



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF A RESTRUCTURED SWEET POTATO FRENCH
FRIES TYPE PRODUCT**

JOKO SUSILO UTOMO

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**DEVELOPMENT OF A RESTRUCTURED
SWEET POTATO FRENCH FRIES TYPE PRODUCT**

By

JOKO SUSILO UTOMO

**Thesis Submitted to the School of Graduate Studies, University Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Doctor Philosophy**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for Doctor of Philosophy

**DEVELOPMENT OF A RESTRUCTURED SWEET POTATO FRENCH
FRIES TYPE PRODUCT**

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JOKO SUSILO UTOMO

July 2009

Chairman : Professor Yaakob B. Che Man, PhD

Faculty : Food Science and Technology

The 17 accessions from UPM collection and 4 commercial cultivars exhibited wide variation in physical and chemical characteristics. Results found that white flesh colour sweet potato showed the lowest hardness and followed by orange, yellow and purple cultivars. Starch content of 17 accessions varied significantly and amylose content of purple group was higher than the others. Yellow flesh group contains the highest fructose followed by orange, white and purple. Gelatinization temperatures for white, yellow, orange and purple were 78, 77, 73, and 72 °C, while the peak viscosity varied from 443 to 621, 510 to 725, 380 to 419 and 691 to 711 BU, respectively. The 17 accessions and 4 cultivars of sweet potato studied exhibit great variation in physical and chemical characteristics.



On the optimizing method for RSS processing, *White* cultivars was chosen as raw material, and processed using the combination of shapes, blanching methods and adding of sweet potato flour. Results showed that chips exhibited a proper shape for blanching compared with dice. Blanching in 1 % STP solution for 2 minutes significantly improved the quality of RSS such as firmness and dry matter content of dough, colour, fat and ash content, and texture. Mixing of 5 % sweet potato flour to the mashed sweet potato produced suitable conditions of the dough for further processing and generated RSS having uniform shape with an intermediate hardness, high lightness and low redness colouration and also the highest value of sensory preferences.

Sweet potato cultivars significantly affected the chemical, physical properties and organoleptic characteristics of RSS. Moisture content of *Orange* fresh tuber was lower than *White* and *Yellow* cultivars, and it generated the lowest moisture content of mashed sweet potato, prefried sticks and fried sticks. *White* cultivar generated the RSS having yellow bright colour, highest value of firmness and low fat content, while *Orange* cultivar produced RSS with bright orange colour, medium firmness but high fat content. RSS made of both varieties were evaluated as acceptable by a sensory panel with sensory score above the average. Recommendation from this study illustrates that *White and Orange* cultivars can be used to make a convenient restructured product.

On the final preparation of RSS, deep frying and heating in microwave oven was evaluated on the texture attributes and sensory preferences of the product. Results

showed that the most suitable condition of producing RSS was by using deep frying for final preparation on RSS made from *White* and *Orange* commercial cultivars as raw material. RSS made from *White* cultivar had hard texture, bright yellow colour and slightly below *like slightly*, while *Orange* RSS had softer texture, bright orange colour and slight above *like slightly*. Deep frying is the preferred method for the final preparation of RSS.

From these findings, one may recommend that RSS can be produced using *White* and *Orange* cultivars. The tubers are peeled, sliced into about 2.3 mm thickness and 25 mm width. Blanching was done by dipping the chip in 1 % (w/v) STP solution at about 100 °C for 2 minutes. The blanched materials were drained for about 3 minutes to remove excess water, and then mashed and CMC was added (0.3 %, w/w) as a binder. The mashed was mixed with 5 % sweet potato flour. Moulding could be done using simple extruder with 10 x 10 mm square holes. The sticks were then deep fried at 163 °C for 1 minute, packaged in plastic bags and frozen at -20 °C for storage purpose until final preparation. The RSS was prepared by deep frying in 175 °C for 2 minutes.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMBANGUNAN PRODUK KELEDEK “FRENCH FRIES” TERSTRUKTUR
SEMULA**

