

SPRAY DRYING OF ANANAS COMOSUS AND PHYSICAL PROPERTIES OF ITS  
POWDER

SHARIFAH NURNAZIHAN BT SYED FARMAN SHAH

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

Faculty of Chemical and Natural Resources Engineering  
Universiti Malaysia Pahang

APRIL 2009

## ABSTRACT

A study was conducted using SD-06 Laboratory Scale Spray Dryer to produce spray-dried pineapple powder using 4 different maltodextrin concentration (0%, 10%, 15% and 20%) as the carrier agent and three different inlet temperatures (160<sup>0</sup>C, 170<sup>0</sup>C and 180<sup>0</sup>C). The spray-dried pineapple powders were analyzed for moisture content, solubility and dissolution. Results demonstrated that as inlet temperature increased, the moisture content decreased. However, as the inlet temperature increased, the solubility and dissolution increased. With the addition of maltodextrin grade 10, the optimum conditions have been obtained are 20% maltodextrin concentration and inlet temperature 180<sup>0</sup>C.

## ABSTRAK

Satu kajian telah dijalankan dengan menggunakan “SD-06 Laboratory Scale Spray Dryer” untuk menghasilkan serbuk nanas dengan menggunakan empat peratusan maltodextrin (0%, 10%, 15% dan 20%) dan tiga suhu berlainan iaitu 160<sup>0</sup>C, 170<sup>0</sup>C dan 180<sup>0</sup>C. Serbuk nanas dianalisa dari segi kandungan kelembapan, keterlarutan dan pembubaran. Keputusan menunjukkan apabila suhu meningkat, kandungan kelembapan menurun. Walaubagaimanapun, apabila suhu meningkat, keterlarutan dan pembubaran meningkat. Dengan penambahan maltodextrin gred 10, nilai optimum yang diperoleh ialah 20% kepekatan maltodextrin dan suhu 180<sup>0</sup>C.

**TABLE OF CONTENTS**

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>ABSTRACT</b>	<b>viii</b>
	<b>ABSTRAK</b>	<b>ix</b>
	<b>TABLE OF CONTENTS</b>	<b>x</b>
	<b>LIST OF TABLES</b>	<b>xiii</b>
	<b>LIST OF FIGURES</b>	<b>xiv</b>
	<b>LIST OF APPENDICES</b>	<b>xv</b>
<b>1</b>	<b>INTRODUCTION</b>	
	1.1 Introduction	1
	1.2 Problem Statement	3
	1.3 Objectives of the Study	4
	1.4 Scope of Study	4
	1.5 Rational and Significance	5
<b>2</b>	<b>LITERATURE REVIEW</b>	
	2.1 Pineapple History	6
	2.2 Pineapple Facts	7
	2.3 Pineapple Varieties	8
	2.4 Pineapple Selection and Storage	13
	2.5 Pineapple and Health	15

2.6	Equipment	18
2.6.1	Spray Dryer	18
2.6.1.1	SD-06 Laboratory Scale Spray Dryer	20
<b>3</b>	<b>METHODOLOGY</b>	
3.1	Introduction	24
3.2	Experimental Site	24
3.3	Raw Material	25
3.3.1	Maltodextrin	25
3.4	Sample Preparation	26
3.5	Obtaining Powders by Spray Drying	27
3.6	Powder Analysis	28
3.6.1	Moisture Content Analysis	28
3.6.2	Solubility Analysis	29
3.6.3	Dissolution Test	29
<b>4</b>	<b>RESULT AND DISCUSSION</b>	
4.1	Effect of Maltodextrin	31
4.3	Moisture Content Analysis	34
4.4	Solubility Analysis	36
4.5	Dissolution Analysis	37

<b>5</b>	<b>CONCLUSION AND RECOMMENDATION</b>	
5.1	Conclusion	39
5.2	Recommendation	40

