PHYSICAL PROPERTIES OF SOURSOP (*ANNONA MURICATA*) POWDER PRODUCED BY SPRAY DRYING

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A dissertation submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Engineering (Chemical Engineering)

Faculty of Chemical and Natural Resources Engineering
Universiti Malaysia Pahang

APRIL 2009

`I declare that this dissertation entitled “Physical Properties of Soursop (*Annona Muricata*) Powder Produced by Spray Drying” is the result of my own research except as cited in the references. The dissertation has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date :

To my beloved mother, Kamariah Bt Osman

ACKNOWLEDGEMENTS

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Prof Madya Nordin Bin Endut, for encouragement, guidance, critics and friendship. Without her continued support and interest, this thesis would not have been the same as presented here. I believe that all his advice and comments are for the benefit of producing the best research project.

My fellow postgraduate students should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. The experiences and knowledge I gained throughout the process of completing this research project would prove invaluable to better equip me for the challenges which lie ahead.

Last but definitely not the least I am grateful to all my family members. I can never thank you enough for your love, and for supporting me throughout my studies in Universiti Malaysia Pahang (UMP).

Praise to God for His help and guidance that I finally able to complete this research project.

ABSTRACT

The growing of fruits 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. Actually, this research, is a about soursop fruits. Soursop fruit does not travel well and is rarely available fresh in areas where it is not grown. Nutritionally, the soursop fruit is high in carbohydrates, particularly fructose and also contains significant amounts of vitamin C, vitamin B1, and vitamin B2. Parts of the soursop tree are used in natural medicine in the tropics, including the bark, leaves, roots, fruit, and fruit seeds. The fruit and fruit juice are taken for worms and parasites, to cool fevers, to increase mother's milk after childbirth, and as an astringent for diarrhea and dysentery. Spray drying has become the most important method for the dehydration of fluid foods such as juices. This study is undertaken to investigate the feasibility of spray drying of soursop juice and to evaluate the physical properties of the powder produced. Independent variables were: inlet air temperature (160–190 °C) and maltodextrin concentration (10–25% of total feed solution). Moisture content, hygroscopicity, process yield, solubility and dissolution were analyzed as responses. Powder moisture content and process yield were positively affected by inlet air temperature which is directly related to heat and mass transfer. Process yield was also negatively influenced by maltodextrin concentration. Powders hygroscopicity decreased with increasing maltodextrin concentration and decreasing temperature. Powders with lower moisture content were more hygroscopic, which is related to the greater water concentration gradient between the product and the surrounding air. The result shows the optimum condition for Inlet Air Temperature is 170^0C. While for maltodextrin concentration is 10%.

ABSTRAK

Pada hakikatnya, buah durian belanda mempunyai keistimewaan tersendiri untuk diterokai. Buah ini tidak boleh dieksport dan jarang sekali didapati segar di kawasan di mana bukan habitatnya. Dari segi kesihatan, buah durian belanda adalah kaya dengan karbohidrat, terutama fruktosa dan juga mengandungi vitamin C, vitamin B1, dan vitamin B2. Penduduk di kawasan pedalaman membuat ubat-ubatan tradisional daripada bahagian-bahagian pokok durian belanda termasuk kulit, daun, akar, buah, dan biji benih. Buah dan jus durian belanda biasanya diambil untuk menghapuskan cacing dan parasit dalam badan, mengurangkan demam, meningkatkan susu ibu selepas bersalin dan sebagai astrigen untuk cirit-birit. Proses pengeringan sembur merupakan kaedah penting yang banyak digunakan dalam pengeringan makanan seperti jus buah-buahan. Kajian ini dijalankan untuk mengkaji keberkesanan proses ini bagi jus durian belanda dan untuk menentukan ciri-ciri fizikal bagi serbuk yang dihasilkan. Pembolehubah tidak bersandar adalah: suhu udara (160–190 °C) dan penambahan maltodekstrin (10–25% daripada jumlah jus yang digunakan). Kandungan lembapan, higroskopian, kelarutan dan jumlah keseluruhan kandungan pepejal dianalisis sebagai tindakbalas. Kandungan lembapan dan jumlah keseluruhan kandungan pepejal bagi serbuk yang dihasilkan dipengaruhi oleh suhu udara yang mana berkaitan dengan pemindahan haba dan jisim. Jumlah keseluruhan kandungan pepejal juga dipengaruhi oleh penambahan maltodekstrin. Penambahan maltodekstrin dan pengurangan suhu udara menyebabkan serbuk higroskopian berkurang. Serbuk dengan kandungan lembapan lebih rendah adalah lebih higroskopik, yang berkaitan dengan perbezaan kepekatan air antara produk dan udara sekeliling. Keputusan menunjukkan keadaan optimum untuk suhu udara adalah 170^0C. Manakala untuk penambahan maltodekstrin adalah 10%.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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. Due to their high value and wide appeal to consumers, fruits and vegetables have always been of interest to food scientists as raw materials for processed products. The most frequent reason for quality deterioration of food products is the result of microbial activity and this often results in food molding, fermenting and change in acidity. In addition, native enzymes in fruits may cause desirable and undesirable effects before, during or after processing of fruit juices. In order to complete my undergraduate research project and with a supported reason above, I choose food engineering as my major topic of research. My research will fully concentrate on preservation of fruits. The fruit that attract my intention is soursop while the preservation technique is drying.