Oleh

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Sebanyak 17 jenis keledak koleksi daripada UPM dan 4 jenis keledak komersial mempunyai sifat fizikal dan kimia yang sangat pelbagai. Keledak putih memiliki kekerasan yang paling terendah dan diikuti dengan jingga, kuning dan ungu. “Chewiness” daripada keledak kukus mempunyai corak yang sama dengan kekerasan. Kandungan kanji daripada 17 varieti adalah berbeza, manakala kandungan amilosa pada keledak ungu adalah lebih tinggi daripada yang lain. Kumpulan keledak kuning mempunyai kandungan fruktosa yang paling tinggi dan diikuti oleh jingga, putih dan ungu. Walau bagaimanapun, kandungan gula iaitu glukosa, sukrosa dan maltosa tidak boleh dikumpulkan berdasarkan warna keledak. Suhu tergelatin bagi keledak putih, kuning, jingga dan ungu adalah masing-masing 78, 77, 73 dan 72 °C, manakala kelikatan puncak adalah dari 443 sampai 621, 510 sampai 725, 380 sampai



419 dan dari 691 sampai 711 BU. Dua puluh satu jenis keledak yang dikaji menunjukkan variasi yang sangat besar pada sifat fizikal dan kimianya.

Untuk mengoptimumkan cara pemprosesan RSS, keledak komersial warna putih (*Putih*) adalah digunakan sebagai bahan mentah, dan diolah menggunakan kombinasi bentuk hirisan keledak, cara mencelur dan penambahan tepung keledak. Hasil ujikaji menunjukkan bahawa “chip” adalah bentuk yang paling sesuai berbanding “dice”. Mencelur di dalam larutan 1 % STP selama 2 minit boleh membaiki kualiti RSS, seumpama kekerasan dan jirim kering doh, warna, kandungan minyak dan abu, serta kekerasan daripada RSS. Pencampuran dengan 5 % tepung keledak menghasilkan doh yang mempunyai keadaan yang sesuai untuk pemprosesan seterusnya dan menghasilkan bentuk RSS yang berbentuk seragam dengan kekerasan yang sederhana, kecerahan yang tinggi dan kemerahan yang rendah, dan nilai kesukaan deria yang paling tinggi.

Pelbagai varieti keledak memberi kesan kepada sifat-sifat fizikal, kimia dan deria RSS. Kandungan air keledak *Oren* adalah lebih rendah daripada *Putih* dan *Kuning*, dan ianya menghasilkan kandungan air yang rendah pada doh, RSS beku dan RSS. Keledak *Putih* menghasilkan RSS dengan warna kuning cerah, nilai kekerasan yang tertinggi, dan kandungan minyak yang rendah, manakala keledak *Oren* menghasilkan warna RSS jingga yang cerah, kekerasan yang sederhana tetapi kandungan minyak yang tinggi. RSS daripada kedua-dua varieti diberi markah diatas purata oleh panel uji deria. Cadangan daripada ujikaji ini menunjukkan bahawa keledak *Putih* dan *Oren* boleh digunakan untuk membuat produk terstruktur semula (RSS) yang disukai.

Pada penyediaan akhir RSS, pemrosesan dilakukan dengan objektif untuk mengujikaji kesan menggoreng dengan minyak penuh dan dipanaskan dalam ketuhar gelombang mikro pada sifat-sifat tekstur dan kesukaan deria bagi produk. Keputusan menunjukkan yang keadaan paling sesuai bagi menyediakan RSS pada kajian ini adalah menggoreng dengan minyak penuh pada RSS yang dibuat dari keledak *Putih* dan *Oren*. RSS yang dibuat daripada keledak *Putih* mempunyai tekstur keras, warna kuning terang dan sedikit di bawah *like slightly*, manakala keledak *Oren* menghasilkan RSS yang mempunyai tekstur lebih lembut, warna jingga cerah dan sedikit di atas *like slightly*. Goreng minyak penuh adalah cara yang dipilih untuk penyediaan akhir RSS.

