DEVELOPMENT OF SPRAY DRIED SUGARCANE POWDER

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DEVELOPMENT OF SPRAY DRIED SUGAR CANE POWDER

KHOMATHAN A/L VALAYETHAM

Thesis submitted to the Faculty of Chemical and Natural Resources Engineering in
Partial Fulfillment of the Requirement for the
Degree of Bachelor Engineering in Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang

APRIL 2009

I declare that this thesis entitled "*Development of spray dried sugarcane juice*" 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	: KHOMATHAN A/L VALAYETHAM
Date	: 16 APRIL 2009

To my beloved father and mother

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At last I had completed my final year project and thesis. This accomplishment was not done by myself alone. There are a lot of good spirits and angels who guided and motivated me along the way. I would like to take this opportunity to express my heartiest gratitude to all of them.

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I hope this research project will be helpful for those who need reference in the field of spray drying fruits. Finally I would like to express my gratefulness to all of them who involved directly or indirectly in the completion of my final year project and thesis. Thank you.

ABSTRACT

This study explains the process and the best parameters to dry sugarcane juice using laboratory scale spray dryer. The raw sugarcane juice bought is filtered in the lab before the process of spray drying. In this process various amount of maltodextrin is added to identify the best amount of maltodextrin that should be added in sugarcane juice. Once the component of maltodextrin is determined, the variation in the temperature is done to find out the optimum temperature. For the part of analytical experiment, solubility test is done using the lab scale centrifugal machine. Solubility test is done on the various amount of matodextrin. Calcium carbonate is used as the anti-caking agent to study the caking ability of the produced powder. Sugarcane powder with the best conditions are done with anti-caking agent and stored in shelf for one month. The final test done is the sensory evaluation. In this evaluation students were randomly picked in the cafeteria. They were given the reconstituted juice and the produced powder to evaluate. The criteria being evaluated in this part are the appearance, flavor and the texture. The students were asked to rank all this categories following the scale of 1 to 5. From this evaluation the commercial value of produced sugarcane can be studied. From this research, it was found that sugarcane juice can be powderised using the lab scale spray dryer. The suitable amount of maltodextrin 20% and the optimum temperature is at 170°C. Sugarcane juice with higher amount of maltodextrin has the highest solubility. Powder with the anti-caking agent can be stored longer then the powder produced without anti-caking agent. This sugarcane powder has commercial values and can be marketed.

ABSTRAK

Kajian yang dijalankan adalah untuk mengetahui cara dan parameter terbaik untuk menghasilkan serbuk tebu menggunakan alat pengering sembur yang terdapat di makmal. Air tebu asli dibeli daripada kedai berdekatan dan ditapis di makmal sebelum proses menjadikan serbuk. Dalam proses ini kuantiti maltodextrin dimanipulasikan untuk mendapatkan kuantiti terbaik yang patut ditambahkan dalam air tebu asli. Setelah mengenal pasti kuantiti maltodextrin yang terbaik proses diteruskan untuk mengenal pasti suhu optimum. Eksperiment dijalankan beberapa kali dengan suhu yang berbeza untuk dapatkan suhu yang terbaik. Untuk bahagian analitikal takat penguraian serbuk dikaji. Eksperimen ini dijalankan dengan menggunakan alat sentrifugal yang terdapat dalam makmal. Eksperimen ini dijalankan bagi pelbagai kuantiti maltodextrin. Satu lagi kajian mengenai kebolehan untuk disimpan lama dijalankan atas serbuk tebu yang didapati. Dua serbuk tebu dihasilkan dengan menggunakan parameter terbaik yang dikenalpasti sebelum ini. Satu serbuk ditambahkan dengan kalsium karbonat sebagai agen untuk mengeklakan kepulan dalam serbuk. Kedua-dua serbuk disimpan dalam bekas yang kedap udara selama sebulan untuk mangkaji sifat tahan lama. Analisis terakhir dijalankan adalah ujian rasa. Seramai 10 orang pelajar UMP dipilih secara rawak di kafeteria. Kesemua pelajar itu diberikan jus tebu yang dihasilakn melalui serbuk tebu yang dihasilkan. Kriteria yang dianalisis dalam kajian ini adalah mengenai warna, saiz bentuk, rasa, kelikatan dan juga bahu serbuk dan jus yang dihasilkan. Keputusan yang diterima digunakan untuk mengkaji ciri-ciri serbuk tebu untuk tujuan komersial. Pada akhir kajian ini didapati 20% maltodextrin adalah kuantiti terbaik dan 170°C adalah suhu optimum untuk melakukan eksperimen ini. Lebih banyak maltodextrin ditambah lebih tinggi takat penguraian serbuk tebu dan kalsium karbonat boleh memenjangkan jangka hayat serbuk tebu. Serbuk tebu yang dihasilkan mempunyai nilai komersial yang tinggi dan produk ini boleh dipasarkan.

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LIST OF ABBREVIATIONS

Vitamin B2	-	Riboflavin
FAD	-	Flavin Adenine Dinucleotide
FMN	-	Flavin Mononucleotide
Ft.	-	Feet
m.	-	Meter
alt.	-	Alternative
fig.	-	Figure
^{tm}	-	Trade mark
co.	-	Company
SD	-	Spray Dryer
DE	-	Dextrose Equivalent
GMP	-	Good manufacturing practice
$CaCo_3$	-	Calcium carbonate
ml.	-	Milliliter
g.	-	gram
mg.	-	milligram
kg.	-	kilogram

CHAPTER 1

INTRODUCTION

1.1 Background of sugarcane

Sugarcane or sugarcane (*Saccharum*) is a genus of 6 to 37 species (depending on taxonomic interpretation) Giant, thick, perennial grass (*Saccharum officinarum*; family Poaceae, or Gramineae), cultivated in tropical and subtropical regions worldwide for its sweet sap, a major source of sugar and molasses.[1] The plant grows in clumps of solid stalks with regularly spaced nodes or joints, each with a bud that can be planted for commercial asexual propagation. Graceful, sword-shaped leaves, similar to those of the corn plant, fold in a sheath around the stem. Mature canes may be 10 – 20 ft (3 – 6 m) tall and 1 – 3 in. (2.5 – 7.5 cm) in diameter. Molasses, the syrup remaining after sugar is crystallized out of the juice, is used in cooking, in making rum, and as feed for farm animals. Residual cane fibre (bagasse) is burned as fuel or used as filler for paper and particleboard [1].

Sugarcane originated in New Guinea where it has been known for thousands of years. Sugarcane plants spread along human migration routes to Asia and the Indian subcontinent. Here it cross-bred with some wild sugar cane relatives to produce the commercial sugar cane we know today [2]. Sugarcane is one of the plants which grow largely in Malaysia. Malaysian weather is very much suitable for the growth of sugarcane plants. The sugarcane contains 18-20 % soluble solids and is reported to impart health benefits to the consumers. The juice obtained by crushing the canes, with its delicate aroma is a popular beverage with the consumers.