There are about 60 or more species of the genus *Annona*, family *Annonaceae*. But from that entire species, the soursop is the most tropical and only itself is best suit for preserving and processing.

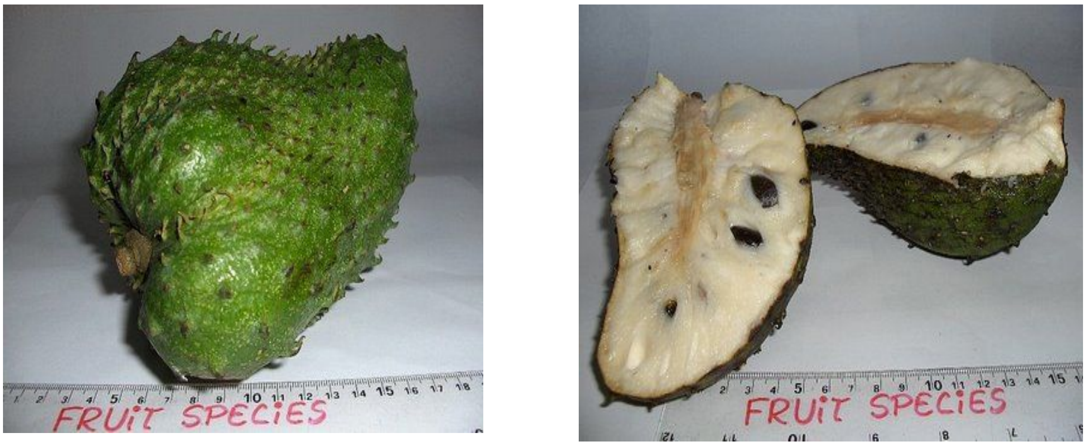

Figure 1.1: Soursop Fruit

- **Common Name: Soursop**
- **Vernacular Names: Sour sop, Guanabana, Soursap**
- **Scientific Name: Annona muricata**
- **Specimens From: Malaysia**

The soursop is also known as soursap, guanábana, graviola, sirsak, zuurzak, coração-da-índia, guyabano or corossol. Soursop or in scientific name, Annona muricata L. is one of the exotic fruits prized for its very pleasant, sub-acid, aromatic and juicy flesh. It is related to pawpaw and custard apple and around 30 tonnes are grown in Australia every year in tropical north Queensland. It is also native to the Caribbean, Central and South America. In the USA it has limited production in Florida. Soursop, known as a native fruit from the West Indies, Central America, down to Brazil and it is a common fruit in tropical Asia nowadays. The soursop tree is actually trees that comes from the Caribbean and northern South America. Today the soursop has spread throughout the humid tropics so it is also grown in Southeast Asia included Malaysia and Indonesia. This fruit can be round, oval or irregular heart shaped. Some cultivars are huge, almost the size of a watermelon. It is dark green when unripe and will turn yellowish-green and slightly soft when it matures. Black blotches will start to appear and that indicates overripe.

As mention above, Soursop (Annona muricata L.) is a common fruit in tropical Asia so it is one of the popular exotic fruits in Malaysia. Soursop also is one of the most nutritious fruits in the tropical region. The white cottony pulp is very juicy, varying in flavour from acid to sweet and highly regarded because of its distinctive aroma and flavour. The flesh or pulp that is creamy white in color and has the texture of juicy candy floss interlaced with black seeds. The taste is not sour as the name suggests but sweet and musky. The flavour was tropical, strong and pungent on entry but with a delicate ending and a soothing creamy aftertaste. They taste similar to lychees but also have a ripe purée pear and bitey pineapple edge to them.

