EFFECTS OF PRE TREATMENTS ON TAPIOCA CHIPS

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ABSTRACT

EFFECTS OF PRE TREATMENTS ON TAPIOCA CHIPS

The aims of this study were to determine the effects of pre treatments on the tapioca chips' quality, to improve the tapioca chips quality and to know the sensory acceptance towards the tapioca chips produced. Sensory evaluation (Ranking test) was conducted to determine the most preferred sample from 3 sessions and 40 semi-trained panels were subjected to this test. There were 5 samples in each session and in each sessions, the overall acceptance sample's pre treatment condition were chosen out to be fitted into the next pre treatment session. The data were analyzed statically using SPSS Version 11.0 program. For comparison, the results obtained were analyzed using one-way analysis variance with the application of Tukey test ($P \leq 0.05$). Steaming was started as the first pre treatment to produce tapioca chips. From the sensory acceptance result, tapioca chips' produced after steaming for 2.5 min and fried at 170°C, 100 sec are most preferred sample. Then this steaming condition was fitted in to the next pre treatment session. The following session were steaming and leaching out the tapioca slices' reducing sugar in water. The sensory acceptance result indicated that the panel preferred the tapioca chips which have been steamed for 2.5 min, leached out tapioca slices' reducing sugar in 70°C water for 3 min and fried at 170°C, 100 sec. The last session were steaming, leaching out reducing sugar and drying. In this session, the best tapioca chips produced were treated with steaming for 2.5 min, steeping in water at 70°C, 3 min; drying at 50°C, 10 min and frying at 170°C, 100 sec. There has been a significant difference with confidence degree at level of ($P<0.05$) in the sensory test for the fried tapioca slices after steaming, steaming and leaching out reducing sugar; and steaming, leaching out reducing sugar and drying pretreatment. This sample was then being compared with the local commercial potato chips in terms of its sensory acceptance, texture, oil uptake and moisture content. In term of the sensory acceptance, there was no significant differences ($P>0.05$) between the tapioca chips produced with the commercial potato chips. There has been a positive outcome as the panel highly accepted the tapioca chips produced when compared with these potato chips. However, the physicochemical analysis's result, shown that there was a significant difference ($P<0.05$) in terms of the texture and the oil uptake of the tapioca chips produced with the potato chips in the market. This showed that the tapioca chips that were produced were similar to commercial potato chips in term of its sensory acceptance has successfully produced but need to improve its texture.

ABSTRAK

KESAN PRA RAWATAN KE ATAS CIP UBI KAYU

Projek penyelidikan ini bertujuan untuk mengetahui kesan daripada rawatan terhadap cip ubi kayu yang dihasilkan selain daripada cubaan untuk menghasilkan cip ubi kayu yang seakan dengan cip ubi kentang dimana produk baru ini dapat menggantikan cip ubi kentang yang ada di dalam pasaran. Dalam projek penyelidikan ini, pengkajian terhadap tahap penerimaan pengguna terhadap cip ubi kayu juga dijalankan. Justerus itu, satu proses penghasilan cip ubi kayu yang terbaik telah dibangunkan. Ujian pemeringkatan (Ranking test) telah dijalankan untuk memilih sampel yang paling digemari daripada 3 sesi dan 40 separa terlatih panel telah digunakan. Dalam setiap sesi terdapat 5 sampel dan hanya satu sampel dipilih keluar untuk dimuatkan ke dalam sesi pemprosesan seterusnya. Pemilihan berdasarkan penerimaan keseluruhan oleh panel. Untuk perbandingan, keputusan yang diperolehi dianalysis menggunakan ujian 'One-way ANOVA' dan ujian 'Turkey' yang ada pada perisian SPSS versi 11.0. Proses penghasilan cip ubi kayu dimulakan dengan kaedah stim. Berdasarkan keputusan, cip ubi kayu yang paling digemari adalah dihasilkan selepas kepingan ubi kayu distim selama 2.5 min dan digoreng pada 170°C selama 100 saat. Sesi seterusnya ialah stim dan penceluran. Keputusan penerimaan sensori menunjukkan bahawa panel paling menyukai sampel yang telah melalui rawatan stim selama 2.5 min, penceluran pada 70°C selama 3 min dan digoreng pada 170°C selama 100 saat. Sesi terakhir ialah kaedah stim, penceluran dan pengeringan. Dalam sesi ini, sampel cip ubi kayu yang paling digemari akan diperolehi dan berdasarkan keputusan, cip ubi kayu yang terbaik adalah dihasilkan selepas rawatan stim selama 2.5 min, dicelur pada 70°C selama 3 min, dikeringkan pada 50°C selama 10 min dan digoreng pada 170°C selama 100 s. Terdapat perbezaan signifikan bagi ujian sensori pada darjah keyakinan ($P< 0.05$) pada cip ubi kayu yang telah melalui proses stim, penceluran dan pengeringan. Dikajikan. Sampel ini kemudiannya dibandingkan dengan cip ubi kentang yang ada dalam pasaran tempatan dari segi penerimaan sensori, tekstur, pengambilan minyak dan kandungan air. Berdasarkan ujian sensori, didapati tiada perbezaan ($P>0.05$) yang signifikan antara cip ubi kayu yang dihasilkan dengan cip ubi kentang yang ada dalam pasaran. Produk ini mendapat sambutan yang menggalakkan dimana panel amat menyukai cip ubi kayu yang dihasilkan apabila ia dibandingkan dengan cip ubi kentang yang ada di dalam pasaran. Walaubagaimanapun, daripada keputusan ujian fizikokimia, terdapat perbezaan yang signifikan ($P<0.05$) dari segi tekstur dan pengambilan minyak cip ubi kayu dan ubi kentang yang ada di pasaran. Maka, cip ubi kayu yang seakan dengan cip ubi kentang yang ada dalam pasaran telah berjaya dihasilkan tetapi teksturnya perlulah diperbaguskan.