It can be an ideal replacement for synthetically flavored beverages or soft drinks. Sugarcane juice contains a lot of nutrients namely vitamin B2 (riboflavin) which plays an essential role in maintaining health in humans and animals. It is the central component of the cofactors FAD and FMN, and is therefore required by all flavoproteins. Besides that sugarcane is also a good source of antioxidant [3].

1.1.1 External structure of the sugarcane plant

1.1.1.1 Stalk

The sugarcane plant consists of a number of unbranched stalks that store the sucrose. The stalks are tall and slender, roughly circular in cross-section, and bear two rows of leaves. The stalks are divided by the nodes, which are distinctive areas where the leaves are attached (one leave at each node)

Situated within the root band is the bud. There is usually one bud at each node. The buds are situated at the alternate sides of the stem. The bud is an embryonic shoot consisting of a small stem bearing miniature leaves, the outer one which is scales. The size and shape of the buds as well as the form of the outer scales or flange vary considerably with variety.

1.1.1.2 Leaf

The leaves are arranged alternatively a single leaf arising from each node. They increase in size as the plant develops. Trash is formed when the leaf ages and dies.

1.1.1.3 Root System

There are three main types of sugarcane root: sett roots shoot roots, and mature roots. The sett roots develop from the primordial in the root band of the cutting. The shoot roots develop from the root primordial on the lower nodes of young shoots. The mature roots arise from root bands of shoots after the initial flash of shoot roots.

Figure 1.1: Sugarcane

The table below shows the top 10 sugarcane producing country in the world.

Country	1000 tons
Brazil	588,025 (2008)
India	232,300
People's Republic of China	87,768
Pakistan	47,244
Mexico	45,195
Thailand	43,665
Colombia	39,849
Australia	37,822
Indonesia	29,505
World Total	1,011,581
Source:UN Food & Agriculture Organisation (FAO)	

Table1.1: Top 10 Sugarcane Producers – 2007

1.2 Problem statement

It is a well known fact that sugarcanes are crushed to obtain the juice and it is a common practice in Malaysia to dispense this juice fresh either as such or with the addition of lime juice or fresh ginger extract in glasses by vendors to the consumers. The major problem encountered in this operation is lack of hygiene resulting in contamination of the juice with the heavy loads of micro-organisms which arises in the improper cleaning of sugarcanes and the handling of the finish product. Raw sugarcane juice is a carbohydrate rich, low acid food and is therefore susceptible to the growth of yeasts, of spoilage bacteria and also pathogenic bacteria. Pathogens such as Salmonnela, S.aureus and c.perfringents are able to grow and proliferate at a PH of more than 4.6.[4] Contamination of raw juice by these bacteria can occur by the food handlers, by the equipment used or by environment in which it is prepared. Such freshly crushed juice cannot be preserved even for few hours since it is known to ferment very quickly. The natural sweetness posses by sugarcane juice makes it easily changed into ethanol by bacterial activities. This makes sugarcane juice hard to be stored. Attempts have been made by many to develop processes for preserving the sugarcane juice in liquid form. However there is no knowledge or information regarding its preparation as a powder. There are few patents relating to the preparation of fruit juices in powder form but none of them are related to sugarcane.

Another important issue related with sugarcane is, as we know it is one of the main sources of sugar beside beet, the problem with refined sugar is that it has gone through a lot chemical processes just to extract the sucrose substance leaving out all the other valuable nutrients. The consumption of white sugar poses a lot of health risk from inflammation to degenerative diseases.[5] Furthermore diabetic which is another sugar related disease is being one of the major chronic diseases in Malaysia.[6] On the other hand, sugarcane juice is not fully commercialized in Malaysia. Usually we can only find sugarcane juice on the roadside hawker stalls. It is quite impossible to get clean fresh sugarcane drink. There are no companies or manufacturers who are producing fresh sugarcane drinks. Though sugarcane has a lot benefits to human diet, there is still no cutting edge technology which can help overcome this problem.

1.3 Objectives

The objectives of the research are

1) To produce sugarcane juice powder by using spray drier.
2) To identify the best temperature to preserve the quality of sugarcane powder.
3) To optimize the amount of maltodextrin in sugarcane powder.
4) To identify the solubility of sugarcane powder.
5) To study on the effect of anti-caking agent on the produced powder.
6) To study the commercial value of produced sugarcane powder.

1.4 Scope

Survey shows very limited or almost no work on processing of sugarcane powder production.[7] Insufficient engineering and lack of nutritional data for sugarcane processing creates a need to do more research and study on this field. Study on drying of sugarcane was, therefore, started in undergraduate research project. In this study, amount of optimum temperature to preserve the quality of sugarcane powder, optimum amount of maltodextrin, solubility of the sugarcane powder, the effect of anti-caking agent and the commercial value of sugarcane powder is investigated. At the end of this study a survey will be conducted among the students of University Malaysia Pahang randomly to know the commercial value of produced sugarcane powder. In this survey the colour, texture, odor, size and taste will be analysed. In brief the scope of the study is stated as below;

1. Sugarcane used as the source of pure juice
2. Maltodextrine used as the carrier agent
3. Following qualities of sugarcane powder is measured; optimum temperature to preserve the best qualities of sugarcane powder, optimum amount of maltodextrin added in sugarcane powder, solubility, effect of anti-caking agent on produced powder, and sensory evaluation.

4. To increase shelf life of sugarcane powder.
5. Produce instant sugarcane powder as formulated drinks.
6. A consumer preference test to determine the quality of the sugarcane powder.
7. Minimizing nutrient loss and preserving the taste in processing by determine the best temperature to spray dry.

CHAPTER 2

LITERATURE REVIEW

2.1 Food preservation

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage caused or accelerated by micro-organisms. Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food, such as cheese and wine. While maintaining or creating nutritional value, texture and flavour is important in preserving its value as food.[8] This is culturally dependent, as what qualifies as food fit for humans in one culture may not qualify in another culture.

Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity.[9] It also includes processes to inhibit natural ageing and decolorisation that can occur during food preparation such as the enzymatic browning reaction in apples which causes browning when apples are cut. Some preservation methods require the food to be sealed after treatment to prevent recontamination with microbes; others, such as drying, allow food to be stored without any special containment for long periods.

Common methods of applying these processes include drying, spray drying, freeze drying, freezing, vacuum-packing, canning, preserving in syrup, sugar crystallisation, food irradiation, and adding preservatives or inert gases such as carbon dioxide. Other methods that not only help to preserve food, but also add flavour, include pickling, salting, smoking, preserving in syrup or alcohol, sugar crystallisation and curing.

2.2 Drying

An operation in which a liquid, usually water, is removed from a wet solid in equipment termed dryers. The use of heat to remove liquids distinguishes drying from mechanical dewatering methods such as centrifugation, decantation or sedimentation, and filtration, in which no change in phase from liquid to vapor is experienced.[10] Drying is preferred to the term dehydration, which usually implies removal of water accompanied by a chemical change. Drying is a widespread operation in the chemical process industries. It is used for chemicals of all types, pharmaceuticals, biological materials, foods, detergents, wood, minerals, and industrial wastes.