Daripada hasil yang diperolehi, adalah disyorkan yang RSS dapat dihasilkan menggunakan keledak *Putih* dan *Oren*. Pemrosesannya adalah ubi dikupas, dihiris dengan ketebalan sekitar 2.3 mm dan 25 mm lebar. Celur dilakukan dengan mencelupkan cip pada larutan 1 % (w/w) STP pada kira-kira 100 °C selama 2 minit. Cip yang telah dicelur ditus selama sekitar 3 minit bagi membuang lebihan air, dan kemudian dilumatkan dan dibubuh CMC (0.3 %, w/w) sebagai satu penambat. Keledak yang telah dilumatkan dicampur dengan tepung keledak sebanyak 5 %. Mencetak boleh dilakukan dengan penyemprit ringkas yang mempunyai lubang persegi bersize 10 x 10 mm. Stik kemudiannya digoreng pada 163 °C untuk 1 minit, dibungkus dalam beg plastik dan disejuk beku pada -20 °C untuk tujuan storan sehingga penyediaan terakhir. RSS disediakan dengan goreng minyak penuh pada 175 °C selama 2 minit.



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I certify that a Thesis Examination Committee has met on 14 July 2009 to conduct the final examination of Joko Susilo Utomo on his thesis entitle: “Development of a Restructured Sweet Potato French Fries Type Product” in accordance with the Universities and University colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

I hereby declare that this thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or any other institution.

JOKO SUSILO UTOMO

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	v
ACKNOWLEDGEMENTS	viii
APPROVAL	x
DECLARATION	xii
LIST OF TABLES	xvii
LIST OF FIGURES	xix
LIST OF ABBREVIATION	xxi
CHAPTER	
1 INTRODUCTION	1
2 LITERATURE REVIEW	5
2.1 Production and consumption, and general characteristics of sweet potato	5
2.2 Chemical composition and physicochemical properties	13
2.2.1 Carbohydrates	13
2.2.2 Nitrogenous constituent	22
2.2.3 Lipids	26
2.2.4 Vitamins	28
2.2.5 Minerals	32
2.2.6 Non-starch polysaccharides	36
2.2.7 Carotenoid	38
2.2.8 Anthocyanins	41
2.2.9 Polyphenolics	42
2.2.10 Enzymes	43
2.3 Sweet potato food products	46
2.3.1 Baked sweet potato	47
2.3.2 Cooked sweet potato (boiled and steamed)	50
2.3.3 Fried sweet potato	52
2.3.4 Dehydrated sweet potato products	55
2.3.5 Restructured products	59
2.3.6 Other products	61
3 THE PHYSICAL AND CHEMICAL CHARACTERIZATION OF 17 ACCESSIONS AND 4 SWEET POTATO CULTIVARS	65
3.1 Introduction	65
3.2 Materials and methods	67
3.2.1 Materials	67



3.2.2	Sample preparation	68
3.2.3	Moisture content	69
3.2.4	Texture analysis	69
3.2.5	Starch pasting properties analysis	70
3.2.6	Starch and amylose analysis	71
3.2.7	Sugar analysis	72
3.2.8	Statistical analysis	73
3.3	Results and discussion	74
3.3.1	Moisture content	78
3.3.2	Textural characteristics	82
3.3.3	Starch pasting properties	88
3.3.4	Starch and amylose content	94
3.3.5	Sugar Content	96
3.4	Conclusions	100
4	THE EFFECT OF STEAMING TIME ON THE TEXTURAL CHARACTERISTICS OF CYLINDRICAL SWEET POTATO SAMPLES	102
4.1	Introduction	102
4.2	Materials and methods	103
4.2.1	Materials	103
4.2.2	Sample preparation	104
4.2.3	Moisture content	104
4.2.4	Texture analysis	105
4.2.5	Statistical analysis	106
4.3	Results and discussion	106
4.3.1	Moisture content	106
4.3.2	Peak force deformation of fresh sweet potato tubers	109
4.3.3	Peak force deformation of steamed sweet potato tubers	110
4.3.4	Texture profile characteristics	114
4.4	Conclusions	119
5	THE EFFECT OF SHAPE, BLANCHING METHODS AND FLOUR ON CHARACTERISTICS OF A RESTRUCTURED SWEET POTATO STICK	120
5.1	Introduction	120
5.2	Materials and methods	122
5.2.1	Materials	122
5.2.2	Preparation of restructured sweet potato sticks (RSS)	123
5.2.3	Physical characteristics	124
5.2.4	Proximate analysis	125
5.2.5	Sensory analysis	127
5.2.6	Statistical analysis	127



