partial frying process (SF2) had crisp slight tough exterior, dry mealy interior and sweet taste. Product of SF3 process had very crisp exterior, darker color, dry tough interior, sweet taste, smallest size under standard size among other products. (Table 2).

Processing treatments affected the shear force of strips (Table 3). Pre-fried and finish-fried strips of the SF3 process were tougher than strips of SF2 process due to surface hardening and moisture loss during processing so it required greater force to shear relative to others.

Pre-fried product stability during storage

Overall acceptability of sweetpotato French-fry type products throughout the one year frozen storage period, were rated between slightly like and very much like in all sensory categories by the panelists. (Table 7).

Mean scores of sensory evalution of

Table 4 Color difference of sweetpotato French-fry type products by comparing to BF1 process.

Processing treatment	CIELAB DIFFERENCE						Explanation of color
	DE*	DL*	Da*	Db*	DC*	DH*	
SF2-66	8.41	-6.58	0.58	-5.21	-5.23	-0.36	Darker, more red, less saturated than BF1-66
SF3-66	7.97	-7.58	1.32	-2.06	-2.10	-1.27	Darker, more red, less saturated than BF1-66
SF2-F66	3.03	-2.82	-0.10	1.11	1.11	0.15	Darker, more green, more saturated than BF1-F66
SF3-F66	6.89	-4.13	4.11	-3.67	-3.11	-4.55	Darker, more red, less saturated than BF1-F66
SF2-88	7.01	-5.01	-0.05	-4.91	-4.90	0.27	Darker, more green, less saturated than BF1-88
SF3-88	9.69	-7.64	-1.07	-5.07	-5.79	1.45	Darker, more green, less saturated than BF1-88
SF2-F88	4.81	-2.21	4.15	1.00	1.08	-4.11	Darker, more red, more saturated than BF1-F88
SF3-F88	4.38	-2.18	3.78	0.39	0.53	-3.77	Darker, more red, more saturated than BF1-F88

CIELAB DIFFERENCE

DL* is the lightness difference

Da* is the red-green color difference

Db* is the yellow-blue color difference

$DE^* = [(DL^*)^2 + (Da^*)^2 + (Db^*)^2]^{1/2}$

$DC^* = [(Da^*)^2 + (Db^*)^2]^{1/2}$

$DH^* = [(DE^*)^2 - (DL^*)^2 - (DC^*)^2]^{1/2}$

Table 5 Mean sensory scores* of French-fry type product (size 6 × 6) of sweetpotatoes subjected to various processing treatments.

Processing treatments	Color	Odor	Flavor	Texture	Overall acceptability
BF1-F66	7.80[a]	7.20[a]	7.20[a]	7.40[a]	7.50[a]
SF2-F66	6.90[b]	7.00[a]	6.70[a]	6.60[b]	6.50[b]
SF3-F66	6.80[b]	7.10[a]	7.00[a]	7.00[ab]	6.95[ab]

* - Hedonic scale where 9-like extremely; 1-dislike extremely (n-10)
- Means followed by the same letter are not significantly different within each column at P<0.05 level.

Table 6 Mean sensory scores* of French-fry type product (size 8 × 8) of sweetpotato subjected to various processing treatments.

Processing treatments	Color	Odor	Flavor	Texture	Overall acceptability
BF1-F88	8.00[a]	7.20[a]	7.40[a]	7.20[a]	7.50[a]
SF2-F88	6.80[b]	6.70[a]	6.80[a]	6.50[b]	6.60[b]
SF3-F88	6.65[b]	6.70[a]	6.70[a]	6.30[b]	6.60[b]

* - Hedonic scale where 9-like extremely; 1-dislike extremely (n-10)
- Means followed by the same letter are not significantly different within each column at P<0.05 level.

Table 7 Effect of different processes on mean sensory scores* of French-fry type product after one year frozen storage period.

Processing treatments	Color	Odor	Flavor	Texture	Overall acceptability
BF1-F66	7.40[a]	7.40[a]	7.33[a]	7.36[a]	7.50[a]
SF2-F66	7.13[a]	6.93[a]	7.06[a]	7.06[a]	7.10[a]
SF3-F66	6.83[a]	6.93[a]	6.86[a]	6.66[a]	6.86[a]

* - Hedonic scale where 9-like extremely; 1-dislike extremely (n-15)
- Means followed by the same letter are not significantly different within each column at P<0.05 level.

sweetpotato french-fry type product were not statistically different (P<0.05). Peroxide values of oil extracted from the pre-fried products were below 10 mEq/kg, indicating not to be affected by the process treatment, and the products had no rancid taste during storage time (Table 8). A rancid taste often begins to be noticeable when PV values is between 20 and 40 mEq/kg (Pearson, 1976).

Table 8 Moisture, oil content, and the peroxide value (mEq/Kg) of oil extraction from sweetpotato pre-fried prodcut after one year frozen storage period.

Pre-fried product	Moisture %	Oil %	Peroxide value (mEq/Kg Fat)
BF1-66	59.36	9.81	7.76
SF2-66	47.33	13.45	7.92
SF3-66	43.99	16.34	7.30

CONCLUSION

Improved process to produce a pre-fried sweetpotato French-fry type product having a low oil content was to blanch sweetpotato strips in hot water at 100°C containing 0.5% SAPP and partially fried in hot oil at 176°C for 1-2 min to give an oil content 7-10%. The sweetpotato strips were frozen and packaged for later finish frying. The quality of product had a crisp, palatable outer surface, golden yellow uniform color, a fluffy interior, enhance flavor and relative low oil perception.

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