Drying processes may evaporate liquids at rates varying from only a few ounces per hour to 10 tons per hour in a single dryer. Drying temperatures may be as high as 1400°F (760°C), or as low as−40°F (−40°C) in freeze drying. Dryers range in size from small cabinets to spray dryers with steel towers 100 ft (30 m) high and 30 ft (9 m) in diameter. [11] The materials dried may be in the form of thin solutions, suspensions, slurries, pastes, granular materials, bulk objects, fibers, or sheets. Drying may be accomplished by convective heat transfer, by conduction from heated surfaces, by radiation, and by dielectric heating. In general, the removal of moisture from liquids (that is, the drying of liquids) and the drying of gases are classified as distillation processes and adsorption processes, respectively, and they are performed in special equipment usually termed distillation columns (for liquids) and adsorbers (for gases and liquids). Gases also may be dried by compression.

2.2.1 Drying of solids

In the drying of solids, the desirable end product is in solid form. Thus, even though the solid is initially in solution, the problem of producing this solid in dry form is classed under this heading. Final moisture contents of dry solids are usually less than 10%, and in many instances, less than 1%.

The mechanism of the drying of solids is reasonably simple in concept. When drying is done with heated gases, in the most general case, a wet solid begins to dry as though the water were present alone without any solid, and hence evaporation proceeds as it would from a so-called free water surface, that is, as water standing in an open pan. The period or stage of drying during this initial phase, therefore, is commonly referred to as the constant-rate period because evaporation occurs at a constant rate and is independent of the solid present. The presence of any dissolved salts will cause the evaporation rate to be less than that of pure water. Nevertheless, this lower rate can still be constant during the first stages of drying.[12]

A fundamental theory of drying depends on a knowledge of the forces governing the flow of liquids inside solids. Attempts have been made to develop a general theory of drying on the basis that liquids move inside solids by a diffusional process. However, this is not true in all cases. In fact, only in a limited number of types of solids does true diffusion of liquids occur. In most cases, the internal flow mechanism results from a combination of forces which may include capillarity, internal pressure gradients caused by shrinkage, a vapor-liquid flow sequence caused by temperature gradients, diffusion, and osmosis. Because of the complexities of the internal flow mechanism, it has not been possible to evolve a generalized theory of drying applicable to all materials. Only in the drying of certain bulk objects such as wood, ceramics, and soap has a significant understanding of the internal mechanism been gained which permits control of product quality[13].

Most investigations of drying have been made from the so-called external viewpoint, wherein the effects of the external drying medium such as air velocity, humidity, temperature, and wet material shape and subdivision are studied with respect to their influence on the drying rate. The results of such investigations are usually presented as drying rate curves, and the natures of these curves are used to interpret the drying mechanism.

When materials are dried in contact with hot surfaces, termed indirect drying, the air humidity and air velocity may no longer be significant factors controlling the rate. The "goodness" of the contact between the wet material and the heated surfaces, plus the surface temperature, will be controlling. This may involve agitation of the wet material in some cases.

Drying equipment for solids may be conveniently grouped into three classes on the basis of the method of transferring heat for evaporation. The first class is termed direct dryers; the second class, indirect dryers; and the third class, radiant heat dryers. Batch dryers are restricted to low capacities and long drying times. Most industrial drying operations are performed in continuous dryers. The large numbers of different types of dryers reflect the efforts to handle the larger numbers of wet materials in ways which result in the most efficient contacting with the drying medium. Thus, filter cakes, pastes, and similar materials, when preformed in small pieces, can be dried many times faster in continuous through-circulation dryers than in batch tray dryers. [14] Similarly, materials which are sprayed to form small drops, as in spray drying, dry much faster than in through-circulation drying.

2.2.2 Drying of gases

The removal of 95–100% of the water vapor in air or other gases is frequently necessary. Gases having a dew point of −40°F (−40°C) are considered commercially dry. The more important reasons for the removal of water vapor from air are comfort, as in air conditioning; control of the humidity of manufacturing atmospheres; protection of electrical equipment against corrosion, short circuits, and electrostatic discharges; requirement of dry air for use in chemical processes where moisture present in air adversely affects the economy of the process; prevention of water adsorption in pneumatic conveying; and as a prerequisite to liquefaction.

Gases may be dried by the following processes: absorption by use of spray chambers with such organic liquids as glycerin, or aqueous solutions of salts such as lithium chloride, and by use of packed columns with countercurrent flow of sulfuric acid, phosphoric acid, or organic liquids; adsorption by use of solid adsorbents such as activated alumina, silica gel, or molecular sieves; compression to a partial pressure of water vapor greater than the saturation pressure to effect condensation of liquid water; cooling below dew point of the gas with surface condensers or coldwater sprays; and compression and cooling, in which liquid desiccants are used in continuous processes in spray chambers and packed towers—solid desiccants are generally used in an intermittent operation that requires periodic interruption for regeneration of the spent desiccant[12].

Desiccants are classified as solid adsorbents, which remove water vapor by the phenomena of surface adsorption and capillary condensation (silica gel and activated alumina); solid absorbents, which remove water vapor by chemical reaction (fused anhydrous calcium sulfate, lime, and magnesium perchlorate); deliquescent absorbents, which remove water vapor by chemical reaction and dissolution (calcium chloride and potassium hydroxide); or liquid absorbents, which remove water vapor by absorption (sulfuric acid, lithium chloride solutions, and ethylene glycol).

The mechanical methods of drying gases, compression and cooling and refrigeration, are used in large-scale operations, and generally are more expensive methods than those using desiccants. Such mechanical methods are used when compression or cooling of the gas is required.

Liquid desiccants (concentrated acids and organic liquids) are generally liquid at all stages of a drying process. Soluble desiccants (calcium chloride and sodium hydroxide) include those solids which are deliquescent in the presence of high concentrations of water vapor.

Deliquescent salts and hydrates are generally used as concentrated solutions because of the practical difficulties in handling, replacing, and regenerating the wet corrosive solids. The degree of drying possible with solutions is much less than with corresponding solids; but, where only moderately low humidities are required and large volumes of air are dried, solutions are satisfactory[11].

2.3 Drying Methods

Application of heated air (convective or direct drying). Air heating reduces air relative humidity, which is the driving force for drying. Besides, higher temperatures speed up diffusion of water inside the solids, so drying is faster. However, product quality considerations limit the applicable rise to air temperature. Too hot air almost completely dehydrates the solid surface, so internal pores shrink and almost close, leading to crust formation or "case hardening".

Indirect or contact drying (heating through a hot wall), as drum drying, vacuum drying.

Dielectric drying (radiofrequency or microwaves being absorbed inside the material) It is the focus of intense research nowadays. It may be used to assist air drying or vacuum drying.