5.3	Results and discussion	128
5.3.1	Physical characteristics of dough	128
5.3.2	Physical characteristics of RSS	131
5.3.3	Chemical composition of RSS	134
5.3.4	Sensory properties	138
5.3.5	Correlation among parameters	141
5.4	Conclusions	143
6	THE PHYSICAL AND CHEMICAL PROPERTIES OF A RESTRUCTURED SWEET POTATO STICK FROM THREE SWEETPOTATO CULTIVARS	
		144
6.1	Introduction	144
6.2	Materials and methods	145
6.2.1	Materials	145
6.2.2	Preparation of restructured sweet potato sticks (RSS)	146
6.2.3	Physicochemical characteristics of 3 sweet potato cultivars	146
6.2.4	Physical characteristics of fried RSS	147
6.2.5	Chemical characteristics of dough and fried RSS	149
6.2.6	Sensory analysis	149
6.2.7	Statistical analysis	150
6.3	Results and discussion	150
6.3.1	Physicochemical characteristics of 3 sweet potato cultivars	150
6.3.2	Moisture content changes	156
6.3.3	Physicochemical characteristics of RSS	158
6.3.4	Sensory properties	165
6.4	Conclusions	167
7	THE EFFECT OF PREPARING METHODS ON SENSORY PREFERENCES OF A RESTRUCTURED SWEET POTATO STICK	
		168
7.1	Introduction	168
7.2	Materials and methods	170
7.2.1	Materials	170
7.2.2	Preparation of restructured sweet potato sticks (RSS)	171
7.2.3	Physical characteristics	171
7.2.4	Sensory analysis	172
7.2.5	Statistical analysis	172
7.3	Results and discussion	173
7.3.1	Textural characteristics of RSS	173
7.3.2	Colour attributes of RSS	177
7.3.3	Sensory properties	181
7.4	Conclusions	186



8	GENERAL CONCLUSIONS AND RECOMENDATIONS	187
8.1	General conclusions	187
8.2	Recommendations	194
	REFERENCES	196
	APPENDICES	222
	BIODATA OF THE STUDENT	228
	LIST OF PUBLICATIONS	229



LIST OF TABLES

Table		Page
1	Sweet potato production and use as food in the world and developing countries.	8
2	Mineral composition of South Pacific sweet potato roots (mg/100 g, fwb)	33
3	Moisture content of sweet potato (fresh and steamed) tuber from 17 accessions and 4 cultivars	80
4	Correlation coefficient (r) of moisture, starch, amylose content and texture profile characteristics of 17 accessions and 4 sweet potato cultivar	81
5	Textural Characteristics of 17 accessions and 4 sweet potato cultivars	85
6	Starch pasting properties of 17 accessions and 4 sweet potato cultivars	92
7	Starch and amylose content of 17 accessions and 4 sweet potato cultivars	95
8	Sugar content of fresh sweet potato tubers from 17 accessions and 4 cultivars	99
9	Texture profile characteristics of 2 commercial sweet potato cultivars	111
10	Effect of experimental factors on firmness and dry matter of dough	129
11	Effect of experimental factors on Hardness, Hunter L , a and b value of fried RSS	132
12	Effect of experimental factors on proximate composition (% w/w) of fried RSS	136
13	Sensory scores ¹ for colour, texture and overall acceptability of RSS made using combination 3 factor of preparation	139
14	Correlation coefficients (r) between parameters measured of dough and RSS	142



15	Moisture content of 3 sweet potato commercial cultivars	151
16	Starch content of fresh tuber and amylose content of starch 3 cultivars	152
17	Texture Profile Characteristics of 3 SP commercial cultivars	153
18	Physical characteristics of dough made from 3 cultivars	158
19	Physical characteristics of RSS made from 3 cultivars	159
20	The colour of RSS made from 3 cultivars	161
21	Chemical characteristics of RSS made from 3 cultivars	164
22	Sensory scores ¹ for colour, texture, flavour and overall acceptability of RSS made from 3 cultivars	166
23	Textural characteristics and moisture content of RSS prepared by deep frying and baking in microwave oven	175
24	Colour value of RSS made from 3 cultivars prepared using two methods.	179
25	Sensory scores ¹ for colour, texture, flavour and overall acceptability of RSS made of 3 cultivars with 2 methods of preparation	182