Soursop is extremely juicy and seedy; hence it is quite a messy fruit to eat. The skin may look leathery but it tears easily. Just cut it like you would cut a watermelon. The interior texture may not look nice but the taste is refreshing and flavorful. However, it softens very rapidly during ripening and becomes mushy and difficult to consume fresh. It is rejected at market because of external injury, or uneven shape and size. It is mostly eaten as fresh fruits. Therefore, soursop can become a potential source of raw material for puree, juice, jam, jelly, powder fruits bars and flakes. It is also excellent for making refreshing drinks, sherbets and flavoring/topping for ice-cream and dessert. It is classified as a premium tropical fruit. As such, it offers potential for the soft drink industry.

But at the same time, the soursop is usually juiced rather than eaten directly because of the white interior pulp is full with many seeds, and pockets of soft flesh are bounded by fibrous membranes. Furthermore, this fruit does not travel well and is rarely available fresh in areas where it is not grown. This is because soursop is a highly perishable fruit with short shelf life. Once the juice has been extracted and placed in storage it will need considerable treatment before being acceptable to the consumer. So that, juiced powder is other alternative to consume this fruit in fresh condition.

Several methods may be used for production of juiced powder, but the most successful include freeze-drying, foam mat drying, spray drying and tunnel drying. Researchers have successfully used freeze drying to convert juiced products into powder although freeze drying is known to be the most expensive method of drying. Tunnel drying is well known to be the cheapest method of drying an acceptable quality powder. The foam-mat drying process is a relatively simple and inexpensive process. One difficulty that has previously been experienced with this process, however, is the lack of stability of the foam during the heating cycle. If the foam does not remain stable, cellular breakdown occur causing serious impairment of the drying operation. But dehydration by means of spray drying is a technique which widely used to produce fruit juices powders ([Abadio et al., 2004], [Cano-Chauca et al., 2005] and [Quek et al., 2007]) and it has been proven to be an effective method to obtain various products.

Spray drying has become the most important method for the dehydration of fluid foods such as milk, coffee and egg powder, and is also used extensively in the pharmaceutical and chemical industries. It is a method whereby solutions or slurries are rapidly dried to particulate form by atomizing the liquid in a heated chamber. Typically performed using aqueous systems, spray drying can also be undertaken with solvent-based systems under controlled conditions.

Spray drying is a process to convert small liquid droplets into dried powder in contact with hot air. Rapid evaporation maintains droplet temperature at low level, so that high drying air temperatures can be applied without affecting the product quality. The drying time of the droplets in spray dryer is very short in comparison with most other drying processes. There are many type of dryer such as constant bed dryer, fluidize bed dryer and microwave dryer that used hot air flow for drying foods. The cyclone spray dryer is the most commonly used. Typically, a liquid product concentrate is pumped to the atomizing device where it is broken into small droplets. These droplets meet a stream of hot gas and lose moisture very rapidly while suspended in the drying air. The dry powder is separated from the moist air in cyclones by centrifugal action. The atomizer comprises either a spinning disc (rotating at 2000-20,000 rpm) or static high velocity jet nozzles. Hot air contacts with solid products such as grains, vegetables and fruits pulps and dry them. These dryers need long time for drying processes. Low product temperature and short drying time allow spray drying of very heat sensitive products such as foods, dairy products and fruit juices. Powder that produced by it is in a good quality, low water activity and easier transport and storage. This is due to the reduction of volume and longer shelf life. Besides, spray dried powder was stable and could be produced at a lower cost.

Spray drying consists of the following unit operations:

- Pre-concentration of liquid (for more economic operation, since evaporation is expensive)
- Atomization (creation of droplets)
- Drying in stream of hot, dry gas (usually air)
- Separation of powder from moist gas
- Cooling
- Packaging of product

The process of materials in spray dryers is a complex interaction involving apparatus, process and product parameters, which affects the final quality of the materials. The quality of spray dried food is quite dependent on the spray dryer operating parameters. The spray drying process is greatly affected by feed flow rate, inlet-air temperature, atomizer speed, feed concentration, feed temperature, inlet air flow rate and etc. (Chegini, Ghobadian, & Barecatin, 2005).