Freeze drying is increasingly applied to dry foods, beyond its already classical pharmaceutical or medical applications. It keeps biological properties of proteins, and retains vitamins and bioactive compounds. [15] Pressure may be reduced by a vacuum pump. If using a vacuum pump, the vapor produced by sublimation is removed from the system by converting it into ice in a condenser, operating at very low temperatures, outside the freeze drying chamber.

Supercritical drying (superheated steam drying) involves steam drying of products containing water. Strange as it seems, this is possible because the water in the product is boiled off, and joined with the drying medium, increasing its flow. It is usually employed in closed circuit and allows a proportion of latent heat to be recovered by recompression, a feature which is not possible with conventional air drying, for instance. May have potential for foods if carried out at reduced pressure, to lower the boiling point.

Natural air drying takes place when materials are dried with unheated forced air, taking advantage of its natural drying potential. The process is slow and weather-dependent, so a wise strategy "fan off-fan on" must be devised considering the following conditions: Air temperature, relative humidity and moisture content and temperature of the material being dried. [11] Grains are increasingly dried with this technique, and the total time (including fan off and on periods) may last from one week to various months, if a winter rest can be tolerated in cold areas.

2.4 General Characteristic of Dryers

Removal of water from solid is most often accomplished by contacting them with air of low humidity and elevated temperature. Less common, although locally important, drying processes apply heat radiatively of dielecrically in these operation as in freeze drying, the role of any gas supply is that of entrainer of the humidity.

The nature size and shape of the solid, the scale of the operation, the method of transporting the stock and contacting it with gas, the heating mode, are some of the many factors that have led to the development of considerable variety of equipment. The most elaborate classification of dryers is that of Kroll (1978) which assigns one of the letters for the kind of operation. As modified by Keey (1972), it comprises 39 main classes and the total of 70 with subclasses[16].

They take into account the method of operation, the physical from the stock, special features, scale of production and drying time. The wide spreads of these numbers reflect the diversity of individual design of the same general kind of equipment, differences in moisture content, and differences in drying properties of various materials. Fluidize bed dryers, for examples, are operated as batch or continuous, for pharmaceuticals of bitumen, at rates of hundred or many thousands of pound per hour. The important characteristic of the dryer is the residence time distribution of solid in it. Dryers in which are particles do not move relatively to each other provide uniform time distribution. In spray, pneumatic conveying, fluidize bed, and other equipment in which the particles tumbles about, a substantial variation in residence time develops. Spray and pneumatic conveyor have wide time distribution while rotary and fluidize bed units have narrower but far from uniform ones and different in particles size.

2.5 Spray Dryer

Spray drying is the most widely used industrial process involving particle formation and drying. It is highly suited for the continuous production of dry solids in either powder, granulate or agglomerate form from liquid feedstocks as solutions, emulsions and pumpable suspensions.[17] Therefore, spray drying is an ideal process where the end-product must comply to precise quality standards regarding particle size distribution, residual moisture content, bulk density, and particle shape.

2.5.1 Background of spray drying

The development of spray drying equipment and techniques evolved over a period of several decades from the 1870s through the early 1900s. The first known spray dryers used nozzle atomizers, with rotary atomizers introduced several decades later. Because of the relatively unsophisticated designs of the early spray dryers and practical difficulties in operating them continuously, very little commercial use of the process was made until the 1920s. [18] By the second decade of the twentieth century, the evolution of spray dryer design made commercial operations practical. Milk drying was the first major commercial application of the technology. During the next 20 years, manufacturers developed designs to accommodate heat-sensitive products, emulsions and mixtures. Spray drying came of age during World War II, with the sudden need to reduce the transport weight of foods and other materials. This surge in interest led to developments in the technology that greatly expanded the range of products that could be successfully spray dried.

2.5.2. Types of Spray Dryers

There are many types of spray dryers in our chemical environment such as co-current flow dryer, conter-current flow dryer, mix flow dryer and so on. [19] A brief description of all the spray dryers exists in the current technology with explanation of it’s part in schematic diagram is given in coming pages;

2.5.2.1 Co-current flow dryer

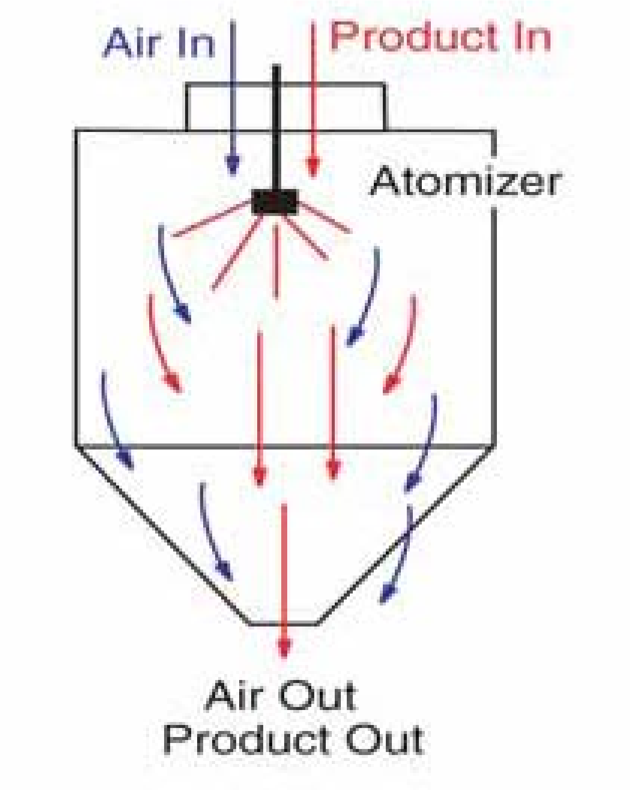

Figure 2.1

In a co-current dryer (Fig. 2.1), the spray is directed into the hot air entering the dryer and both pass through the chamber in the same direction. Co-current dryers are the preferred design for heat sensitive products because the hottest drying air contacts the droplets at their maximum moisture content. Spray evaporation is rapid, and the temperature of the drying air is quickly reduced by the vaporization of water. The product does not suffer from heat degradation because the droplet temperature is low during most of the evaporation time. Once the moisture content reaches the target level, the temperature of the particle does not increase greatly because the surrounding air is now much cooler. Dairy and other heat-sensitive food products are usually dried in co-current dryers.