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LIST OF SYMBOLS

^{o}C	= Degree Celcius
%	= Percentage
cm	= centimeter
mm	= millimeter
Kg	= kilogram
Kcal	= kilo calorie
mg	= milligram
N	= Newton
μm	= micrometer
g	= gram
ml	= milliliter
MSG	Monosodium glutamate
NACl	Sodium chloride
&	and
MT	Million tones
He	Hectare
MARDI	Malaysia Agriculture Research and Development Institute
ARC	Agriculture Research Center
min	minute
sec	second
Nmm	Newton milliliter
HCN	cyanogenic glucoside

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CHAPTER 1

INTRODUCTION

With much changes in the eating habits of the population coupled with industrial food processing and marketing needs have directed research attention toward products based on cassava in Malaysia. Cassava (*Manihot esculenta Crantz*) or better known as tapioca in Malaysia is probably the most important food crop in tropical and sub-tropical regions. It ranks forth after rice, wheat and corn as source of complex food energy (FAO, 2002). In year 2002, the total value of production of cassava planted in Malaysia was RM18,484.6 million from 2,440.74 ha production area (Department of Agriculture Malaysia, 2002). This shown that tapioca is one of the cash crop in Malaysia. According to Flach & Rumawas (1996), cassava has the second highest energy content after sugar cane. In Asia, over 40% of the cassava produced is for direct human consumption, with much of the remainder exported as chips and pellet (FAO, 1999).

There are many ways of preparing tapioca for consumption such as steaming (tart), frying (chip), boiling, roasted or turn into intermediate products such as flour, gari (in Africa), and starch. Cassava is a cheap source of calories and often supplements insufficient rice supplies. According to FAO (1999), the major tapioca consumers are concentrated in India and Indonesia. There are two types of cassava recognized 'bitter' and 'sweet' (Stephens, 1994). The classification of tapioca is according to the cyanogenic glucoside content. Referring to O'Hair (1995), the sweet cultivar can produce as little as

20mg of HCN per kg of fresh roots, while bitter ones may produce more than 50 times as much.

There are many varieties of tapioca which is planted but not all are suitable to be processed or consumed. Tapioca which is normally being processed and eaten in Malaysia are '*Sri Pontian*', '*Mentega*', '*Medan*' and '*Perintis*'. Black Twig variety is not suitable to be eaten but only can be process into starch (MARDI, 2005). Tapioca roots are prepared much like potato; peeled and boiled, baked or fried. Although the cyanogenic glucosides content in tapioca can be reduced to innocuous levels through cooking however it is not recommended to consume tapioca in raw form (Flach & Rumawas, 1996).

Tapioca is not a staple food in Malaysia except in times of emergency when rice is short. Starch from tapioca is used in both food and non-food industry (MSG, dextrin, textile and paper industries). The largest commercial uses of tapioca are the monosodium glutamate (MSG). There were also production of tapioca-based products such as alcohol and starch-based sweetener, example high fructose glucose syrup (HFGS) (Tan & Cock, 1979; Vuilleumier, 1993; Pontoh & Low, 1995). While for human consumption, only a very small portion was used. The usage of tapioca in human direct consumption in Malaysia is mainly for traditional snack food production (tuber or roots) and dishes makes from the leaves. Examples of these snacks are cake, tart, *lopes*, *talam*, pudding, and tapai which is a popular type of fermented tapioca.