**REFERENCES**

**APPENDIX A-B**

**LIST OF TABLE**

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Nutritional Value for The Raw Pineapple	17
2.2	Technical Information of SD-06 Lab Scale Spray Dryer	23
3.1	Specifications of Maltodextrin	26
4.1	Physical Properties of The Spray-dried Powders	32

**LIST OF FIGURES**

<b>FIGURES NO</b>	<b>TITLE</b>	<b>PAGE</b>
4.1	The Effect of Inlet Temperature on Moisture Content	34
4.2	The Effect of Inlet Temperature on Solubility	36
4.3	The Effect of Inlet Temperature on Dissolution	37

**LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	Results for experiments to revise the parameter setting	47
B	Pictures of equipments and apparatus	52

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

The pineapple is the leading edible member of the family Bromeliaceae which embraces about 2000 species. Now it is known botanically as *Ananas comosus*, L. Merrill. Basically, this fruit are spread throughout South America by the natives of southern Brazil and Paraguay. Then, it was successfully cultivated in European hothouses, and pineapple pits, beginning in 1720. The pineapple usually eaten fresh, as dessert or canned or utilize it in curries and various dishes by Malayans. But, this fresh fruit is difficult to ship and the juice which is having high content of ascorbic acid cannot last longer. Therefore, juiced powder is other alternative to consume this fruit in fresh condition.

Dehydration by means of spray drying is one technique widely used in the food industry, and under optimal processing conditions, it has been proven to be an effective method to obtain various products. A dry powder product is highly desirable since it not only possesses long shelf-life, but also requires relatively low transportation cost and storage capacity and the product can be distributed over a wide area. Thus, a process for

producing a dried pineapple powder is highly desirable. However, relatively little research, especially recent studies have been carried out on dehydration of pineapple.

Spray drying is the transformation of feed from a fluid state into a dried particulate form by spraying the feed into a hot drying medium. The production of dry particles from a liquid feed in a single processing step makes a spray drying a unique and important unit operation. The design of spray drying process includes establishment of the operating conditions that increase product recovery and produce an end product of a precise quality specification.

Product recovery is mainly determined by powder collection efficiency. Material loss in a spray drying system is due mostly to the attachment of sprayed droplets and dry powder to the wall of the dryer. Particle adhesions to the wall are affected by the nature of the spray-dried material and spray drying conditions, and are commonly recognized effect in spray drying solutions containing sugars, such as fruit juices and pineapple products (Bhandari et al., 1997). During the drying process they may either remain as syrup or thick on the dryer chamber wall. Various ways of coping with such products have been researched for many years (Goose and Binsted, 1964; Gransmith, 1971; Ponting et al. 1973).

The most commonly quoted specifications of a powder involve moisture content, dissolution and solubility. The temperatures and drying conditions experienced by a droplet during have an important influence on the above powder properties (Masters, 1997; Oakley, 1997). However, the effect of process variables (e.g. the residence time of particles within the drying chamber, the conditions of atomization, the drying air temperature) upon powder properties are difficult to assess in general terms (Walton and Mumford, 1999a). This is due to the lack of information within the literature review and to the specific drying nature of most materials.

The objective of this work was to study the effect of inlet temperature and maltodextrin addition on pineapple powder moisture, solubility and dissolution.

## 1.2 Problem Statement

*Ananas comosus*, L. Merrill which belongs to the Bromeliaceae family is the common name for an edible tropical plant. This herbaceous perennial plant which is the ripe fruits one are best for eating fresh. But there are some people soaking pineapple slices in salted water before eating to make it tastier. Furthermore, the ripening of pineapple can be rather difficult as they will not ripen for some time and in a day or two become over ripe. Therefore, canned pineapple is much more preferable and widely consumed throughout the world. But, today there is growing demand for it as a beverages and powdered extract which has various roles in the food industry. In addition, fresh pineapple is often somewhat expensive as the tropical fruit is delicate and difficult to ship. Besides, cold storage at a temperature of 4.44 °C and lower causes chilling injury and breakdown in this fruit. The existence of adequate air circulation and relative humidity of 80-90% at 7-8 °C, leads to ripening progresses during and after storage. At best, pineapples may be stored for no more than 4-6 weeks. Due to this entire storage problem, pineapple cannot be exported to that kind of countries without being preservation first. So, the best way to overcome that problem is by spray drying the fruit. But drying process conditions for these products have not been determined yet. Above and beyond, transportation cost would be reduced significantly when shipping this product to distant markets. In addition pineapple 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 pineapple juice and at the same time to design best drying process from the study.