2.5.2.2 Counter-current flow dryer

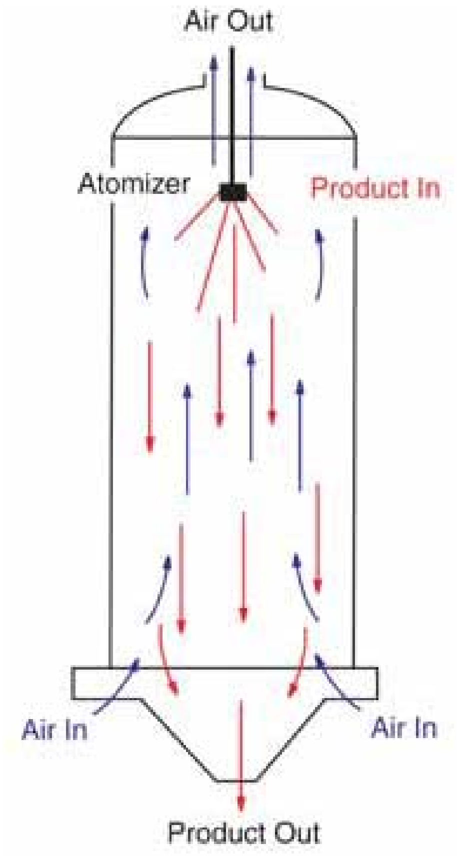

Figure 2.2

In this dryer design (Fig. 2.2), the spray and the air are introduced at opposite ends of the dryer, with the atomizer positioned at the top and the air entering at the bottom. A counter-current dryer offers more rapid evaporation and higher energy efficiency than a concurrent design. Because the driest particles are in contact with hottest air, this design is not suitable for heat-sensitive products. Counter-current dryers normally use nozzles for atomization because the energy of the spray can be directed against the air movement. Soaps and detergents are commonly dried in counter-current dryers.

2.5.2.3 Mixed flow dryer

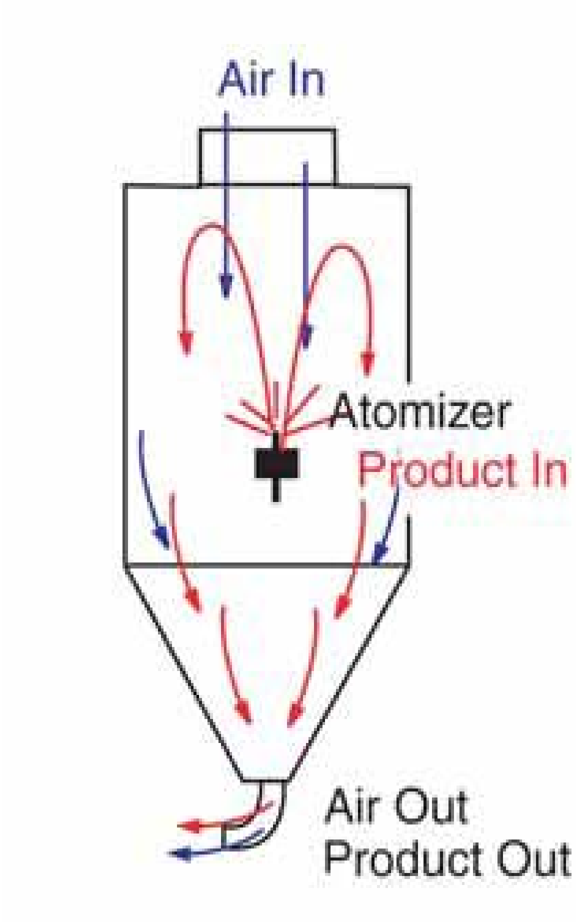

Figure 2.3

Dryers of this type (Fig. 2.3) combine both co-current and counter current flow. In a mixed flow dryer, the air enters at the top and the atomizer is located at the bottom. Like the counter-current design, a mixed flow dryer exposes the driest particles to the hottest air, so this design is not used with heat-sensitive products.

2.5.2.4 Open cycle dryer

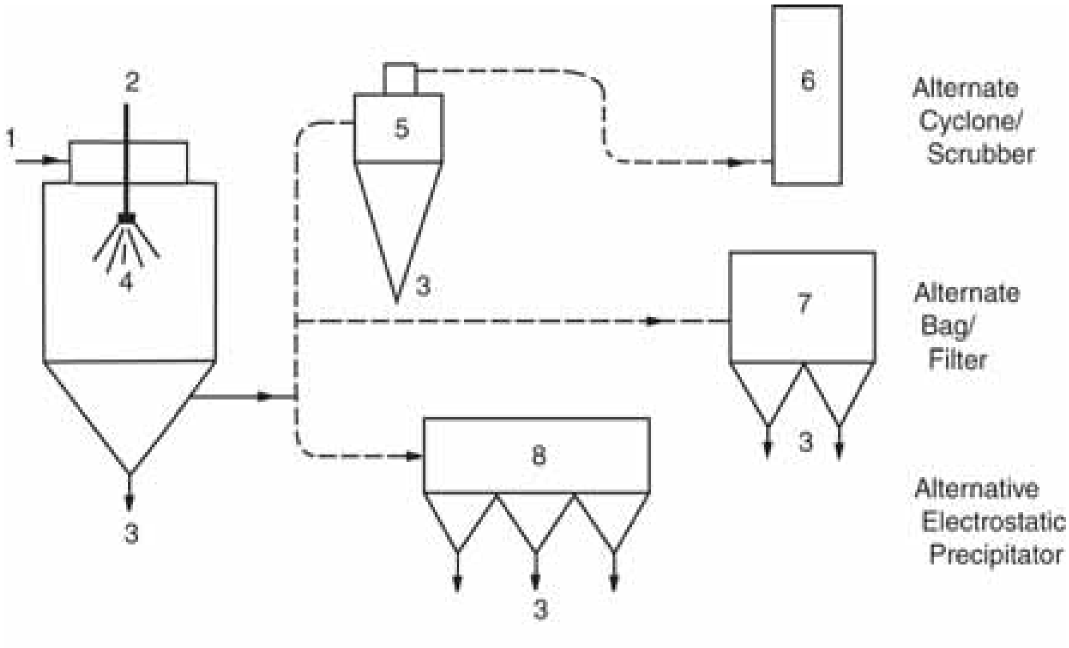

Figure 2.4

1. drying air
2. feedstock
3. dried product
4. drying chamber
5. cyclone
6. Alt. A: wet scrubber
7. Alt. B: bag filter
8. Alt. C: electrostatic precipitator

In an open cycle dryer (Fig. 2.4), drying air is drawn from the atmosphere, heated, conveyed through the chamber and then exhausted to the atmosphere. This is by far the most commonly used design.

2.5.2.5 Close cycle dryer

A closed cycle dryer recycles the drying gas, which may be air or more commonly, an inert gas such as nitrogen. Closed cycle units are the dryers of choice when:

- Feedstock consists of solids mixed with flammable organic solvents.
- Complete recovery of solvent is required.
- Pollution due to vapor, particulate emissions or odor is not permitted.
- Explosion risks must be eliminated.
- The powder will degrade by oxidation during drying.