According to Sajilata (2005), snack such as tapioca chip is a light meal eaten between regular meals. Snack is one of the most popular processed foods (Aminlari, Ramezani, & Khalili, 2005). Snack food industry in Malaysia is growing due to the high demand from the consumers. Potato chip is a very popular salty snack for 150 years and it represents 33% of total sales of snack in the US Market (Garayo & Moreira, 2002). Vitrac *et al.* (2000), reported that there might be a suitable potato chip substitutes found among tropical roots, tubers and plantain. Therefore in order to open a new market, new uses of cassava are being sought.

Frying is one of the oldest and most popular cooking methods in existence. Large amounts of food are simultaneously dried and cooked by deep-fat-frying. Deep frying or immersion frying has defined as the immersion of food product in an edible fat heated above the boiling point of water (Hubbard & Farkas, 1999) and may therefore, be considered a dehydration process. These conditions lead to high heat transfer rates, rapid cooking, browning, textures and flavor development (Farkas, Singh & Rumsey, 1996). High heat transfer rates are largely responsible for the development of desired and undesired sensorial properties in fried foods. Frying can create a unique flavor, color and textures in processed foods that improve its palatability.

Nowadays the health awareness between the consumers had increased. They tend to look for healthier snack which are consist of lower fat content. Due to public health concern, there is a strong demand to reduce the oil content of fried foods (Moreira & Barrufet, 1999). Several studies have been done to create a new product that can suit the current trend of consumers and at the same time retaining the desirable texture and flavor (Garayo & Moreira, 2002) in fried food products to reduce the oil uptake such as using edible coating from cellulose derivatives in deep-fat frying carrot slices (Garcia *et al.*, 2002; Akdeniz, Sahin & Sumnu, 2006) and protein based coating which derives from plants or animal sources, collagen or milk protein in potato chips (Aminlari, Ramezani, & Khalili, 2005); improving texture, color and reduce oil uptake by blanching with hydrocolloid addition in fried potato strips (Rimac-Brncic, 2004); NaCl soaking treatment in french-fried potatoes (Bunger, Moyano & Rioseco, 2003) and drying (Moyano & Pedreschi, 2006).

The hard texture of tapioca is the main technical problem while producing tapioca chips. Therefore it is logical to make the tapioca softer by treatments which loosen the intercellular pectic substances via cell liberation in order to produce chip which is crispy. According to Kita (2002) the texture of potato crisp is depends on the starch contents, non-starch polysaccharide, lignin and protein nitrogen of the potato tubers. Therefore is makes sense that the texture of tapioca chips is also connected to the dry matter content of the raw cassava tuber. Among non-starch polysaccharide that have the most impact on influencing the chips texture, is protopectins (Kita, 2002). Vitrac *et al.* (2002) have proven that color, texture and final oil uptake of cassava chips were primarily related to the frying conditions. According to Vitrac *et al.* (2000), the required characteristics of chips (final moisture content, browning and texture) are the result of both raw material properties (moisture, cyanide, starch, sugar, reducing sugar and crops age) and it processing.

Many studies about cassava to be processed into food have been carried out (Edijala, Okoh, Anigoro, 1999; Kimaryo *et al.* 2000; Kostinek *et al.* 2005; Vitrac *et al*, 2002; Oboh & Akindahunsi, 2003). Grizotto & Menezes (2002), have highlighted the effect of using heat pretreatment (cooking) on crispness of cassava chips. However, none of these studies have reported the effect of pretreatments oil content and color of cassava chips. Therefore the study was needed to be carried out to determine the effect of the pretreatment on the quality of tapioca chip as a snack. From this study, a tapioca chips processing can be developed to improve the quality of tapioca chips.

The specific objectives of the study were:

1. To determine the effect of steaming, leaching out the reducing sugar by steeping in water and drying on the organoleptic and physicochemical properties of tapioca chips
2. To develop suitable tapioca chips process to produce crispier, lower oil uptake and better color's tapioca chips.
3. To compare the physicochemical and organoleptic properties of tapioca chips produced with the potato chips in the market.

CHAPTER 2

LITERATURE REVIEW

2.1 Tapioca

Cassava or known as tapioca in Malaysia, falls within the species *Manihot esculenta Crantz* which belong to the family of *Euphorbiaceae*, is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world (Flach & Rumawas, 1996). Tapioca is a well known crop that is recognized by several names in different regions of the world. It is also known as yuca, *rumu* or *manioca* in Latin America, *manioc* in French-speaking Africa and Madagascar, cassava in English speaking Africa, Ceylon and Thailand, *mandioca* or *aipim* in Brazil, tapioca in India and Malaysia, *kamoting-kahoy* in Philippines, *bi ketella* or *kaspe* in Indonesia (FAO, 1998). Cassava is originated from Brazil and Paraguay. Today it has been given the status of cutigen with no wild forms of this species being known (O'Hair, 1995).

