GUAVA POWDER PRODUCTION USING PILOT SCALE SPRAY DRYER AND NUTRIENT RETENTION STUDY

KOGULAN A/L M.SAIGER

A thesis submitted in fulfillment of the requirements for the award of the Degree of Bachelor of Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
University Malaysia Pahang

MAY 2008

“Saya/Kami* akui bahawa saya telah membaca karya ini dan pada pandangan saya/kami* karya ini adalah memadai dari segi skop dan kualiti untuk tujuan Penganugerahan Ijazah Sarjana Muda Kejuruteraan Kimia.”

Tandatangan	: ....
Nama Penyelia I	: ....
Tarikh	: ....
Tandatangan	: ....
Nama Penyelia II	: ....
Tarikh	: ....
Tandatangan	: ....
Nama Penyelia III	: ....
Tarikh	: ....

**Potong yang tidak berkenaan*

*Potong yang tidak berkenaan

I declare that this thesis entitled "***GUAVA POWDER PRODUCTION USING PILOT SCALE SPRAY DRYER AND NUTRIENT RETENTION STUDY***" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	: ………………………..........
Name of Candidate	: ………………….......…..
Date	: ………………................

Specially dedicated to my father.............

ACKNOWLEDGEMENT

I wish to express my sincere appreciation to my supervisor, Prof Madya Nordin Endut for his constructive ideas, supports, invaluable guidance, back-up regardless place and time, confidence, patience, continual encouragement and particularly, his understanding.

Moreover, I would like to thanks to the technical staff at FKKSA lab for their assistance and cooperation, especially, Miss Idayu. for her indispensable help in HPLC analysis.

Finally, and above all, I would like to express my wholehearted apperiaciation to my mother for her care, patience, and support all the time.

ABSTRACT

For drying run, highly concentrated puree were prepared from guava. Maltodextrin 10 to the prepared puree as a carrier. The Pilot Scale Spray Dryer model ZLG-10 used for drying process. Retention of nutrients in food during processing is nowadays an important matter for food processors. This is mainly due to the change of food consumption pattern, the current market demand and the regulatory requirement. The study investigates some of the important aspects involved in spray drying processing of guava, a tropical fruit which among all the fruits ranked second in terms of vitamin C content and, also, has a high amount of fiber. In this study, water activity and temperature effect on nutrient retention of guava juice in spray drying process investigated. The best temperature to spray dry which gives low deterioration of vitamin C is identified too. Vitamin C is known as the least stable one among all the nutrients, thus it is selected as an index for nutrient retention study. HPLC analyses were performed to determine vitamin C level in spray dried and initial guava puree. The research shows 170 ^{o}C is most fine and applicable temperature compare to any other temperature to give minimum vitamin C loss. Vitamin C deterioration depends both on temperature and water activity but experimentally proved water activity would play a more dominant role compared to temperature. Hence, a fast reduction of moisture content at higher temperature will help retaining vitamin C. First order reaction is used to describe the deterioration of vitamin C in spray drying process.