2.5.2.6 Semi-closed cycle dryer

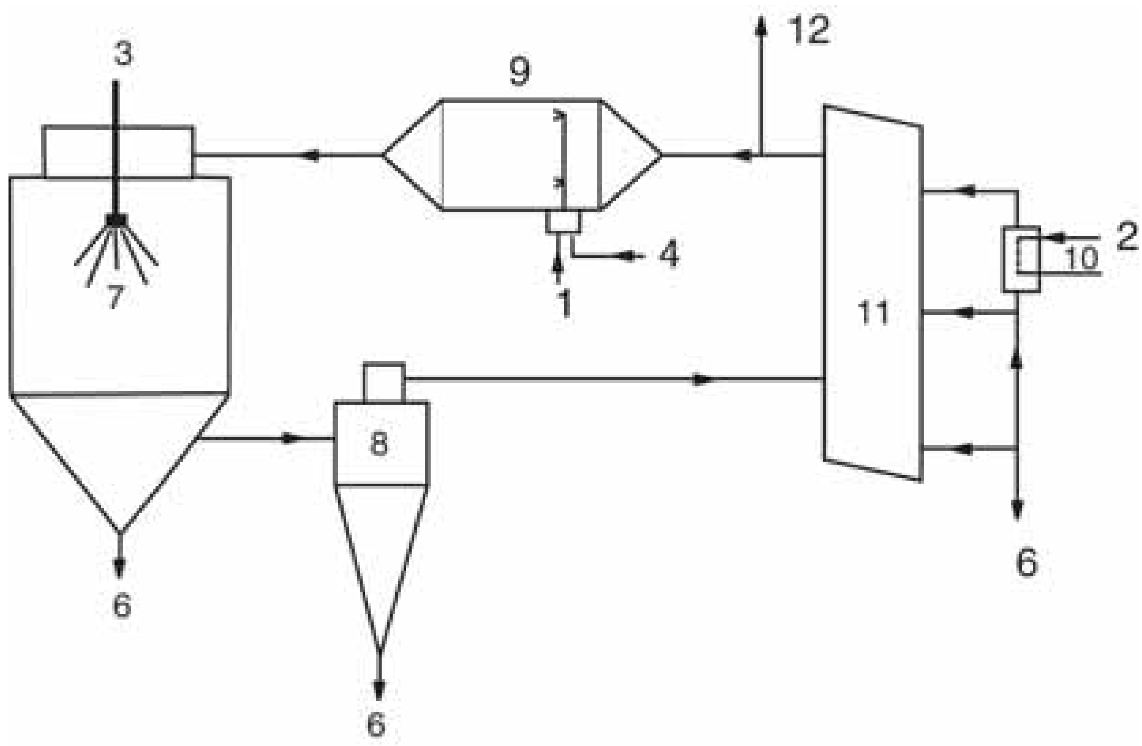

Figure 2.5

1. combustion air
2. coolant
3. feedstock
4. heater fuel
5. condensed water discharge
6. dried product
7. drying chamber
8. cyclone
9. direct heater (gas)
10. heat exchanger
11. scrubber/condenser
12. air bleed to atmosphere

This design is a cross between open and closed cycle dryers and it is not gas tight. There are many variations on this design, with the most important being the “direct heated” or “self-inertizing” system (Fig. 2.5). In the self-inertizing design, a direct-fired heater is used and the air entering the system is limited to that required for combustion. An amount of air equal to the combustion air is bled from the system at the other end of the process. The gas (mainly products of combustion) is recycled through the dryer. The recycled gas has a very low oxygen content, making it suitable for materials that cannot be exposed to oxygen, due to explosive hazard or product degradation.

2.5.2.7 Single stage dryer

In a single stage dryer, the moisture is reduced to the target (typically 2% - 5% by weight) in one pass through the dryer. The single stage dryer is used in the majority of designs.

2.5.2.8 Two stage dryer

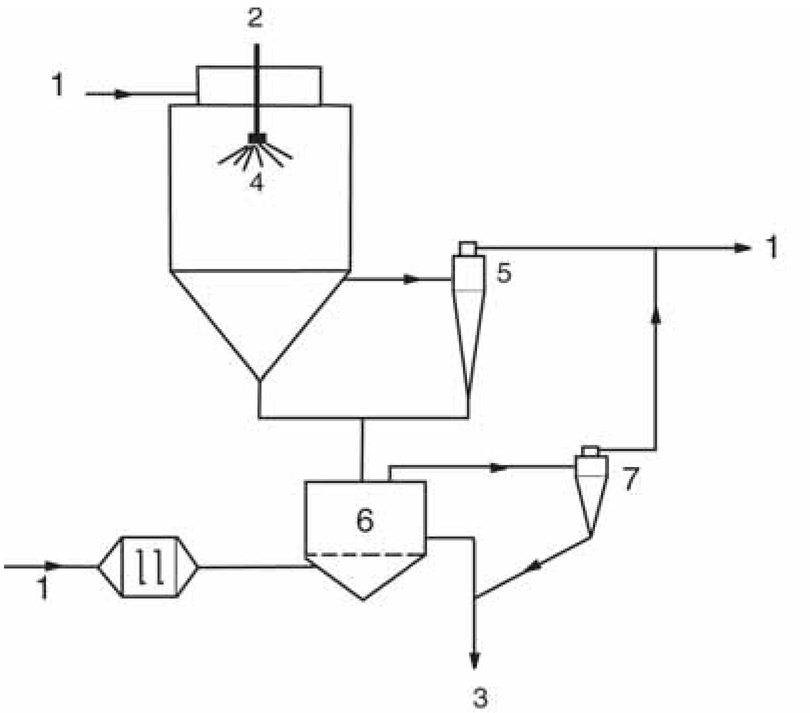

Figure 2.6

1. air
2. feedstock
3. dried product
4. drying chamber
5. cyclone
6. stationary fluid bed
7. fluid bed cyclone
8. transport cyclone

In a two stage dryer, the moisture content of product leaving the chamber is higher (typically 5% - 10%) than for the final product. After leaving the chamber, the moisture content is further reduced during a second stage. Second stage drying may be done in a fluidized bed dryer (Fig. 2.6) or a vibrating bed dryer. Two stage dryers allow the use of lower temperatures in the dryer, making the design a good choice for products that are particularly heat sensitive

2.5.2.9 Vertical dryer

The chamber of a vertical (tower) dryer has the form of a tall cylinder with a cone-shaped bottom. Spray nozzles may be located at the top (co-current flow) or bottom (counter-current flow or mixed flow) of the chamber. BETE Twist & Dry™ nozzles are commonly used in vertical dryers. Inlets for the drying air may be located at the top, bottom or side of the chamber. Vertical spray dryers are usually large and the residence time of sprayed particles is relatively long, allowing the use of higher flow nozzles such as the TD, which produce relatively large particles.

