UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A RESTRUCTURED SWEET POTATO FRENCH FRIES TYPE PRODUCT

JOKO SUSILO UTOMO

FSTM 2009 14

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

July 2009

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

By

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

JOKO SUSILO UTOMO

Julai 2009

Pengerusi : Professor Yaakob B. Che Man, Ph. D

Fakulti : Sains dan Teknologi Makanan

Sebanyak 17 jenis keledek koleksi daripada UPM dan 4 jenis keledek komersial mempunyai sifat fizikal dan kimia yang sangat pelbagi. Keledek putih memiliki kekerasan yang paling terendah dan diikuti dengan jingga, kuning dan ungu. "Chewiness" daripada keledek kukus mempunyai corak yang sama dengan kekerasan. Kandungan kanji daripada 17 varieti adalah berbeza, manakala kandungan amilosa pada keledek ungu adalah lebih tinggi daripada yang lain. Kumpulan keledek kuning mempunyai kandungan fruktosa yang paling tinggi dan diikuti oleh jingga, putih dan ungu. Walau bagaimana, kandungan gula iaitu glukosa, sukrosa dan maltosa tidak boleh dikumpulkan berdasarkan warna keledek. Suhu tergelatin bagi keledek 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 keledek yang dikaji menunjukkan variasi yang sangat besar pada sifat fizikal dan kimianya.

Untuk mengoptimumkan cara pemprosesan RSS, keledek komersial warna putih (*Putih*) adalah digunakan sebagai bahan mentah, dan diolah menggunakan kombinasi bentuk hirisan keledek, cara mencelur dan penambahan tepung keledek. 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 keledek 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.

Pelbagi varieti keledek memberi kesan kepada sifat-sifat fisikal, kimia dan deria RSS. Kandungan air keledek *Oren* adalah lebih rendah daripada *Putih* dan *Kuning*, dan ianya menghasilkan kandungan air yang rendah pada doh, RSS beku dan RSS. Keledek *Putih* menghasilkan RSS dengan warna kuning cerah, nilai kekerasan yang tertinggi, dan kandungan minyak yang rendah, manakala keledek *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 keledek *Putih* dan *Oren* boleh digunakan untuk membuat produk terstruktur semula (RSS) yang disukai.

Pada penyediaan akhir RSS, pemprosesan 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 minuak penuh pada RSS yang dibuat dari keledek *Putih* dan *Oren.* RSS yang dibuat daripada keledek *Putih* mempunyai tekstur keras, warna kuning terang dan sedikit di bawah *like slightly*, manakala keledek *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 keledek *Putih* dan *Oren*. Pemprosesannya 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. Keledek yang telah dilumatkan dicampur dengan tepung keledek 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.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Prof. Dr. Yaakob B. Che Man for his supervision, constructive criticisms, and his invaluable guidance and encouragement throughout my study and preparation of this thesis.

My sincere thanks are also addressed to my supervisory committee members, Prof. Dr. Russly Abdul Rahman, and Assoc. Prof. Dr. Mohd. Said Saad, for their advice and encouragement during my study and preparation of this thesis.

I am grateful to the Ministry of Agriculture of the Government of Indonesia, the Director of Agency for Agriculture Research and Development (AARD), the Head of Committee Of Human Resources, Project leader of Participatory Development of Agricultural Technology Project (PAATP), and also the Director of Indonesia Legume and Tuber Crops Research Institute (ILETRI) for the opportunity and scholarship to pursue a postgraduate program for doctoral degree at Universiti Putra Malaysia.

I would also like to express my deepest thanks to my beloved wife Dyah Mustika and my daughters Amalia Ratnaputri Utomo and Azmi Kusumastuti Utomo for their encouragement, patience, moral support and endless praying during the period of my study. Also to my mother who taught me to look for the good in the worst of us, and to my father (in memory) who warned me to beware of the bad in the best of us. Last

but not least, to my father and mother (in memory) in law for their moral support and endless praying during the period of my study.

Above all, Alhamdulillah, be praised to Allah swt, the most beneficent, the most gracious and merciful who give me physical and psychological strength and comfort to successfully complete my studies.

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.

Members for Thesis Examination Committee were as follows:

Mohd. Yazid Abdul Manap, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Sharifah Kharidah Syed Muhammad, PhD
Associate Professor
Department of Food Science
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Internal Examiner)

Roselina Karim, PhD
Lecturer
Department of Food Technology
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Internal Examiner)

Abdul Karim Alias, PhD
Professor
Department of Food Technology
Industrial Technology Research Centre
Universiti Sains Malaysia
11800 USM Minden
Pulau Pinang
(External Examiner)

BUJANG KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 27 August 2009

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of requirement for the degree of Doctor of Philosophy.
The members of the Supervisory Committee were as follows:

Yaakob B. Che Man, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Russly Abdul Rahman, PhD
Professor
Faculty of Food Science and Technology/Faculty of Engineering
Universiti Putra Malaysia
(Member)

Mohd. Said Saad, PhD.
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 11 September 2009

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

Date: 1 September 2009

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 trypolyphosphate
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