### **1.3 Objectives of the Study**

The proposed research was studied to achieve the following objectives:

1. To prepare pineapple powder using the spray drying method.
2. To evaluate the effects of drying on physical properties.

### **1.4 Scope of study**

In order to achieve the objectives, the following scopes have been identified:

1. Effect of inlet air temperature
2. Effect of maltodextrin addition.

## **1.5 Rational and Significance**

This study is to obtain the new product of pineapple that has higher values in market. Despite the fact that pineapple has become familiar item in market, it's still a true exotic. For one thing, it is a member of the bromeliad family, in which edible fruits are rare. Due to its wonderful flavor and limited in certain countries, this new product is produced to cater the market demand. As we all know, fresh pineapple simply could not survive the long journey and its juice also cannot last longer. Therefore; this study is to produce pineapple juice powder. The method that will be used is spray drying. Several researches must be done before the best quality of pineapple juice powder can be obtained. If all the research is successful, all part of the world can consume fresh distinctive aromatic qualities of pineapple.

Moreover, this new product which is pineapple powder will take much less storage space than canned or frozen foods. Therefore, transportation cost would be reduced significantly when shipping this product to distant markets. At the same time, dried product would provide a stable, natural ingredient that could be easily manipulated and used in formulated foods.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Pineapple History**

Ananas comosus is the botanical name of the fruit we know as the pineapple. Native to South America, it was named from the similarity of the fruit to a pine cone. The word was first recorded in 1938. The term pineapple (or pinappel in Middle English) did not appear in print until nearly three centuries later in 1664. Christopher Columbus is credited with discovering the pineapple on the island of Guadeloupe in 1493, although the fruit had long been grown in South America. He called it piña de Indes meaning "pine of the Indians." South American Guarani Indians cultivated pineapples for food. They called it naná, meaning "excellent fruit." Another explorer, Magellan, is credited with finding pineapples in Brazil in 1519, and by 1555, the luscious fruit was being exported with gusto to England. It soon spread to India, Asia, and the West Indies. When George Washington tasted pineapple in 1751 in Barbados, he declared it his favorite tropical fruit. Although the pineapple thrived in Florida, it was still a rarity for most Americans. Captain James Cook later introduced the pineapple to Hawaii circa 1770. However, commercial cultivation did not begin until the 1880s when steamships made transporting the perishable fruit viable. In 1903,

James Drummond Dole began canning pineapple, making it easily accessible worldwide. Production stepped up dramatically when a new machine automated the skinning and coring of the fruit. The Dole Hawaiian Pineapple Company was a booming business by 1921, making pineapple Hawaii's largest crop and industry. Today, Hawaii produces only ten percent of the world's pineapple crops. Other countries contributing to the pineapple industry include Mexico, Honduras, Dominican Republic, Philippines, Thailand, Costa Rica, China, and Asia. Pineapple is the third most canned fruit behind applesauce and peaches.