Sweet varieties of the crop such as *Manihot utilissima Pohl* have lower levels of cyanogenic glycosides while bitter tasting varieties exemplified by cultivars such as *Manihot palmate Muell* and *Manihot aipr Pohl* have higher level of cyanogenic glycosides content (Niba & Jackson, 1999). According to Stephens (1994), the bitterness of cassava is caused by cyanogenic glucoside content in the roots. During the unfavorable growth condition such as drought, these types of crops can still survive from the storage roots which formed during the first year of plantation and resume vegetative growth upon the return of rain (Flach & Rumawas, 1996). The plant may assume the shape of a branching shrub or an unbranched small tree from 1-5m tall depending on the variety (MARDI, 2005).

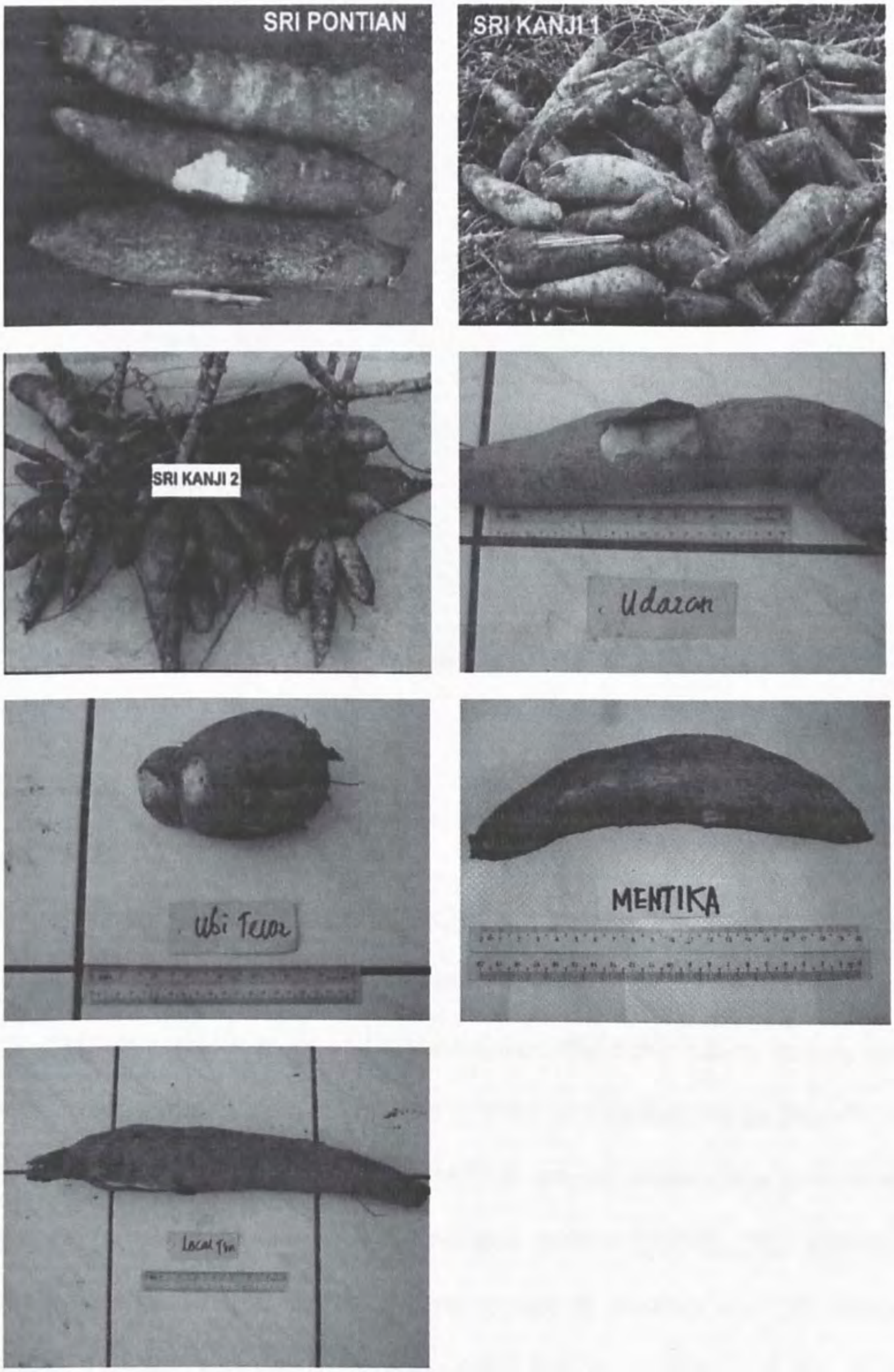
In Malaysia, there are many tapioca's varieties and different tapioca varieties have different usage. These varieties of tapioca are differentiated by the morphology of the plants (leaves' shape; petioles' color; tuber's shape, skin color, corky periderms' color and color of the flesh) (Liaw, 1985). Usually the leaves' shape is oblanc and long oblanc while color of the tuber's flesh is either white, cream or yellow. The latest varieties of tapioca in Malaysia are '*Sri Pontian*', '*Sri Kanji 1*' and ' *Sri Kanji 2*', which are produced by Malaysia Agricultural Research & Development Institute (MARDI) for food and starch production (MARDI, 2005). Table 2.1 shown some of the varieties that are available in Malaysia. From the table we identify the tapioca varieties which are available in Malaysia. Each different variety has different usage according to its characteristics such as the starch content and cynogenic content.