2.5.2.10Horizontal dryer

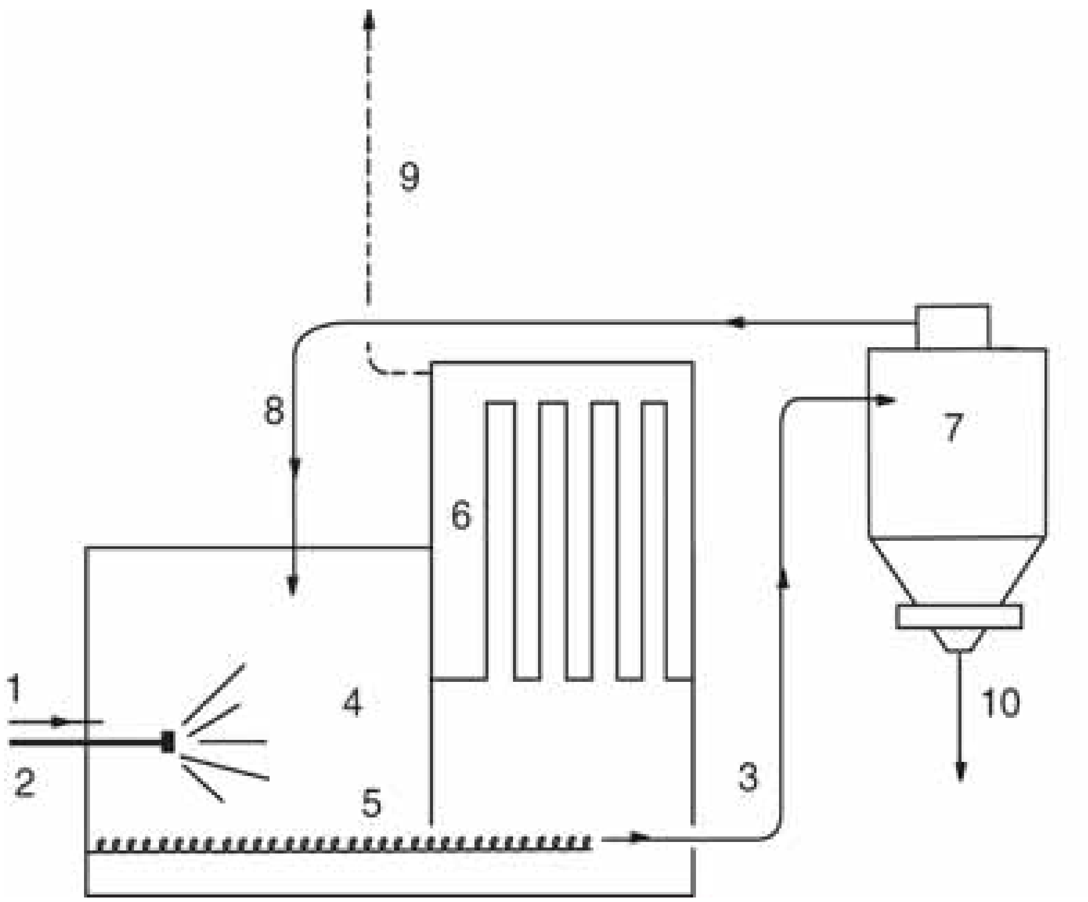

Figure 2.7

1. drying air
2. feedstock
3. pneumatic conveyor
4. drying chamber
5. powder conveyor
6. filter bags
7. cyclone
8. dust return
9. exhaust to atmosphere
10. dried powder

The chamber of a horizontal dryer (Fig. 2.7) has the form of a rectangular box with either a flat or a "V" shaped bottom. Nozzles in a box dryer normally spray horizontally, with the dried particles falling to the floor, where they are removed to a bagging area by a sweep conveyor or screw conveyor. Box dryers are usually small and the particle residence time relatively short, requiring the use of low flow nozzles such as the low flow version of the BETE Twist & Dry, which produce relatively small particles. Manufacturers of flat-bottom box dryers include: CE Rogers, Marriott Walker, Henningsen Foods, Food Engineering Co. and Henszey Co. Manufacturers of "V" bottom dryers include: Blaw-Knox, Bufflovak and Mora Industries.

2.6 Advantages of spray drying:

- Able to operate in applications that range from aseptic pharmaceutical processing to ceramic powder production.
- Can be designed to virtually any capacity required. Feed rates range from a few pounds per hour to over 100 tons per hour.
- Powder quality remains constant during the entire run of the dryer.
- Operation is continuous and adaptable to full automatic control.

- A great variety of spray dryer designs are available to meet various product specifications.
- Can be used with both heat-resistant and heat sensitive products.
- As long as they are can be pumped, the feedstock can be abrasive, corrosive, flammable, explosive or toxic.
- Feedstock can be in solution, slurry, paste, gel, suspension or melt form.
- Product density can be controlled
- Nearly spherical particles can be produced.
- Material does not contact metal surfaces until dried, reducing corrosion problems[20].

2.7 Spray drying basics

2.7.1 Concentration

Feedstock is normally concentrated prior to introduction into the spray dryer. The concentration stage increases the solids content thereby reducing the amount of liquid that must be evaporated in the spray dryer.

2.7.2 Atomization

Spray dryers are characterized by the atomization of the feedstock and the contacting of the spray with heated air. The atomization stage is designed to create the optimum conditions for evaporation and to lead to a dried product having the desired characteristics. Nozzles and rotary atomizers are used to form sprays. Dryers can range from just one nozzle to having over 100.

2.7.3 Droplet-air contact

The central element of a spray dryer is the spray dry chamber. In the chamber, atomized liquid is brought into contact with hot gas (usually air, at a vacuum),resulting in the evaporation of 95%+ of the water contained in the droplets in a matter of a few seconds. The way in which the spray makes contact with the air in the dryer influences the behavior of the droplet during the drying phase and has a direct bearing on the properties of the dried product. The type of contact between the spray and the air is determined by the position of the atomizer relative to the air inlet. Nozzle headers are usually located at the top of the dryer and spray down.

2.7.4 Droplet drying

Moisture evaporation takes place in two stages. During the first stage, the temperature in the saturated air at the surface of the droplet is approximately equal to the wet-bulb temperature of the drying air. There is sufficient moisture in the drop to replace the liquid evaporated at the surface and evaporation takes place at a relatively constant rate. The second stage begins when there is no longer enough moisture to maintain saturated conditions at the droplet surface, causing a dried shell to form at the surface. Evaporation then depends on the diffusion of moisture through the shell, which is increasing in thickness. The rate of evaporation falls rapidly during the second phase. Different products have differing evaporation and particle-forming characteristics. Some expand; others contract, fracture or disintegrate. The resulting particles may be relatively uniform hollow spheres, or porous and irregularly shaped.

2.7.5 Separation

Following completion of drying, the particles of product must be separated from the drying air. .Primary separation is accomplished by the particles simply falling to the bottom of the chamber. A small fraction of the particles remain entrained with the air and must be recovered in separation equipment. Cyclones, bag filters, and electrostatic precipitators may be used for the final separation stage. Wet scrubbers are then often used to purify and cool the air so that it can be released to atmosphere.