## 2.2 Pineapple Facts

The pineapple is technically not a single fruit, but a *sorosis*. The fruits of a hundred or more separate flowers grow on the plant spike. As they grow, they swell with juice and pulp, expanding to become the "fruit." Pineapples do not grow on trees, as many erroneously think. They are the fruit of a bromeliad, rising from the center on a single spike surrounded by sword-like leaves. The pineapple plant is the only bromeliad to produce edible fruit. Commercial pineapple plants are only harvested two to three years, because the fruit begins to get smaller with each year of plant life. Pineapples weigh between four and nine pounds on average but can reach weights up to twenty pounds. The waste parts left from canning plants, including the skin, core and ends, are used to make alcohol, vinegar and food for livestock. Pineapple also known as the fruit of kings, for many years, pineapples were available only to natives of the tropics and to wealthy Europeans. Despite the fact that the pineapple has become a familiar item in U.S. markets, it's still a true exotic. For one thing, it is a member of the bromeliad family, in which edible fruits are rare.

## 2.3 Pineapple Varieties

In international trade, the numerous pineapple cultivars are grouped in four main classes: 'Smooth Cayenne', 'Red Spanish', 'Queen', and 'Abacaxi', despite much variation in the types within each class.

'Smooth Cayenne' or 'Cayenne', 'Cayena Lisa' in Spanish (often known in India, Sri Lanka, Malaysia and Thailand as 'Sarawak' or 'Kew') was selected and cultivated by Indians in Venezuela long ago and introduced from Cayenne (French Guyana) in 1820. From there it reached the Royal Botanical Gardens, Kew, England, where it was improved and distributed to Jamaica and Queensland, Australia. Because of the plants near freedom from spines except for the needle at the leaf tip and the size; 4 to 10 lbs (1.8 4.5 kg), cylindrical form, shallow eyes, orange rind, yellow flesh, low fiber, juiciness and rich mildly acid flavor, it has become of greatest importance worldwide even though it is subject to disease and does not ship well. Mainly, it is prized for canning, having sufficient fiber for firm slices and cubes as well as excellent flavor. It was the introduction of this cultivar into the Philippines from Hawaii in 1912 that upgraded the Philippine industry from the casual growing of the semi-wild type which was often seedy. There are several clones of 'Smooth Cayenne' in Hawaii which have been selected for resistance to mealy bug wilt. It is the leading cultivar in Taiwan. In 1975, the Queensland Department of Primary Industries, after 20 years of breeding and testing, released a dual purpose cultivar named the 'Queensland Cayenne'. South Africa's Pineapple Research Station, East London, after 20 years of selecting and testing of 'Smooth Cayenne' clones, has chosen 4 as superior especially for the canning industry.

'Hilo' is a variant of 'Smooth Cayenne' selected in Hawaii in 1960. The plant is more compact, the fruit is smaller, more cylindrical; produces no slips but numerous

suckers. It may be the same as the 'Cayenne Lisse' strain grown in Martinique and on the Ivory Coast, the fruit of which weighs from 2 to 2 3/4 lbs (1-1 1/2 kg) and has a very small crown. 'St. Michael', another strain of 'Smooth Cayenne' is the famous product of the Azores. The fruit weighs 5 to 6 lbs (2.25-2.75 kg), has a very small crown, a small core, is sweet with low acidity, and some regard it as insipid when fully ripe.

'Giant Kew', well-known in India, bears a large fruit averaging 6 lbs (2.75 kg), often up to 10 lbs (4.5 kg) and occasional up to 22 lbs (10 kg). The core is large and its extraction results in too large a hole in canned slices. 'Charlotte Rothschild', second to 'Giant Kew' in size in India, tapers toward the crown, is orange-yellow when ripe, aromatic, very juicy. The crop comes in early. 'Baron Rothschild', a Cayenne strain, grown in Guinea, has a smaller fruit 1 3/4 to 5 lbs (0.8-2 kg) in weight, marketed fresh. 'Perolera' (also called 'Tachirensis', 'Capachera', 'Motilona', and 'Lebrija') is a 'Smooth Cayenne' type ranking second to 'Red Spanish' in importance in Venezuela. It has long been grown in Colombia. The plant is entirely smooth with no spine at the leaf tip. The fruit is yellow, large-7 to 9 lbs (3-4 kg) and cylindrical.