Mentega also known as *Mentika* in Sabah is a yellow fresh variety of tapioca that is preferable for making cakes and snack such as *kerepek, opak* and *keropok* which are Malays traditional food (ARC, 2002). Adetan, Adekoya & Aluko, (2003), said that cassava has a fibrous root system. Some of these roots develop radically into root tubers forming 5-10 tubers per plant are the main economically useful parts of the cassava plant. The shape and the morphology of a cassava root (*Mentika)* are shown in Figure 2.1. The transverse section of the tuber Figure 2.2 shows that it consists of a central core called the pith and is surrounded by the starchy flesh

Table 2.1: Tapioca varieties in Malaysia

Variety	Leaves		Tuber				Usage
	Shape	Petiole color	Shape	Skin's color	Color of corky periderm	Flesh	
Sri Kanji 1	Oblanc	Green yellowish	Cone	Brown	Light brown	White	Suitable for eating
Sri Kanji 2	Oblanc	Green yellowish	Cylinder	Dark brown	Light brown	White	Suitable for eating
Sri Pontian	Oblanc	Red	Cylinder	Brown reddish	Cream	White cream	Suitable for eating
Mentika	Oblanc	Red upper yellow lower	Cylinder	Brown reddish	Yellowish brown	Yellow	Suitable for eating
Black Twig	Oblanc	Pale yellow, red at stipule	Cylinder	Dark brown	Light brown	White	Commercial starch production
Green Twig	Long oblanc	Green	Cylinder	Brown	Light brown	White	Commercial starch production
Medan	Oblanc	Very red	Cylinder	Brown	Cream	Yellow	Suitable for eating
MM92	Oblanc	Red	Cylinder	Brown	Light brown	White	Suitable for eating and starch production
Perintis	Oblanc	Red	Cylinder	Dark brown	Light brown	White cream	Commercial starch production
Local Tuaran	Oblanc	Very red	Cylinder	Brown	Pinkish	White	Suitable for eating
Ubi telor	Oblanc	Red	Cone	Brown	Brown yellowish	Yellow	Suitable for eating
Udaran	Oblanc	Dark red	Cylinder	Brown	Pinkish	White	Suitable for eating

(ARC, 2002)



(Source: MARDI, 2005)
Figure 2.1 : Tapioca's variety in Malaysia

REFERENCES

Abu-Ghannam, N. & Crowley, H.2006. The effect of low temperature blanching on the texture of whole processed new potatoes. *Journal of Food Engineering.* **74**:335-344

Adetan, D.A., Adekoyu, L.O & Aluko, O.B. 2003. Characteristic of some properties of cassava root tubers. *Journal of Food Engineering.* **57**:349-353

Aguilera, J.M. & Stanley, D.W. 1999. *Microstructural Principles of Food Processing and Engineering.* (2th Edition). USA. Aspen Publication.

Aguilar, C.N., Anzaldua-Morales, R., Talamas, R. & Gastelum, G. 1997. Low temperature blanch improves textural quality of French-fries. *Journal of Food Science.* **65**:568-571

Aminlari, M., Ramezani, R. & Khalili, M. H. 2005. Production of Protein- Coated Low Fat Potato Chips. *Food Sci Tech Int.* **11(3)**:177-181

Akdeniz, N., Sahin, S. & Sumnu, G. 2006. Functionality of batters containing different gums for deep-fat frying of carrot slices. *Journal of food Engineering.* **75**:522-526

Aversa, M., Curcio, S., Calabro, V. & Iorio, G. 2006. An analysis of the transport phenomena occurring during food drying process. *Journal of Food Engineering* (In Press)

Bauman, B & Escher, F .1995.Mass & heat transfer during deep-fat frying of potato slices-I rate of drying & oil uptake.*LWT.***28(4)**:395-403

Bourne, M. C. 2002. *Food texture and viscosity concepts and measurements.* Academic Press. London

Bunger, A., Moyano,P. & Rioseco,V. 2003. NaCl soaking treatment for improving the quality of French-fried potatoes. *Food Research International.* **36(2)**:161-166