Atomization is of particular interest to the metal industry for generating fine powders. Generally it is carried out using an inert carrier gas. This gas forces molten powder (notably aluminum or solder) through a nozzle and then cools the droplets into highly spherical powders. The physics of gas atomization of metal powders involves multiphase gas flow, heat transfer, droplet formation, and solidification. Interaction between these individual mechanisms complicates understanding and modeling of the process. In addition, the chemical activity between some metals introduces further complexity. The challenge is to increase the powder yield, improve the powder quality and reduce the production cost. This requires both a thorough understanding of the process and a comprehensive experimental investigation in order to guide the design of the gas atomizer and to determine optimal settings of critical process variables.

Therefore, it is important to optimize the drying process in order to obtain products with better performance included sensory and nutritional characteristics and better process yield. In addition to the powder production, the quality of food spray dryer depend the operating variables. Studying the effect of operating parameters on powder physical properties help us in obtaining the optimum operating conditions of spray dryer and powder characteristics.

1.2 Problem Statement

Several varieties of the fruits are grown for export and for local consumption. Some of the fruit is, however, wasted at the production points due to nonavailability of sufficient storage, transportation and processing facilities. Soursop utilization as we can see whether in the producer country or for export to premium markets have always been limited by the perishable nature of the fruits. As mention earlier, soursop also known as *Annona Muricata* is one of exotic fruits. It is a well-known fruit throughout much of world because of its delicious white pulp and has pleasantness sub acid taste that is very exquisite. Those characteristics make soursop very unique fruits and have higher ability to be commercialized. Soursop can be found in tropical market, but is rarely found fresh anywhere else due to its short shelf life. The soursop is adapted to areas of high humidity and relatively warm. While, temperatures below 5 ^{o}C will cause damage to leaves and small branches, and temperatures below 3 ^{o}C can be fatal to the soursop trees. In association with this climates problem, most of these products present high water content, making them more susceptible to decomposition by microorganisms, chemical and enzymatic reactions. Therefore, these products are extremely perishable and cannot be marketed or exported as fresh produce. Furthermore, soursops are quite costly these days, and many fruit vendors do not like to stock them because they ripened very quickly, and cannot be stored for long.

One of the alternatives to overcome those problems is to make soursop juice, so that every country can taste the freshness of soursop pulp at every second of time. But in the same time, freshly expressed juice, is highly susceptible to spoilage, in fact more so than whole fruit. Unprotected by skin or cell walls, fluid components are thoroughly mixed with air and microorganism from the environment. Thus, unheated juice is subject to rapid microbial, enzymatic, chemical and physical deterioration. The goal of processing is to minimizing these undesirable reactions while still maintaining and in cases enhancing, the inherent quality of the starting fruit (Bates et al., 2001).

The most frequent reason for quality deterioration of food product is the result of microbial activity and this often result in food molding, fermenting and change in acidity. Concentrated fruits juice also cannot stand longer; therefore productions of juice powder are very suitable to fulfill any transportation conditions. Juice powders allow longer periods of storage, minimize packaging requirements and reduce shipping weight. At the same time, the soursop often made into juice because eating raw is a somewhat messy proposition.

All parts of the soursop, including the skin and seeds, are poisonous except for the fruit itself. A very suitable condition must be investigated to determine temperature effect and water activity level or moisture content effect on soursop juice and at the same time to design best drying process. As in this research, spray drying was used. But fruit juice powders obtained by spray drying may have some problems in their properties, such as stickiness, hygroscopicity and solubility, due to the presence of low molecular weight sugars and acids, which have low glass transition temperature (Bhandari et al., 1993). Thus they can stick on the dryer chamber wall during drying, leading to low product yield and operational problems. Part of these problems can be solved by the addition of some carrier agents, like polymers and gums, to the product before being atomized. Besides reducing powder hygroscopicity, such agents, normally used for microencapsulating, can protect sensitive food components against unfavorable ambient conditions, mask or preserve flavors and aromas, reduce the volatility and reactivity and provide additional attractiveness for the merchandising of food products (Ré, 1998).

Some researchers have used carrier agents in order to protect sensitive components like vitamin C in fruits such as camu–camu juice and to increase product stability in acerola powder. In the case of açai juice, spray drying with carrier agents represents an interesting process, which can promote the protection of anthocyanins against adverse conditions like heat, light and oxygen, besides resulting in less hygroscopic powders. For this experiment, carrier agent that was being used are maltodextrin. Addition of maltodextrin could increase the total solid content in the feed and thus, reduce the moisture content of the product. It was suggested that maltodextrin could alter the surface stickiness of low molecular weight sugars such as glucose, sucrose and fructose and organic acids, therefore, facilitated drying and reduced the stickiness of the spray-dried product.