Other variants of 'Smooth Cayenne' include the 'Esmeralda' grown in Mexico and formerly in Florida for fresh, local markets; 'Typhone', of Taiwan; 'Cayenne Guadeloupe', of Guadeloupe, which is more disease resistant than 'Smooth Cayenne'; and 'Smooth Guatemalan' and 'Palin' grown in Guatemala; also 'Piamba da Marquita' of Colombia. Some who have made efforts to classify pineapple strains have proposed grouping all smooth-leaved types under the collective name 'Maipure'. In Amazonas, Venezuela, this name is given to a large plant with smooth leaves stained with red. The fruit has 170 to 190 eyes.

Philipps Platts, a leading pineapple authority, experimented with 60 to 70 cultivars in Florida but 'Red Spanish' proved most dependable. Despite the spininess of

the plant, it still is the most popular among growers in the West Indies, Venezuela and Mexico. 'Red Spanish' constitutes 85% of all commercial planting in Puerto Rico and 75% of the production for the fresh fruit market. It is only fair for canning. The fruit is more or less round, orange-red externally, with deep eyes, and ranges from 3 to 6 lbs (1.36-2.7 kg). The flesh is pale-yellow, fibrous, with a large core, aromatic and flavorful. The fruit is hard when mature, breaks off easily and cleanly at the base in harvesting, and stands handling and transport well. It is highly resistant to fruit rot though subject to gummosis.

'Cabezona' ('Bull Head', or 'Pina de agua') is a prominent variant (a natural tetraploid) of 'Red Spanish' long grown in Puerto Rico in the semiarid region of Lajas, to which it is well suited; also in El Salvador. The plant is large, over 3 ft (1 m) high; the leaves are gray-green. The fruit is conical but not as tall as that of 'Valera'; averages 4 to 6 lbs (1.8-2.75 kg) and may reach 18 lbs (8 kg) or more. It is orange-yellow at maturity, has few fibers and sweet-acid flesh. The stem is large and extends up into the base of the fruit and if the fruit is broken off when harvested it leaves a cavity. Consequently, it must be cut with a machete and later trimmed flush with the base in the packing house. It is marketed fresh only. It is resistant to gummosis. There are small plantings in the States of Trujillo and Monagas, Venezuela. It has been cultivated frequently in the Philippines.

'Valera Amarilla' is a 'Red Spanish' strain grown in the States of Lara and Trujillo in Venezuela. The fruit is broad cylindrical and tall with a large crown; weighs 4 1/2 to 9 lbs (2-4 kg); is yellow externally with very deep eyes, about 72 to 88 in number. The flesh is pale-yellow and very sweet in flavor. 'Valera Roja', grown in Lara, Trujillo and Merida, Venezuela, is a small-to-medium plant with cylindrical fruit 1 1/2 to 2.2 lbs (0.6-1 kg) in weight, reddish externally, with 100 eyes. It has pale-yellow flesh.

'Castilla' is a 'Red Spanish' strain grown in Colombia and El Salvador. 'Cumanesa', supposedly a selection of 'Red Spanish', grown mainly in the State of Sucre, Venezuela, is a medium-sized plant, very spiny, producing an oblong fruit with a large crown. It is orange-yellow externally; weighs 2 to 3 3/4 lbs (0.9-1.70 kg) and has yellowish-white flesh. 'Morada', believed to be a variant of 'Red Spanish', is one of the less important cultivars of Colombia and the State of Monagas, Venezuela. The plant is large, with long, narrow, purple-red leaves. The fruit is broad-cylindrical, purple-red externally, with white flesh.

'Abacaxi' (also called 'White Abacaxi of Pernambuco', 'Pernambuco', 'Eleuthera', and 'English') is well known in Brazil, the Bahamas and Florida. The plant is spiny and disease-resistant. Leaves are bluish-green with red-purple tinge in the bud. The numerous suckers need thinning out. The fruit weighs 2.2 to 11 lbs (1-5 kg), is tall and straight-sided; sunburns even when erect. It is very fragrant. The flesh is white or very pale yellowish, of rich, sweet flavor, succulent and juicy with only a narrow vestige of a core. This is rated by many as the most delicious pineapple. It is too tender for commercial handling, and the yield is low. The fruit can be harvested without a knife; breaks off easily for marketing fresh.