Canet, W., Alvarez, M.D. & Fernandez, C. 2005. Optimization of low-temperature blanching fo retention of potato firmness: Effect of previous storage time on compression properties. *Eur Food Mes Technol.* **221**:423-433

Cardoso, A. P., Mirione, E., Ernesto, M., Massaza, F., Cliff, J., Haque, M. R. & Bradbury, J. H. 2005. Processing of cassava roots to remove cyanogens. *Journal of Food Composition and Analysis.* **18(5)**:451-460

Caixeta, A.T., Moreira, R. & Castell-Perez, M.E. 2002. Impingement drying on potato chips. *Journal of Food Process Engineering.***25**:63-90

Cooke, R.D. & Maduagwu, E.N.1978. The effect of simple processing on the cynide content of cassava chips. *Journal of Food Technology.* **13**:299-306

Costa, R.M., Oliveira,F.A.R. & Boutcheva, G. 2001. Structural changes and shrinkage of potato during frying. *International Journal of Food Science & Technology.* **36(1)**:11

Department of Agriculture Malaysia, 2002

Ding, Q. B., Ainsworth, P., Tucker, G. & Marson, H. 2005. The effect of extrusion condition on the physicochemical properties and sensory characteristics of rice-based expanded snack. *Journal of Food Engineering.***66**:283-289

Edijala, J.K., Okoh, P.N. & Anigoro, R. 1999. Chemical assay of cyanide levels of short time-fermented cassava products in the Abraka area of Delta State, Nigeria. *Food Chemistry.* **64(1)**:107-110

Euromonitor. 2006.at

http://www.euromonitor.com.my

FAO. 1998. *Food Outlook.* Rome. FAO

FAO, 2004. *Food Outlook No 2*

fao.org/WAICENT/faoinfo/economic/giews/English/giewse.htm

FAOSTAT. 2004. Global Cassava Market
http://www.apps.fao.org

FAO, 2006. June 2003 Global cassava production rose by 2 percent in 2002
http://www.apps.fao./WAICENT/faoinfo/economic/giews/English/giewse.htm

Farkas, B. E. Singh, R. P & Rumsey, T. R. 1996. Modeling heat and mass transfer in immersion frying I. Model development. *Journal of Food Engineering.* **29**:211-226

Flach, M & Rumawas, F (Editor). 1996. Plant Resource of South East Asia 9, Plant Yielding non-seed carbohydrates. Leidun. Backhuys Publishers. 17

Food Technology Research Centre, MARDI. 1992. Situation and Outlook of the Malaysian Food Processing Sector. *Technical Review of MARDI Food*

Fuglie,K.O., Oates, C.G. & Xie, J. 2005. Root Crops, Starch and Agro-Industrilization in Asia.
http://www.puslittan.bogor.net

Garayo, J & Moreira, R. 2002.Vaccum frying of potato chips. *Journal of Food Engineering*. **55**:181-191

Garrote, R.L., Silva, E.R & Bertone, R.A. 2000. Effect of thermal treatment on steam peeled potatoes. *Journal of Food Engineering*. **45(2)**:67-76

Ghani, S. 1999. *Small-Scale Food Processing Enterprises in Malaysia*. Food Technology Research Station MARDI. Malaysia

Gidamis, A.B., O'Brien, G.M. & Poulter, N.H.1993.Cassava detoxification of traditional Tanzanian cassava foods. *International Journal of Food Science and Technology*. **(28)**:211-218

Golubowska, G. 2005. Changes of polysaccharide content and texture of potato during French fries production. *Food Chemistry*. **90(4)**:847-851

Gracia, M.A. Ferrero, C., Bertola, N., Martino, M. & Zaritzky, N. 2002. Edible coating from cellulose derivatives to reduce oil uptake in fried products. *Innovative Food Science and Emerging Technologies*. **3(4)**:391-397

Grizotto, R & Menezes, H.C. 2002. Effect of Cooking on the crispness of cassava chips. *Journal of Food Science*. **67(3)**:1219-1222

Hubbard, L. J & Farkas, B.E. 1999. A method for determining the convective heat transfer coefficient during immersion frying. *Journal of Food Process Engineering*. **22**:201-214

Howeler, R. 2004. Cassava in Asia: Present Situation and its Future Potential in Agro-Industry. CIAT Cassava office for Asia, Department of Agricultural. Thailand.