1.3 Objectives of the Study

There are considerably substantial amount of works on spray drying of fruit juice up-to-date. However, there have been limited scientific literatures concerning drying of soursop juice. Based on the above reasons, this study is undertaken to investigate the feasibility of spray drying of soursop juice and to evaluate the physicochemical properties of the powder produced. Due to a lack of studies on the influence of the process variables on the physicochemical properties of soursop powdered juices, the research was studied to achieve the following objectives:

1. To produce soursop powders using spray drying.
2. To study the influence of inlet air temperature and maltodextrin concentration on process yield of soursop powders.
3. To study the hygroscopicity, dissolution, solubility and sensory evaluation of powders obtained.

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 concentration.

1.5 Rationale and Significance

This study is to obtain the best product of soursop that has higher values in market. Soursop is one of exotic fruits that have higher potential to be commercialized. Since the soursop is rarely found and is a seasonal fruit, thus the food industry is constantly looking for inexpensive and more stable stages of sources. One of the best solutions is by producing juice powder of soursop. Several researches must be done before the best quality of soursop juice powder can be obtained. Powders obtained by drying concentrated fruits juices or pulps could represent interesting commodities. If all the research is successful, all part of the world can consume fresh distinctive aromatic qualities of soursop.

Others rationale that we can elaborate is saving cost in terms of transportation. Transportation costs 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 Soursop, *Annona muricata*

2.1.1 Name History

The soursop, *Annona muricata* L., is one of the exotic fruits that can be found in Malaysia. Actually there are about 60 or more species of the genus *Annona*, family *Annonaceae* but the largest-fruited, and the only one lending itself well to preservation and processing is *Annona Muricata.* It is a broadleaf flowering evergreen tree native to Mexico, Central America, the Caribbean and northern South America. Nowadays, it is also grown in some areas of Southeast Asia. Thus, there will be a different name for soursop in a different country. In Malaysia it may be called *durian belanda, durian maki*; or *seri kaya belanda*. The name may have originally come from the Dutch "zuurzak", which is also used in the Netherlands Antilles and Indonesia; but the derivation is uncertain. The Malay name does indicate this Dutch origin. The word "Belanda" means Hollander and was used to indicate something foreign and made known by the Dutch. Because the fruit is spiny, the word "durian" was also applied to indicate its similarity to the familiar durian fruit. This interpretation indicates that the fruit was "foreign", but resembled something "familiar" or already known and has resulted in other interesting etymology of that region. "Halwa belanda" means chocolate and "kuching belanda" means "foreign cat' or "rabbit", which was also introduced into Malaysia. Soursop is also known as "western durian" among the Chinese community, mainly because of the soft spikes on the skin that look similar to the durian. But it is totally unrelated, as in fruit family classifications, and tastes totally different too.

2.1.2 Description

The soursop tree is low-branching and bushy but slender because of its upturned limbs, and reaches a height of 25 or 30 ft (7.5-9 m). The malodorous leaves, normally evergreen, are alternate, smooth, glossy, dark green on the upper surface, lighter beneath; oblong, elliptic or narrowobovate, pointed at both ends. The small trees bear their fruit indiscriminately on twigs, branches and trunk. These fruits range in size from four to twelve inches in length, and up to about ten pounds in weight. They can be oval or irregularly shaped as one side usually grows faster than the other. The fruit is more or less oval or heart-shaped, some times irregular, lopsided or curved, due to improper carper development or insect injury. The size ranges from 4 to 12 inches long and up to 6 inches in width and the weight may be up to 10 or 15 pounds. The fruit is compound and covered with a reticulated, leathery-appearing but tender, inedible, bitter skin from which protrude few or many stubby, or more elongated and curved, soft, pliable "spines". The tips break off easily when the fruit is fully ripe. The thin skin has a leathery appearance, but is surprisingly tender. This skin is a dark green, but later turns yellowish-green, and finally all yellow when over-ripe. Because of the soft spines on the skin, the soursop is sometimes called the prickly custard apple. The white flesh consists of numerous segments. If there are seeds, they cannot be eaten as they contain toxins. The fruits are picked while still firm and said to be at their best if eaten five or six days later. The flavour varies from poor (like wet cotton) to very good, but it is more acidic than its relatives. The aroma is like that of a pineapple. Depending on the variety, some can be opened like a melon and eaten raw; while others, especially unripened fruit is best used as a vegetable. When boiled, it has the flavour of corn. Large fruit of soursop may contain from a few dozen to 200 or more seeds.