'Sugarloaf' (also called 'Pan de Azucar') is closely related to 'Abacaxi', and much appreciated in Central and South America, Puerto Rico, Cuba and the Philippines. The leaves of the plants and crowns pull out easily and this fact gave rise to the unreliable theory that pineapple ripeness is indicated by the looseness of the leaves. The fruit is more or less conical, sometimes round; not colorful; weighs 1 1/2 to 3 lbs (0.68-1.36 kg). Flesh is white to yellow, very sweet, juicy. This cultivar is too tender for shipping.

'Singapore Red' (Also called 'Red Jamaica', 'Singapore Spanish', 'Singapore Queen', 'Singapore Common') is second to 'Mauritius' in popularity. The leaves are usually all-green but sometimes have a reddish stripe near the margins; they are rarely spiny except at the tips. The fruits, cylindrical, reddish, with deep eyes, are small; 3 1/2 to 5 lbs (1.6-2.25 kg) with slender core, fibrous, golden-yellow flesh; insipid raw but valued for canning. The plant is disease and pest-resistant. The related 'Green Selangor' (also called 'Selangor Green', 'Green Spanish', and 'Selassie') of Malaysia has all-green leaves prickly only at the tips. The flesh is golden-yellow, often with white dots. This cultivar is grown for canning.

'Queen' (also called 'Common Rough' in Australia) is the leading cultivar in South Africa, Queensland and the Philippines. The plant is dwarf, compact, more cold-resistant and more disease-resistant than 'Smooth Cayenne'. It matures its fruit early but suckers freely and needs thinning, and the yield is low. The fruit is conical, deep-yellow, with deep eyes; weighs 1 to 2 1/2 lbs (0.45-1.13 kg); is less fibrous than 'Smooth Cayenne', but more fragrant; it is juicy, of fine flavor with a small, tender core. It is sold fresh and keeps well. It is only fair for canning because of its shape which makes for much waste.

'Natal Queen' of South Africa, also grown in El Salvador, produces many suckers. The fruit weighs 1 1/2 to 2 lbs (0.75-0.9 kg). 'MacGregor', a variant of 'Natal Queen' selected in South Africa and grown also in Queensland, is a spreading, more vigorous plant with broad leaves and large suckers produced less freely. The fruit is cylindrical, medium to large, with firm flesh and flavor resembling 'Queen'. 'James Queen' (formerly 'Z') is a mutation of 'Natal Queen' that originated in South Africa. It has larger fruit with square shoulders.

'Ripley' or 'Ripley Queen', grown in Queensland, is a dwarf, compact plant with crimson tinge on leaves; takes 22 weeks from flowering to fruit maturity; is an irregular bearer. The fruit weighs 3 to 6 lbs (1.36-2.7 kg); is pale-copper externally; flesh is pale-yellow, non-fibrous, very sweet and rich. In Florida this cultivar tends to produce suckers without fruiting. 'Alexandria', a selection of 'Ripley Queen' in Queensland, is more vigorous with large suckers and fruit. The fruit is conical, tender, with 'Ripley Queen' flavor. 'Egyptian Queen' was introduced into Florida in 1870. It was popular at first, later abandoned. The fruit weighs 2 to 4 lbs (0.9-1.8 kg). 'Kallara Local' is a little-known cultivar in India. Minor strains in Thailand are 'Pattavia', 'Calcutta', 'Sri Racha', 'Intorachit' and 'Chantabun'.

In the evaluation of pineapples, the crown can be an asset or a liability. Small crowns detract from the decorative appearance of the fruit; large crowns are more attractive but hamper packing and constitute too great a proportion of inedible material from the standpoint of the purchaser.