LIST OF FIGURES

FIGURE		Page
1	Evolution of annual per capita consumption of fresh sweet potato root in China, Asia, Developing countries and the World for 1995 – 1999.	10
2	White flesh colour group of sweet potato tubers	75
3	Yellow flesh colour group of sweet potato tubers	76
4	Orange flesh colour group of sweet potato tubers	77
5	Purple flesh colour group of sweet potato tubers	78
6	Typical chromatogram of sugar separation in fresh sweet potato tubers. Very first Peak = Acetonitrile-water solvent, Peak 1=Fructose, Peak 2=Glucose, Peak 3=Sucrose and Peak 4=Maltose. MV = milivolt	97
7	Changes of moisture content of <i>White</i> and <i>Yellow</i> cultivars during steaming at 100 °C, atmospheric pressure for 0, 5, 10, 15 and 20 minutes.	107
8	Force deformation curve of uniaxial compression test for fresh tubers of <i>White</i> and <i>Yellow</i> cultivars.	109
9	Force-deformation curves of uniaxial compression test of <i>White</i> cultivar for 4 duration steaming time	112
10	Force-deformation curves of uniaxial compression test of <i>Yellow</i> cultivar for 4 duration steaming time	113
11	Changes of hardness of <i>White</i> and <i>Yellow</i> cultivars during steaming at 100 °C, atmospheric pressure for 0, 5, 10, 15 and 20 minutes.	115
12	Changes of adhesiveness of <i>White</i> and <i>Yellow</i> cultivars during steaming at 100 °C, atmospheric pressure for 0, 5, 10, 15 and 20 minutes.	116
13	Changes of springiness of <i>White</i> and <i>Yellow</i> cultivars during steaming at 100 °C, atmospheric pressure for 0, 5, 10, 15 and 20 minutes.	117
14	Changes of chewiness of <i>White</i> and <i>Yellow</i> cultivars during	



	steaming at 100 °C, atmospheric pressure for 0, 5, 10, 15 and 20 minutes.	118
15	Colour of chips and cubes of <i>White</i> sweet potato tuber before and after blanching in water or STP solution	134
16	TPA curves of <i>White</i> , <i>Yellow</i> and <i>Orange</i> cultivars	152
17	Correlation between hardness and starch content for combination of 3 commercial cultivars	154
18	Correlation between springiness and amylose content for combination of 3 commercial cultivars	155
19	Moisture content changes during RSS processing	156
20	Frozen and fried RSS made from <i>White</i> , <i>Yellow</i> and <i>Orange</i> sweet potato cultivars.	163
21	Cutting-shear test curve of restructured sweet potato stick made from three cultivars and prepared using two methods of cooking. (1 = <i>White</i> RSS-deep fried, 2 = <i>Yellow</i> RSS-deep fried, 3 = <i>Orange</i> RSS-deep fried, 4 = <i>White</i> RSS-microwave oven, 5 = <i>Yellow</i> RSS-microwave oven, 6 = <i>Orange</i> RSS-microwave oven)	174
22	RSS made of 3 cultivars prepared using deep frying and baking in microwave oven.	180
23	Correlation between colour preference with <i>a</i> and <i>b</i> values of RSS made from 3 cultivars and prepared using 2 methods	183
24	Correlation between texture preference with cohesiveness and chewiness of RSS made from 3 cultivars and prepared using 2 methods	185

LIST OF ABBREVIATION

ANOVA	analysis of variance
BU	brabender unit
BV	brabender viscograph
CMC	carboxy methyl cellulose
fwb	fresh weight bases
HPLC	high performance liquid chromatography
IU	international unit
N	newton
NPN	non-protein nitrogen
Ns	newton-second
P	probability
RSS	restructured sweetpotato stick
sd	standard deviation
SP	sweet potato
STP	sodium triphosphate
TPA	texture profile analysis
USRDA	United State Recommended Dietary Allowances
var	variant
v/v	volume per volume
w/v	weight per volume
w/w	weight per weight



