UNIVERSITI PUTRA MALAYSIA

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**By**

**ROZAIHAN BINTI RAZALI**

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**March 2007**

**Chairman : Norhafizah Abdullah, PhD**

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Population drift from rural to urban areas has increased the demand ready to eat traditional processed food. Thus, there is a great need for better ways of preparing this food at both domestic and factory scale. Cassava ranks fourth in crops importance in the world and various types of traditional foods are locally made from it especially in the tropics. However, cassava is low in vitamins and minerals content. In addition, it contains cyanogenic glycosides which are known to be toxic because the glycosides yield hydrogen cyanide (HCN) when enzymically degraded. Thus, the most important requirement in the processing of cassava roots is its detoxification by the reduction of the total cyanide content (bound and free) to acceptable levels. Furthermore, the conventional methods used previously have not necessarily detoxified the final products sufficiently for safe consumption. The field of study is process development and the research issue is the development of safe processes to for the manufacture of indigenous food containing toxins. The

development of new processes to reduce cyanogen from cassava flour using fermentation and drying processes can be easily done in a well equipped laboratory. The process in the present study adopted the conventional gari (most popular traditional food for Nigerians) making process with some modifications. The new process consists of fermentation in a bioreactor, drying using a fluidized bed dryer and fortification by carotene oil in order to reduce the cyanide content of the final product of cassava flour and at the same time, fortifying it with ß-carotene. It was found that the overall process flow sheet is improved, and the processing time is reduced. The cassava flour obtained was free from cyanide content and successfully fortified with ß-carotene. Fermentation time was improved during which the sour flavor and desired aroma was achieved within 20 h as compared to 2 days under conventional technique. Removal of hydrogen cyanide was facilitated by drying for 15 minutes at 80 ºC, while reducing moisture content to acceptable level. Drying step had also improved the process flow sheet with shorter duration and ease of handling continuously. The fortification of the fermented cassava flour with ß-carotene was also successful. On the other hand, with the present methods used to produce cassava flour, risks associated with conventional and some industrial scale of cassava processing techniques and its products were removed. With a better control over processing conditions such as time and temperature, higher quality of cassava flour may be guaranteed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**KESAN-KESAN PENAPAIAN, PENGERINGAN DAN PENAMBAHAN MINYAK KAROTIN KE ATAS NILAI NUTRISI TEPUNG UBI**

Oleh

**ROZAIHAN BINTI RAZALI**

**Pengerusi : Norhafizah Abdullah, PhD**

**Fakulti : Kejuruteraan**

Perpindahan populasi dari kawasan luar bandar ke bandar telah meningkatkan permintaan terhadap makanan tradisi yang sedia diproses dan dibungkus. Oleh itu, wujud keperluan bagi membaiki pemprosesan bahan makanan ini sama ada dalam skala domestik atau industri. Ubi kayu berada di tempat ke empat terpenting antara makanan ruji lain di dunia. Berbagai jenis makanan tradisi dihasilkan daripadanya terutamanya oleh negara-negara dari kawasan tropika. Walau bagaimanapun, kandungan vitamin dan mineral dalam ubi kayu adalah rendah. Malah ia juga telah diketahui mengandungi sejenis bahan bertoksik yang dikenali sebagai glikosida sianogen. Bahan ini akan menghasilkan gas sianida apabila bertindak balas dengan enzim yang sedia wujud dalam ubi kayu itu sendiri. Oleh itu, adalah amat penting untuk ubi kayu diproses sehingga kandungan sianida berkurangan ke tahap yang selamat. Cara pemprosesan tradisi yang sering diamalkan, tidak berjaya menurunkan kandungan racun dalam produk hasilan ubi kayu ke tahap selamat. Lapangan kajian ini ialah pembangunan proses dan isu bagi kajian ini ialah pembangunan satu proses

yang selamat bagi pembuatan makanan yang mengandungi toksin semulajadi. Pembangunan proses bagi menurunkan kandungan sianogen dalam tepung ubi dapat dilakukan dengan mudah menggunakan kaedah penapaian dan pengeringan serta alatan makmal yang cukup dan sempurna. Kajian ini mengubah suai kaedah tradisi pemprosesan gari (makanan tradisi popular di Nigeria). Proses-proses yang terlibat dalam kajian ini ialah, penapaian dalam bioreaktor, pengeringan menggunakan pengering lapisan terbendalir dan penambahan minyak karotin. Keseluruhan proses ini bertujuan untuk menurunkan kandungan sianida dalam produk akhir dan dalam masa yang sama menambahkan nilai ß-karotin di dalamnya. Hasil yang berjaya diperoleh dari kajian ini menunjukkan bahawa keseluruhan masa bagi pemprosesan ubi kayu ini berjaya dipendekkan, dan keseluruhan carta alir prosesnya diperbaiki. Tepung ubi yang terhasil juga berjaya diperkaya dengan ß-karotin. Tempoh penapaian telah diperbaiki apabila didapati dalam masa 20 jam, rasa masam dan aroma yang dikehendaki telah berjaya dicapai jika dibandingkan tempoh 2 hari jika menggunakan kaedah konvensional. Proses pengeringan pula mendapati, pada suhu 80 ºC, tempoh 15 minit telah berjaya menghapuskan kandungan sianida dalam tepung ubi sekaligus menurunkan kadar lembapan ke tahap yang dibenarkan. Langkah pengeringan yang dijalankan ialah satu langkah berterusan, mudah dan menjimatkan masa keseluruhan proses. Selain daripada itu, dengan penggunaan kaedah baru memproses tepung ubi ini, kewujudan risiko-risiko berkaitan memproses ubi kayu dengan kaedah konvensional dan kaedah oleh beberapa industri dapat dihapuskan. Dengan kawalan yang lebih baik terhadap kondisi-kondisi proses seperti masa dan suhu, penghasilan tepung ubi yang lebih berkualiti dapat dijamin.