ABSTRAK

Mengeringkan jambu biji dengan cara *spray drying* (pengeringan semprot) dapat dilakukan dengan cara membuat konsentrat jus jambu. Kemudian konsentrat jus tersebut dikeringkan dengan menggunakan alat ZLG-10 spray dryer. Maltodextrin 10 ditambahkan pada bahan sebagai pembawa sebelum dimasukkan dalam spray drier. Maklumat berkenaan nutrisi makanan yang diproses adalah aspek paling penting perlu diketahui pengkilang makanan. Hal ini kerana wujudnya pertukaran cara pengambilan makanan di kalangan pengguna sejak akhir-akhir ini. Selain itu, permintaan pasaran terkini serta peraturan pihak berkuasa mendorong pengkilang makanan untuk berusaha sebaik mungkin untuk mengekalkan nutrisi dalam makanan diproses.Demikian, kajian dijalankan di atas beberapa aspek melibatkan pengeringan spray dan jus buah jambu yang dikenali sebagai buah yang mengandungi sumber vitamin C kedua tertinggi antara semua jenis buah-buahan dan juga yang tinggi kandungan fibernya. Dalam kajian ini, kesan aktiviti air dan kesan suhu di atas jus guava diselidik. Suhu paling sesuai yang mengakibatkan kehilangan nutrisi rendah juga ditentukan. Vitamin C adalah nutrisi yang tidak stabil atau mudah dirosakkan. Demikian vitamin C dipilih sebagai index nutrisi. HPLC analisis digunakan untuk mengenal jumlah vitamin C dalam jus diproses dan sebelum diproses. Kajian menunjukkan 170 ^{o}C adalah suhu yang paling sesuai dan mengakibakan kehilangan vitamin C yang rendah. Penguraian vitamin C bergantung pada factor suhu dan aktiviti air tetapi dibuktikan secara eksperimen aktiviti air memainkan peranan penting berbanding suhu. Maksudnya tindak balas yang menyebabkan kehilangan air yang cepat pada suhu tinngi boleh mengekalkan lebih banyak vitamin C. Penguraian vitamin C dalam proses pengeringan spray ditakrifkan sebagai tindakbalas tertib pertama.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ABSTRACT	**v**
	ABSTRAK	**vi**
	LIST OF TABLES	**x**
	LIST OF FIGURES	**xi**
	LIST OF SYMBOLS	**xii**
	LIST OF APPENDICE	**xiii**
1	**INTRODUCTION**	
	1.1 Background	1
	1.2 Problem statement	5
	1.3 Objective	6
	1.4 Research scope	6
2	**LITERATURE REVIEW**	
	2.1 Drying	8
	2.2 Nutrient retention	10
	2.2.1 Vitamin C retention	11
	2.3 General characteristic of dryer	12
	2.3.1 Types of Dryer Equipment	13
	2.3.2 Spray Dryer	13

2.3.2.1 Introduction 13
2.3.2.2 Spray Dry 14
2.3.2.3 Brief history of spray drying 15
2.3.3 Spray drying basics 15
2.3.3.1 Concentration 15
2.3.3.2 Atomization 16
2.3.3.3 Droplet-air contact 16
2.3.3.4 Droplet drying 16
2.3.3.5 Separation 17
2.3.3.6 Spray drying process 17

2.4 Vitamin C retention analysis 18

3 METHODOLOGY

3.1 Introduction 19

3.2 Materials 19
3.2.1 Guava purees 19
3.2.2 Maltodextrin 20

3.3 Equipment 22
3.3.1 Spray dryer 22

3.4 Method of the research 23
3.4.1 Qualitative HPLC analysis 23
3.4.2 Experimental analysis HPLC 25
3.4.3 Drying Process 27
3.4.2.1 General Advice to Get Optimum Product 28

3.5 Experiment flow chart 29

3.6 Flow chart for overall research 30

4 RESULT AND DISCUSSION

4.1 Spray Drying 31

4.2 Vitamin C retention studies 35

4.2.1 Vitamin C retention study in different various temperatures 35

4.2.2 Nutrient retention study in determined appropriate temperature for minimum Vitamin C loss. 39

4.2.3 Rate constant and reaction order determination 44

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion 46

5.1.1 Spray drier 46

5.1.2 Nutrient (vitamin C) retention 46

5.2 Recommendation 47

REFERENCES 48

APPENDICES 52

LIST OF TABLE

TABLE NO	TITLE	PAGE
Table 1.1	Composition of fresh guava per 100g	4
Table 1.2	Comparison of vitamin C content	5
Table 3.1	Specification of Maltodextrin 10	21
Table 3.2	Specification of spray drier	27
Table 4.1	Condition in spray dryer based on temperature and feed flow. The time taken to get dry product of certain volume of guava puree is stated.	31
Table 4.2	Net weight of guava powder for samples of 1 L	32
Table 4.3	Drying condition and percentage of vitamin C loss.	37
Table 4.4	Guava puree properties collected by time	41

LIST OF FIGURE

FIGURE NO	TITLE	PAGE
Figure 1.1	Guava (*Psidium guajava*)	3
Figure 2.1	Working principle of spray drier	18
Figure 3.1	UMP pilot plant spray dryer	22
Figure 3.2	Diagrams of working principles of HPLC	26
Figure 3.3	Schematic diagram for the process to convert guava puree to powder	29
Figure 3.4	Schematic diagram for the overall research	30
Figure 4.1	Guava powder	33
Figure 4.2	Reconstituted guava puree	34
Figure 4.3	Deterioration Vitamin (%) C VS Sample graph	38
Figure 4.4	Graph concentration deteriorated vitamin C versus time	42
Figure 4.5	Graph of reduction rate versus time	43
Figure 4.6	Graph of reduction rate versus concentration	45