2.1.3 Climate

The soursop is truly tropical. This was proven in much country that possesses soursop trees. All young trees in exposed places in southem Florida are killed by only a few degrees of frost. The trees that survive to fruiting age on the mainland are in protected situations, close to the south side of a house and sometimes near a source of heat. Even so, there will be temporary defoliation and interruption of fruiting when the temperature drops to near freezing. In Key West, where the tropical breadfruit thrives, the soursop is perfectly at home. In Puerto Rico, the tree is said to prefer an altitude between 800 and 1,000 ft (244300 m), with moderate humidity, plenty of sun and shelter from strong winds. From this situation, the researchers have jump to conclusion that the soursop is adapted to areas of high humidity and relatively warm winters. The temperatures below 5 °C will cause damage to leaves and small branches while temperatures below 3 °C can be fatal. In the tropics, soursops are grown from sea level to 1000m, particularly in humid regions where the tree grows particularly well. In addition, soursops cannot tolerate standing water, and its roots are shallow, so it does not require a very deep soil base. As the best growth of soursop is achieved in deep, rich, well-drained, semi-drysoil, but the soursop tree can be and is commonly grown in acid and sandy soil.

2.1.4 Harvesting

The soursop tends to flower and fruit more or less continuously, but in every growing area there is a principal season of ripening. The fruit is picked when full grown and still firm but slightly yellow-green. If allowed to soften on the tree, it will fall and crush. It is easily bruised and punctured and must be handled with care. Firm fruits are held a few days at room temperature. When eating ripe, they are soft enough to yield to the slight pressure of one's thumb. Having reached this stage, the fruit can be held 2 or 3 days longer in a refrigerator. The skin will blacken and become unsightly while the flesh is still unspoiled and usable. Studies of the ripening process have determined that the optimum stage for eating is 5 to 6 days after harvest, at the peak of ethylene production. Thereafter, the flavor is less pronounced and a faint off odor develops. In Venezuela, the chief handicap in commercial processing is that the fruits stored on racks in a cool shed must be gone over every day to select those that are ripe and ready for juice extraction.

2.1.5 Nutrition and Medical Uses

Table 2.1: Nutrient values and weights are for edible portion of Soursop, raw

Nutrient	Units	Value per 100 grams	Number of Data Points	Std. Error	1.00 X 1 cup, pulp ------- 225g	1.00 X 1 fruit (7" x 5-1/4" dia) ------- 625g
Proximates						
Water	g	81.16	1	0	182.61	507.25
Energy	kcal	66	0	0	148	412
Energy	kj	276	0	0	621	1725
Protein	g	1.00	0	0	2.25	6.25
Total lipid (fat)	g	0.30	0	0	0.68	1.88
Ash	g	0.70	0	0	1.57	4.38
Carbohydrate, by difference	g	16.84	0	0	37.89	105.25
Fiber, total dietary	g	3.3	0	0	7.4	20.6
Sugars, total	g	13.54	0	0	30.46	84.62
Minerals						
Calcium, Ca	mg	14	0	0	32	88
Iron, Fe	mg	0.60	0	0	1.35	3.75
Magnesium, Mg	mg	21	1	0	47	131
Phosphorus, P	mg	27	0	0	61	169
Potassium, K	mg	278	3	12.676	626	1738
Sodium, Na	mg	14	3	5.526	32	88
Zinc, Zn	mg	0.10	0	0	0.23	0.62
Copper, Cu	mg	0.086	0	0	0.193	0.537
Selenium, Se	mcg	0.6	0	0	1.4	3.8
Vitamins						
Vitamin C, total ascorbic acid	mg	20.6	16	1.503	46.4	128.8
Thiamin	mg	0.070	0	0	0.158	0.438
Riboflavin	mg	0.050	0	0	0.113	0.312
Niacin	mg	0.900	0	0	2.025	5.625
Pantothenic acid	mg	0.253	0	0	0.569	1.581
Vitamin B-6	mg	0.059	1	0	0.133	0.369