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To my husband and daughters, my mother whom gave me her fullest support, my family members and all my master students friends. For those whom I didn't mention here, thank you for your kindness, you are not forgotten.

I certify that an Examination Committee has met on 16 March 2007 to conduct the final examination of Rozaihan binti Razali on her Master of Science thesis entitled "Effects of Fermentation, Drying and Additional of Carotene Oil on Nutritional Value of Cassava Flour" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date: 17 JULY 2007

**DECLARATION**

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

**ROZAIHAN BINTI RAZALI**

Date: 22 MARCH 2007

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| HCN | Hydrogen cyanide |
| ICP | Inductive Coupled Plasma |
| NIOSH | National Institute for Occupational Safety and Health |
| OSHA | Occupational Safety and Health Administration |
| PEL | Permissible exposure limit |
| SCN | Thiocyanate |
| TAN | Tropical Ataxic Neuropathy |
| TCP | Tropical Calcifying Pancreatitis |
| TWA | Time-weighted average |

# CHAPTER 1

# INTRODUCTION

The objective of this study is to produce cassava flour that is cyanide free and nutritionally improved from cassava tubers using a new process that is modified from the traditional gari production method. In order to fulfill the objectives of this study, there is the need to understand the reaction that produce hydrogen cyanide (HCN) cassava and to find the most effective way eliminating it from the final cassava flour product. The scope of the study consists of fermentation, drying and fortification in the cassava flour production from cassava tuber as the raw material. Elimination of HCN from the end product during the fermentation and the drying processes will be investigated and the effectiveness of each method will be assessed. This is followed by the fortification of the cassava flour with pro-vitamin A (ß-carotene). Related research performed elsewhere will also be reviewed and used in the decision making process for the best methods to be used in the present work.

## 1.1 Processing Method: Conventional versus Proposed Study

Method selected for the production of cassava flour is a modified process flow sheet of gari making processes. The gari processing method is chosen because it had proved to be the best method that is economical, easy to perform and to scale up without compromising the taste and palatability of the final product. Gari also have a high demand from consumers. Gari is a granular meal which is creamy white in color or yellow if palm oil is added during the cooking step to prevent burning. The traditional method of cassava fermentation used in gari production is carried out in a sack rather than in a fermentor or a bioreactor. During gari preparation, the disintegrated cassava is fermented for 3 to 7 days depending on the desired taste required. The liquid fraction of the fermented cassava is extracted throughout the fermentation process using in-situ presser. The presser usually is made of heavy metal or stone. The extracted juice contains most of the cyanide content from the fermented cassava. When fermentation is completed, the partially dried homogenate containing cassava pulp is taken out of the sacks and sieved to remove fibrous material. The retentate is then heated in wide, shallow iron pans and stirred continuously until it becomes light and crisp (Balagopalan *et al.,* 1988). The process flow chart for conventional processing method for gari is illustrated in figure 1. The process contains 5 cascade steps which are peeling, grating, compressing and fermentation, sieving and toast drying.