## **2.4 Pineapple Selection and Storage**

Peak season for fresh pineapple in Malaysia is from March to July, but it is available year-round in most markets. Once the fresh pineapple is cut from the plant, it will not ripen any further, so forget about letting it ripen on the counter. Without any starch reserves to convert to sugar, it will simply begin to rot and ferment. Fresh ripe pineapples should have green, fresh-looking leaves in a small, compact crown, and a leaf should be easy to remove if fully ripe. Once again, the nose proves to be a powerful tool in determining ripeness.

The fruit should be plump, feel heavy and have a strong sweet, but not fermented, pineapple aroma. Coloring may be green or yellow-gold, depending on the variety. Feel the bottom. It should yield to medium pressure, have no indication of mold, and the eyes should be bright, shiny and flat. Avoid any that are dry or look old and wrinkly. Dark eyes, soft spots and yellowed leaves are all indicators of a pineapple way past its prime. Many grocery stores stock fresh pineapple and will peel and core it on demand using a simple machine. If you do not have the benefit of your grocer's machine, use a sturdy, sharp serrated knife to cut off the base and the crown (save the crown and try growing your own pineapple at home.). Slice off the skin in a downward vertical motion, following the natural curvature of the fruit. Be sure to slice far enough in to cut off the eyes, which are woody or dig out the eyes with the knife tip or the tip of a peeler. To preserve the escaping juice, trim the pineapple on a platter. Don't discard those skins just yet. They will still hold some juice which you can squeeze out. The center core of the pineapple is tough and fibrous. It is usually trimmed away before using the remainder of the pineapple flesh.

Fresh pineapple is often somewhat expensive as the tropical fruit is delicate and difficult to ship. Pineapples can ripen after harvest, but require certain temperatures for this process to occur. It is also quite perishable. It bruises easily in spite of its seemingly armored exterior and will ferment if kept at room temperature for too long. If storing at room temperature, use within two days. Storing at room temperature will increase the acidity level of the pineapple, but will not improve sweetness. You can extend the lifespan to three to five days by refrigerating the whole pineapple in a perforated plastic bag. Once trimmed and cut, be sure the pineapple is covered in juice in an airtight container, refrigerate and use within five to seven days. Let the fruit return to room temperature before eating to improve flavor. Freshly-cut pineapple can be frozen in juice or syrup, but it will lose some flavor. Peel, core and cut into chunks. Place in airtight plastic bags or covered containers with their natural juice and freeze up to 6 months. Canned pineapple is available in slices, chunks, crushed, and juice. It

takes three pineapples to produce one can of sliced rings. Fancy grade comes from the sweeter bottom portion of the pineapple. Soaking canned pineapple in cold water for half an hour will remove some of the tinny flavor. Canned pineapple can be stored up to one year on the shelf in a cool, dry cabinet. Leftover canned pineapple should be refrigerated in its juice in a covered container and consumed within a week.

## **2.5 Pineapple and Health**

Pineapple juice has been fermented into an alcoholic beverage in the past, and used to alleviate body heat and fevers. It was used externally to dissolve warts, callouses and painful corns. Due to the large amounts of natural acids (citric, malic, and tartaric) and bromelain enzyme, large amounts of fresh pineapple should not be consumed as a main dish. On the other hand, it is these same juices in moderate amounts that aid in digestion as they closely resemble natural gastric juices. Pineapple is also a natural diuretic; helps clear mucous from bronchial tissues, and its fiber aids in elimination.

The resin in the pineapple skin may cause an itchy rash in some people (as does the mango). Gloves are recommended for those prone to rashes while handling and skinning the fresh fruit. Unripe pineapple is not only inedible, it is poisonous, causing throat irritation and severe vomiting and diarrhea. Excessive consumption of the fibrous pineapple core can result in fiber balls collecting in the digestive tract.

Pineapple contains a proteolytic enzyme bromelain, which digests food by breaking down protein. Pineapple juice can thus be used as a marinade and tenderizer