LIST OF SYMBOL

V	=	volume
μm	=	micrometer
mg	=	milligram
ppm	=	part per million
%	=	percentage
Kg	=	kilogram
hr	=	hour
KW	=	kilowatts
L	=	liter
min	=	minute
Hz	=	hertz
t	=	time
C	=	concentration of guava juice, mg/L
Co	=	initial concentration of guava juice, mg/L
Ct	=	concentration of guava juice at time t, mg/L
K	=	rate constant, 1/min
T	=	temperature
Tg	=	Glass transition temperature

LIST OF APPENDICES

APPENDICES	TITLE
A-K	HPLC Chromatograms peak for vitamin C concentrations.

CHAPTER 1

INTRODUCTION

1.1 Background

The growing of fruits and vegetables is limited in many countries to certain seasons and localities. In order to meet the demand of the market throughout the year in all areas, the commodities are preserved using different techniques. High moisture content will lead to the drop of quality and, indirectly, to a decrease in quantity. The drying of fruits and vegetables controls the moisture content by either removing moisture or binding it so that the food becomes stable to both microbial and chemical deterioration. It is an ancient method of preservation that came into existence 5,000 years ago and considered as one of the oldest technique**.** Until now, drying is a common and economical preservation method for many fruits and vegetables in many countries. Although most of the drying methods are traditional and primitive, there is an impelling need to apply modern techniques such as spray drying, freeze drying and so one, with the objectives of increasing productivity and obtaining closer control of the process to achieve a product quality. This requires basic data on drying together with knowledge of the fundamental principles involved. Nowadays, the fast economic development has changed the pattern of consumption of food from calories assurance to diet nutrient fortification. The consumers today are well educated and well informed. They are more aware of nutrient contents than ever before. In order to safeguard the rights and interests of the consumers, many regulations have been worked out and implemented. For example, it is stipulated in the Code of Federal Regulation (21 CFR 101.9) of USA that the label must have a panel of information about the nutritional quality of that food.

Hence, it is important today to develop new nutritional food, maximize their nutrient content in both processing and storage and extend the shelf-life, thus to meet the requirement of the market. In this regard, the information on nutrient change in processing and storage will be of great importance.

Guava, with the scientific name, *Psidium guajava,* derived from the Spanish "guayabe", is a member of dicotyledon family Myrtaceae. It is cultivated or grows wild throughout the tropical and subtropical regions of the world. The fruit is reported growing in more than 50 countries in the world, whose major producers are India, Brazil, and Mecca (**Lim and Khoo, 1990**). India was reported leading in the world in guava production with approximately 165,000 metric tons of fresh fruit per year while the world production was estimated to exceed 500,000 tonnes (**Jagtiani et al., 1988**). As fresh, guava is delicious and is one of the most nutritious fruits. The typical composition of guava is listed in Table 1.1 (**Holland et al., 1991**). It shows that the fruit contains high quantities of vitamin C, carotene and diet fiber. The commercial value of guava can mainly be attributed to its superior nutritive character, especially, vitamin C content. The vitamin C contents of some fruits are compared in Table 1.2 (**Belitz and Grosch, 1987**). The table shows that guava is the second richest vitamin C content among all the fruits, and it is three to six times higher than that of orange. Hence, there is a world-wide growing demand for guava as a healthy and nutritive fruit.

Guava is a seasonal fruit and is primarily consumed fresh. Currently, world trade in the processed guava products is not as much as other common fruits. However, for its nutritional value and being a seasonal fruit, the demand of processed guava products in future is likely to have steady and significant increase. Presently, the following product are being processed from guava ; ascorbic acid (vitamin C), canned slices, cheese, concentrate, dehydrated products, jam, jelly, juice, nectar, pectin, puree, spread, syrup and yoghurt (**JagtianietaI.,1988**). Clarified and cloudy guava juices are currently produced and may have greater market potential, but optimal process conditions for these products have not been determined.