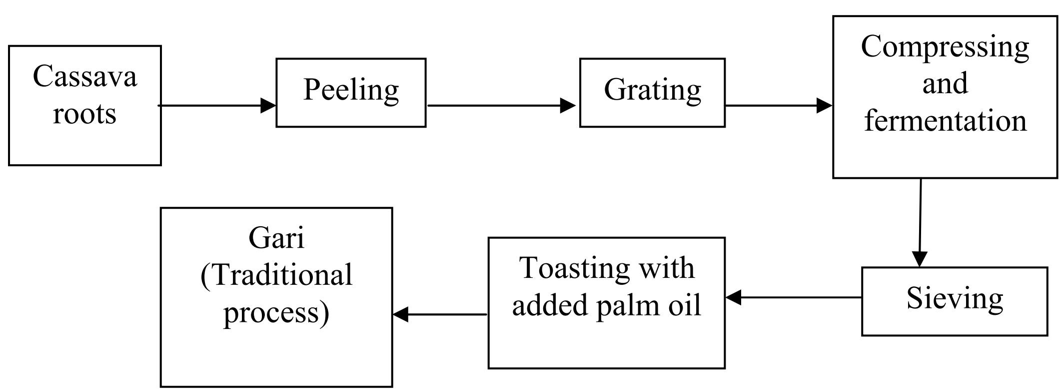


**Figure 1: Conventional gari processing method containing 5 cascade steps.**

Besides fermentation, another method in preparing cassava for processing involved chipping and steeping of cassava roots (Iwouha *et al.,* 1997) before drying. Various methods have also been used for drying purposes in the conventional process. This includes sun drying (Onyekwere *et al.*, 1989; Iwouha *et al.,* 1997), toasting and frying using a domestic shallow pan (Sokari, 1992), roasting using a garifier cooker (Onyekwere *et al*., 1989) and microwave oven drying (Oduro and Clarke, 1999).

There are several problems in the conventional method, associated with the methods used in preparing cassava as foods. The problems include high residual cyanide content in the product (Mlingi *et al.*, 1995), occupational diseases acquired during processing of cassava into food products (Okafor *et al.,* 2002). The drawbacks associated from the use of conventional drying techniques are the large fuel consumption and the health and fire risks associated with open frying pans. Mixing during pan drying is usually required to prevent re-agglomeration of the granules or sticking of the gari to the base of the pan (Oduro and Clarke, 1999). Above all, the products are not reproducible since the methods used for cassava processing is not standardized and uncontrolled.

In the present study, fermentation was done in a bioreactor while drying was performed using a fluidized bed system in a rapid dryer. These systems were chosen as the fermentation and drying profiles can be easily monitored and optimized. The fermentation temperature and time was optimized with respect to cyanide and ß-carotene content while the drying temperature and time was optimized with respect to moisture and cyanide content. With the use of controlled processing method, both small and large factories can easily meet the cassava food products' quality standard specification. Furthermore, this method offers a better control over processing conditions such as time and temperature, so that a higher quality may be guaranteed compared to that obtained by the existing conventional method.

### 1.2 Motivations to Improve Cassava Flour Product and its Processing Method

A study done by Iwuoha and Eke (1996) found some problems associated with Nigerian indigenous fermented foods:

- Production environment – in the traditional setting, the processing environment is very unpredictable: the equipment used is rudimentary (leaves, cloth), the hygiene of handlers, equipment and facilities is not checked, the water used, especially at the edges of streams cannot be said potable; tropical climate (temperature and humidity) cannot be said to be optimum for all fermentation and storage purposes. All these factors affect the quality of final product and the health of ultimate consumers.

- Microbiology of process – there is no way to assure a consistently uncontaminated environment for the fermentation.

- Process control – there is no scientific protocol in food process operations, and the practice of process control is virtually impossible to maintain. Fermentation periods were chosen according arbitrarily. The quality and

- Toxicological status - the type and degree of danger posed by the consumption of fermented products which are unfit for human consumption due to the handling process or post-fermentation contamination is not known.

These problems have added reasons for the author to find solutions to overcome then. There are also health hazard factors associated with the cassava flour process flow sheet that will be discussed in the next chapter in section 2.13. Besides the problems discussed above, other reasons which motivate the author to carry out this research includes:

### 1.2.1 Longer Shelf-life

Cassava is a highly perishable, starchy root crop that starts to deteriorate within two or three days after harvesting, if not processed. Since there are millions of people who plant cassava as their staple food, the need to process the flour into a longer shelf-life product is vital. Dried cassava flour is one of the forms in which processed tubers can have guaranteed long shelf-life (Iwouha *et al.*, 1996).

### 1.2.2 Quality Control

A variety that is sweet, if grown in one area may become bitter in another (Raheem and Chukwuma, 2001). This phenomenon depends on many factors that will be discussed in the next chapter. Current processing method does not apply any quality control; hence the products are not reproducible. Furthermore, the quality and the toxicology content are also unknown. This study proposes a technology that can formulate cassava to a nutritious and appetizing novel product and applicable even to the bitterest species. Thus, quality control will be no longer a problem. The product of this study will be; cyanide free-cassava flour enriched with ß-carotene.

### 1.2.3 Occupational Diseases

There are occupational diseases due to cyanide exposure in the course of processing gari (Okafor *et al*., 2002). It means that not only a safe end product is needed but also a harmless processing environment is also required. The advantage of the proposed cassava processing method is that, it can control the HCN released during processing since the fermentation and drying steps are done in a close control environment.

### 1.2.4 Improving the Conventional Method

Fermentation process improves the nutritional values of low protein and high carbohydrate foods. Fermentation also imparts characteristic flavor and aroma and also improves the palatability of foods. As an example, cassava fermentation reduces the cyanide content while releasing some bound minerals, including calcium and magnesium (Oyewole, 1992). There is also a relative increase in protein content after cassava processing which is possibly due to increase in total nitrogen affected by fermentation during the second steeping process (Iwouha *et al.,* 1997).