Isamah, G. K., Asagba, S. O & Ekakitie, A. O. 2003. Lipid peroxidation, activities of superoxide dismutase and catalase during post- harvest deterioration of cassava (Manihot esculenta Crantz) root tubers. *International Biodeterioration & Biodegradation*. **52**:129-133

Jacobson, G.A. 1991. Quality control in deep-fat frying operations. Food Technology. **45(2)**:72-74

Jaswir, I., Che Man, Y. & Kitts, D.D. 2000.Use of natural antioxidants in refined palm olein during repeated deep-fat frying. *Food Research*. **33(6)**:501-508

Kidmose,U. & Martens,H.J.1999.Changes in texture, microstructure and nutritional quality of carrot slices during blanching and freezing. *Journal of the Science of Food and Agricultural*. **79(12)**:1747-1753

Kidmose,U. & Martens,H.J.1999.Changes in texture, microstructure and nutritional quality of carrot slices during blanching and freezing. *Journal of the Science of Food and Agricultural.* **79(12)**:1747-1753

Kimaryo, V.M., Massawe, G.A., Olasupo,N.A & Holzapfel, W.H. 2000. The use of a starter culture in the fermentation of cassava for the production of "kivunde", a traditional Tanzanian food product. *International Journal of Food Microbiology.***56(2-3)**:179-190

Kita, A. 2002. The influence of potato chemical composition on crisp texture. *Food Chemistry.* 76.2173-179

Kostinek, M., Specht, I., Edward, V.A., Schillinger, U., Hertel, C., Holzapfel, W.H. & Franz, C.M.A.P. 2005. Diversity and technological properties of predominant lactic acid bacteria from fermented cassava used for the preparation of Gari, a traditional African food. *Systemic and Applied Microbiology.* **25(6)**:527-540

Krokida, M.K., Maroulis, Z.B. & Saravacos, G.D. 2001. The effect of the method of drying on the colour of dehydrated products. *International Journal of Food Science and Technology.***36**:53-59

Krokida, M.K., Oreopoulou, V & Maroulis, Z.B. 2000. Water loss and oil uptake as a function of frying time. *Journal of Food Engineering.* **44(1)**:39-46

Krokida, M.K., Oreopoulou, V., Maroulis, Z.B. & Marinos-Kouris, D. 2001. Color changes during deep fat frying. *Journal of Food Engineering.* **48**:219-225

Leeratanarak, N., Devahastin, S. & Chiewchan, N. 2005. Drying kinetics and quality of potato chips undergoing different drying techniques. *Journal of Food Engineering.*(In Press)

Liaw,H.L. 1985. Cassava Variety in Malaysia. Agricultural Research Centre

Lisińska, G & Gołubowska, G. 2005. Structural changes of potato tissue during French fries production. *Food Chemistry.* **93(4)**:681-687

Malaysia Agricultural Research And Development Institute (MARDI). 2005. at http://www.mardi.my

Maskan, M. 2001. Kinetics of colour change of kiwifruits during hot air and microwave drying. *Journal of Food Engineering.* **48**:169-175

Mehta, U. & Swinburn, B. 2001. A Review of Factors Affecting Fat Adsorption in Hot Chips. *Critical Reviews in Food Science and Nutrition.* **41(2)**: 133-154

Mlingi, N.L.V., Assey, V., Swai, A., McLarty, D., Karlen, H. & Rosling, H. 1993. Determinants of cyanide exposure from cassava in konzo-affected population in Northern Tanzania. *International Journal of Food Science Nutrition.* **44**:137–144.

Moreira, R. G & Barrufet, M. A. 1999. A new approach to describe oil adsorption in fried foods: a stimulation study. *Journal of Food Engineering.* **77**:194-204

Moyano, P., Rioseco, V.K.& Gonzalez, P.A.2002. Kinetics of crust color changes during deep-fat frying of impregnated French fries. *Journal of Food Engineering.* **54(3)**:249-255

Moyano, P.C & Pedreschi, F. 2006. Kinetic of oil uptake during frying of potato slices: Effect of pretreatments. *Lebansmittel-Wissenschoft und- Technologie.* **39**:285-291

Niba, L. L & Jackson, F. L. C. 1999. *Tapioca and Tapioca Flour: Consumption and Potential.* Symposium Cultural and Historical Aspects of Foods. Oregon State University, Corvallis, O. R. Food Resource at http://food.oregonstate.edu.