Figure 1.1: Guava (*Psidium guajava*)

Table 1.1: Composition of fresh guava per 100g (**Holland et aI., 1991**)

Composition of fresh guava per 100g (**Holland et aI., 1991**)			
Water (g)	84.7	CI (mg)	4
Protein (g)	0.8	Mn(mg)	0.1
Fat (g)	0.5	Retinol *(μg)*	0
Carbohydrate (g)	5.0	Carotene *(μg)*	435
Energy Value (kJ)	112	Vitamin D *(μg)*	0
Total Nitrogen (g)	0.13	Vitamin E (mg)	Nt
Starch (g)	0.1	Thiamine (mg)	0.04
Total Sugars (g)	0.9	Riboflavin (mg)	0.04
Dietary Fiber (g)	4.7	Niacin (mg)	1.0
Na (mg)	5	Trypt 60 (mg)	0.1
K (mg)	230	Vitamin B6 (mg)	0.14
Ca (mg)	13	Vitamin BI2 *(μg)*	0
Mg (mg)	12	Folate *(μg)*	Nt
P (mg)	25	Pantothenate (mg)	0.15
Fe (mg)	0.4	Biotin *(μg)*	Nt
Cu (mg)	0.10	Vitamin C (mg)	230

Nt indicates Not detected

Table 1.2: Comparison of vitamin C content of some selected fruits

fruits	ascorbic acid (mg/100g portion)
acerola	1300
guava	300
black currant	210
strawberry	60
orange	50

1.2 Problem statement

Guava (*Psidium guajava* L.), which belongs to the Myrtaceae family, is a native of tropical America and grows well in tropical and subtropical regions. Guava fruit has a characteristic flavor, to which its acidity (pH 4.0 to 5.2) contributes (**Jagtiani *et al.* 1988**). It is a rich source of ascorbic acid, containing over 100 to 300 mg/100 g (depends on variety). Most of the guava produced around the world is consumed fresh. Clarified and cloudy guava juices are currently produced and may have greater market potential, but drying process conditions for these products have not been determined to preservation purposes.

Drying process also capable to cause a reduction in ascorbic acid content of the juice due to oxidation and temperature change. There is also potential for use of an instant guava powder in formulated drinks, baby foods and other products. Transportation costs would be reduced significantly when shipping this product to distant markets. However, information about guava powders does not exist in the literature. Guava has best nutritional properties and drying operations must be carefully designed to maintain these nutritional properties. Nutrient retention in different temperature and after dried must be investigated to determine temperature effect and water activity level or moisture content effect on guava juice and to design best drying process from the study.

1.3 Objectives

- Guava powder production spray drying methods
- Study on temperature and water activity effect to vitamin C in spray drying.

1.4 Scope

Literature shows very limited work on processing of guava powder production. Lack of sufficient engineering and nutritional data for guava processing emphasizes that more efforts need to be focused in these areas. Study on drying of guava was, therefore, started in undergraduate research work. In this study, moisture transfer and nutrient retention of guava during spray drying is investigated. In this study, nutrient level of guava puree at initial state and after powdered using spray drying in different temperature is investigated.

The objective was to prepare guava powders using spray drying methods and evaluate the effects of drying on physico-chemical properties especially temperature effect on vitamin C in guava juice. A qualitative analysis was conducted to determine the level of nutrient retention in juice a guava juice or puree after dried using spray drier which is also known as one of the highest nutrient retention drier (**Chetan A. Chopra, 2005**) compare to freeze-drying, foam mat drying, and tunnel drying. In brief, the scopes of the study are state as;

1. To preserve guava by spray drying (powdered).

2. Reduce transportation cost to distant market.

3. Evaluate temperature and moisture content effect on nutrient (vitamin C selected as index) when dried.

4. To increase shelf life

5. Produce instant guava powder as formulated drinks and baby foods.

6. To meet consumer demand guava powder.

7. Minimizing nutrient loss in processing by determine best temperature to spray dry.

CHAPTER 2

LITERATURE REVIEW

In this part literature review of food material (guava puree) will be presented.