CHAPTER 1

INTRODUCTION

Sweet potato, *Ipomoea batatas* Lam., is a dicotyledonous plant belonging to the *Convolvulaceae* family, in which there are approximately 50 genera and over 1,000 species (Woolfe, 1992). Its origin is probably from Central or Tropical America (Engel, 1970, O'Brien, 1972, Austin, 1977, Yen, 1982). Sweet potatoes are mostly grown in developing countries, which account for over 99 % of world output. Over 90 % of the production in developing countries is in Asia, especially in China producing about 86 % of the total world production. The rest was under 5 % in Africa; and about 5 % in all the rest of the world such as North, Central and South America; Oceania and Europe; and only about 2 % of the world's sweet potatoes are grown in industrial countries, mainly in United States and Japan. It has been estimated that sweet potato production in developing countries was about 130 million metric tonnes per annum, representing 34 % of all roots and tubers cultivated in these regions. The fluctuation of sweet potato production occurred significantly. World sweet potato production increased by 50 % from 1961 to 1973 and then decline to about 15 %. Over the last quarter of a century, production has fallen sharply in industrial country; however, in Latin America sweet potato production rose in the 1960s, but then fell to about 80 % of its initial level. The declining of sweet potato production followed a similar but less pronounced trend as occurred in Asia. The only world region that sweet potato production increased throughout the period is Africa (FAO, 1990).



The parts of the sweet potato used for food are roots and leaves or tips. Only these parts are relevant to the use of sweet potato as food, from the point of nutrition, quality or food processing. In common with other roots and tubers, sweet potato has high moisture content, resulting in relatively low dry matter content. The average of dry matter content is approximately 30 %, but varies very widely depending on factors cultivar, location, climate, day length, soil type, incidence of pest and diseases, and cultivation practices (Bradbury & Holloway, 1988b). Approximately 80 - 90 % of sweet potato dry matter (24 – 27 % fresh weight) is made of carbohydrates, which consist mainly of starch and sugars, with lesser amount of pectin, hemicelluloses and celluloses (Woolfe, 1992). The relative carbohydrate composition varies not only with cultivars and maturity of the tubers, but also with storage time and cooking or processing, and has considerable influence on quality factors such as texture, including firmness, dryness, mouthfeel, and taste. It is well known that sweet potato is not only a source of energy, but also an excellent source of vitamins, certain other minerals, dietary fiber and some protein (Edmond & Ammerman, 1978, Lanier & Sistrunk, 1979, Picha, 1985).

Despite these general nutritional excellences, the sweet potato is not a popular food item. Sweet potato can be boiled, steamed, baked, fried, chipped, candied, canned, frozen, made into flour and starch or processed into a number of products. However, it seems that presently sweet potato is underexploited as a direct human food. In some traditional sweet potato growing areas, production is decreasing as food consumption patterns change to imported cereal-based food. Attempts to expand the marketability of sweet potatoes have focus on processed products,



such as fries, chips and leathers (Hoover & Miller, 1973, Walter & Hoover, 1986, Collins & Washam-Hutsell, 1987, Schwartz *et al.*, 1987). Hence, the increase of sweet potato consumption can be achieved by convincing people of its nutritional goodness, as well as palatability, so that they will prefer it to foods of lower nutritional value (Che Man, 1996).

One of the fried products from sweet potato is French fry-type product or strip or stick that is popular in United States, but is not well expanded in developing countries. Difficulty in controlling textural properties affecting the quality of sweet potato French fry-type product is the major reason for the scarcity of such product available in the market. Texture is mainly formed by the interaction between the raw material characteristics and the method of processing. From the raw material point of view, the difficulties arise due to the variation of sweet potato cultivars and its characteristics. To solve the inadequacy of sweet potato French fry-type to be produced from the regular roots, restructuring is an attempt to control the textural properties and to get the uniform quality of sweet potato stick. Method of processing is a critical stage which needs to be studied for producing desirable products. Many reports have described several pureed sweet potato products, however, no information of the use of blanching method for preparing restructured sweet potato French fry product. Blanching is a heating process subjected to control firmness of some agriculture commodity such as vegetables and fruits (Fuchigami *et al.*, 1995, Stanley *et al.*, 1995, Jackson *et al.*, 1996, Howard *et al.*, 1997). However, such information on sweet potato is limited. High temperature blanching disrupts cell integrity and cell adhesion, resulting in softening in sweet potato tissue. Beside that, browning which occurred when