Oboh, G. & Akindahunsi, A.A. 2003. Biochemical changes in cassava products (flour & Gari) subjected to *Sacchromyces* cerevisaesolid media fermentation. *Food Chemistry.* **82(4)**:599-602

O'Hair, S.K. 1995. *Cassava.* Tropical Research and Education Center. University of Florida Florida

Ojo, O & Deane, R. 2002. Effects of cassava processing methods on antinutrional components and health status of children. *Journal of the Science of Food and Agricultural.* **82**:252-257

Oliveira, F.F.A. & Silva, C.L.M. 1992. Freezing infuences diffusion of reducing sugars in carrot cortex. *Journal of Food Science.* **57**:932-934

Omobuwajo, T.O. 2003. Compositional characteristics and sensory quality of biscuits, prawn crackers and fried chips produced from beadfruit. *Innovative Food Science & Emerging Technologies.***4(2)**:219-225

Pedreschi, F. Moyano. 2005. Oil uptake and texture development in fried potato slices. *Journal of Food Engineering.* **70**:557-563

Pedreschi, F. Moyano. 2005. Effect of pre-drying on texture and oil uptake of potato chips. *Food Science and Technology.* **38(6)**:599- 604

Pedreschi, F. Moyano, P. Kaack, K & Granby, K. 2005. Color changes and acrylamide formation in fried potato slices. *Food Research International.* **38(1)**:1-9

Pontoh, J & Low, N. H. 1995. Glucose Syrup Production from Indonesia Palm and Cassava Starch. *Food Research International.* **28(4)**: 379-385

Sajilata, M. G & Singhai, R. S. 2005. Specialty starches for snack foods. *Carbohydrate Polymers*. **59(2)**: 131- 151

Scott, G.J., Rosegrant, M.W. & Ringler, C. 2000. Roots and Tubers for the 21st Century: Trends, Projections, and Policy Options. *2020 Brief No 66*. at http://www.ifpri.org/2020/briefs/number66.htm

Severini, C., Baiano, A., De Pilli, T., Carbone, B.F., & Derossi, A. 2005. Combined treatments of blanching and dehydration: study on potato cubes. *Journal of Food Enginerring*. **68**:289-296

Segnini, S., Dejmek,P. & Oste, R.1999.Reproducible Texture Analysis of Potato Chips. *Journal of Food Science*. **64(2)**:309-312

Shyu, S. L & Hwang, L. S. 2001. Effects of processing conditions on the quality of vacuum fried apple chips. *Food Research International*. **34(2-3)**:133-142

Sperling, C.R. & King, S.R. 1990. Andean Tuber Crops: Worldwide Potential. Advances in new crops. Timber Press, Portland, OR:428-435.

Stephens, J. M. 1994. *Cassava—Manihot esculenta Crantz* from http://edis.ifas.ufl.edu/MV042

Sulaeman, A., Keeler, L., Taylor, S.L., Giraud, D.W. & Driskell, J.A. 2001. Carotenoid Content, Physiochemical, and Sensory Qualities of Deep-Fried Carrot Chips As Affected by Dehydration/Redehydration, Antioxidant, and Fermentation. *Journal of Agricultural & Food Chemistry*. **49**:3253-3261

Tan, S. L & Cock, J. H. 1979. Cassava plant forms and their associated morpho-physiological characters. *MARDI Buletin Penyelidikan,* MARDI **7(2)**: 55-69

Tunku Mahmud Tunku Yahya. 1984. Demand and Supply Analysis of Tapioca Products in Penisular Malaysia. *MARDI Report 84*. MARDI

Truong, V.D., Walter, W.M. & Bett, K.L. 1998. Textural properties and sensory quality of processed sweetpotatoes as affected by low temperature blanching. *Journal of Food Science*. **63(4)**: 739-743

Vasanti Nair, C.K., Seow, C.C. & Sulebele, G.A. 1996. Effect of frying parameters on physical changes of tapioca chips during deep fat frying. *International Journal of Food Science and Technology*. **31**:249-256

Vegetable and Cash Crop Statistic Malaysia. 2002. Department of Agriculture Malaysia

Vitrac, O., Dufour, D., Trystram, G. & Raoult-Wack, A.L. 2000. Deep-fat frying of cassava: influence of raw material properties on chip quality. *Journal of the Science of Food and Agriculture*. **81(2)**:227-236

Vitrac, O., Dufour, D., Trystram, G. & Raoult-Wack, A.L. 2001. Characterization of heat and mass transfer during deep-fat frying and its effect on cassava chip quality. *Journal of Food Engineering*. **53**.161-176

Vuilleumier, S. 1993. Worldwide Production of High Fructose Syrup and Crystalline Fructose. *America Journal Clinical Nutrition*. **58(5)**:733-736

Wangcharoen, W., Ngarmsak, T. & Wilkinson, B.H. 2005. Snack product consumer surveys: large versus small samples. *Food Quality and Preferance*.**16(6)**:511-516

Wennberg, M., Ekvall, J., Olsson, K. & Nyman, M. 2006.Changes in carbohydrate and glucosinolate composition in white cabbage (*Brassica oleracea* var. *capitata*) during blanching and treatment with acetic acid. *Food Chemistry*.**95(2)**:226-236

Zhang, M & Chen, D. 2005.*Effects of low temperature soaking on color and texture of green eggplant*. Journal of Food Engineering.**74:**54-59