2.1 Drying

Drying is defined as the application of heat under controlled conditions to remove the majority of the water normally present in a food by evaporation. It is a complicated process involving simultaneous heat and mass transfer in which heat penetrates into the product and moisture is removed by evaporation into an unsaturated gas phase.

Drying Mechanism

The mechanism of moisture movement within the solid in drying process has received much attention in the literature and a significant number of drying theories have been developed. Mechanisms such as, molecular diffusion, capillary motion, liquid diffusion through solid pores, vapor diffusion in air-filled pores, Knudsen flow, vaporization condensation sequence flow and hydrodynamic flow were considered. These mechanisms are of particular importance for fruits and vegetables as product structure will influence the moisture movement. **Mujumdar** (1990) reviewed theories on the mechanism of moisture migration. Generally, there appear to be four probable major modes of transfer:

1. Liquid movement caused by capillary forces;
2. Liquid diffusion resulting from concentration gradients;
3. Vapor diffusion due to partial pressure gradients;
4. Diffusion in liquid layers absorbed at solid interfaces.

Foods can be classified as *hygroscopic* and *non-hygroscopic.* The partial pressure of water vapor in hygroscopic food varies with the moisture content, while that of non-hygroscopic food is constant at different moisture contents. Thus, non- hygroscopic foods have a single falling-rate period, whereas hygroscopic foods have two falling rate periods. In the falling rate periods, the rate of moisture movement within the solid and the effects of external factors.

Moisture transfer in drying is a complex process where different mechanisms can occur at the same time. In the process of drying, mechanisms may vary considerably. A realistic model should consider as many as of the different phenomenon (e.g., simultaneous heat and mass transfer, multi-dimensional transfer, material shrinkage) occurring in the course of drying. It may not be possible to use same drying model for different foods or drying conditions.

Guava puree drying can be done by many ways. The spray-drying process has a higher retention of Vitamin C and the pro-vitamins A and beta-carotene. (**Manila Times**…). The juice or puree is dispersed or atomized to form droplets and sprayed into a heated chamber where it is dried and forms a “free-flowing” powder. The more common technologies such as convection, cabinet and drum drying are more costly, more labor-intensive, more complicated, and more likely to cause “powder burns.”

2.2 Nutrient Retention

By the definition of *ANSV* ASQC standard (ASQC, 1986), quality means “the features and characteristics of a product or service to the ability of that product or service to satisfy given needs”. In other words, it is the acceptability of the buyers, or the customers, that finally determine the degree of quality. In the present day, the majority of consumers either has a high level of educational background or get information from the guide of the authorities concerned, such as Nutritional Labeling Education of FDA in U.S.A, (**Block and Langseth, 1994**). They would rather choose natural or minimally processed food than food that contains artificial additives, such as saccharine, nitrite, etc., or “over” -processed food (**King et aI., 1989**). Such thought is somewhat correct as nutrient loss always occurs in processing and storage.

The nutrient retention of processed foods at the time of purchasing or consumption depends mainly on the compositions of the raw materials, the preprocessing or pre-storage conditions, the processing method, and the storage conditions in transportation, distribution, wholesale and retail before consumption. For the majority of food products in which the quality decreases with time, it follows that there will be a limited period of time, which is so-called the shelf-life, before the product becomes unacceptable. From the viewpoint of food processors, by the definition of Institute of Food Technologists in the USA, shelf-life is “the period between the manufacture and the retail purchase of a product, during which time the product is in a state of satisfactory quality in terms of nutritional value, taste, texture and appearance” (**Robertson, 1993**). From the definition, it encompasses the chemical, biochemical, microbiological, sensorial and nutritional stability attributes to the quality of foods. The nutrient retention will occupy a more important position in the scope of shelf-life, other than the texture, flavor and microbiological change. Hence, more attention has been paid by the food processors to determine the nutrient aspect of shelf-life of their products. The North Central Region Committee on Food Losses and Conservation (NCR-122) of U.S.A. established definitions of yield, loss and waste, in food processing and might be applied in storage as well. “Loss” was classified into two categories - avoidable waste “that loss which is avoidable by use of the best practical technology”, and unavoidable waste, “nutrients”. Now the challenge that a modern food technologist should face is to find a solution to convert the nutrient unavoidable losses to avoidable losses as much as possible not only in the processing but