2.7.6 Spray dryer used

In this research we use lab scale spray dryer lab quip/ SD06. The details of the equipment is given in the table below;

SPRAY DRYER	
Equipment	Type of Equipment : Spray Dryer Brand / Model : Lab Quip / SD 06
Application	Dry liquid products into power form
Further Description	A menu driven microprocessor controller allow the selection of inlet temperature, automatic de-blocker frequency and pump speed. An inlet filter design to remove 99.99% air laden particles. Spray assembly incorporates an automatic de-blocking device for nozzle

Table 2.1: Details of spray dryer

CHAPTER 3

METHODOLOGY

3.1 Introduction

Experiment method is the main method used in this research. The process used to convert sugarcane juice to powder is drying. There are four major parts in this experiment. First, drying process of sugarcane juice using spray drier in different temperature and various amount of maltodextrin and secondly the measurement of solubility of produced powder, using the method of centrifugation, thirdly spray drying again using anti-caking agent, and finally doing sensory analysis on the produced juice.

The main part of this research is to prepare sugarcane powder from sugarcane puree while preserving its best quality.

3.2 Material

3.2.1 Sugarcane puree

The fresh sugarcane firstly washed cleanly with plain water. After that the outer layer of sugarcane was removed from the stalk. The stalk was cut into small pieces. Then it was crushed using a mechanical device. This process was done in a drink shop in Jaya Gading, Kuantan. The puree was bought from there and brought over to chemical lab in University Malaysia Pahang for the drying process. Here the juice was filtered using sieve and filtrate. The prepared sample must be highly concentrated with low solubility and low hygroscopic. Selection of fully ripe, firm green fruit without bruises is essential to prevent suspended solid during crushing process and to get optimal amount of nutrient.

Figure 3.1: Sugar cane puree

Figure 3.2: Filtration process

3.2.2 Maltodextrin

Maltodextrin is based products line; cover the dextrose equivalent (DE) range from 10 to 40. Each product differs in its degree of hydrolysis, providing wide range of functionalities and properties for special applications. Maltodextrin often use as bulking agent, dispersant, carrier, binding agent, processing aid and texture improver in a variety of food and beverage products.[21] Maltodextrin also decrease the puree solubility and the level of hygroscopic

Maltodextrin 10 was used in this study. This product is sponsored by AAA San Soon Seng food industries Sdn. Bhd (Sungai Buloh, Selangor). Maltodextrin does not have any taste and produce no impact on typical flavor of the juice. [22] Hence the final spray dried product contains fruit solids, hydrolyzed maltodextrin solids, and in liquid solution contribute the typical flavor and color of the original fruit. Maltodextrin act only as a medium in the process of spray drying. The specification of the product is given below.

Specification	
Dextrose Equivalent	9 - 12
Moisture, %	Max. 5.0
pH (20% Solution)	4.5 - 5.5
Sulphur Dioxide, ppm	Max. 10
Colour (O.D.)	Max. 2.0
Bulk Density (tapped), g/l	450 - 600
Shelf life	2 years
Raw material	Tapioca Starch
Storage condition	Cool & dry condition

Table 3.1: Specification of Maltodextrin 10

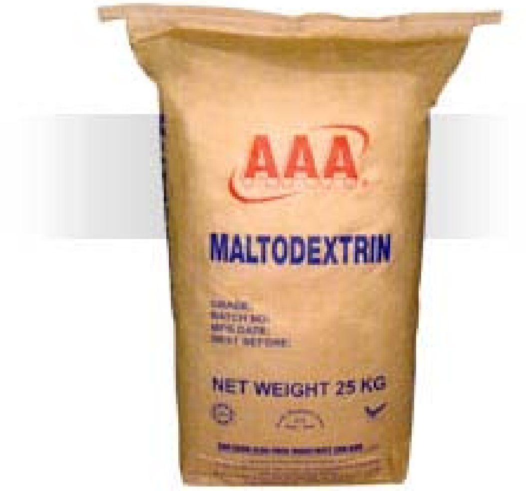

Figure 3.3: Maltodextrin

In this process different amount of maltodextrin is added to sugarcane juice every time the experiment was carried out. This is to determine the optimum amount of maltodextrin that should be added in order to preserve the best texture, colour and the taste of the powder. For every run of experiment 500ml of sugarcane juice is prepared. Then, maltodextrin is weighed using the weighing machine in lab and slowly added to sugarcane juice while the juice is being stirred using magnetic stirrer until it is well mixed. The table below shows the different amount of maltodextrin added and its ratio.

Experiment	Sugarcane juice (ml)	Maltodextrin (g)	Percentage of maltodextrin (%)
1	500	50	10
2	500	75	15
3	500	100	20
4	500	125	25
5	500	150	30

Table 3.2: Percentage of maltodextrin in 500ml sugarcane juice

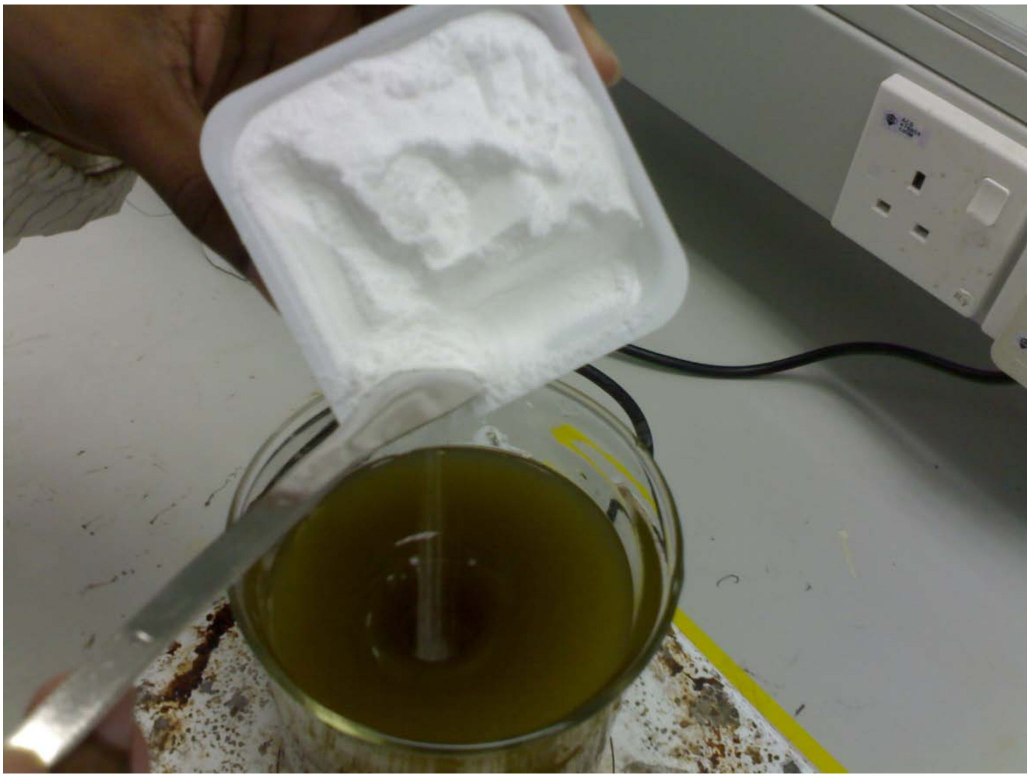

Figure 3.4: Addition of maltodextrin-10

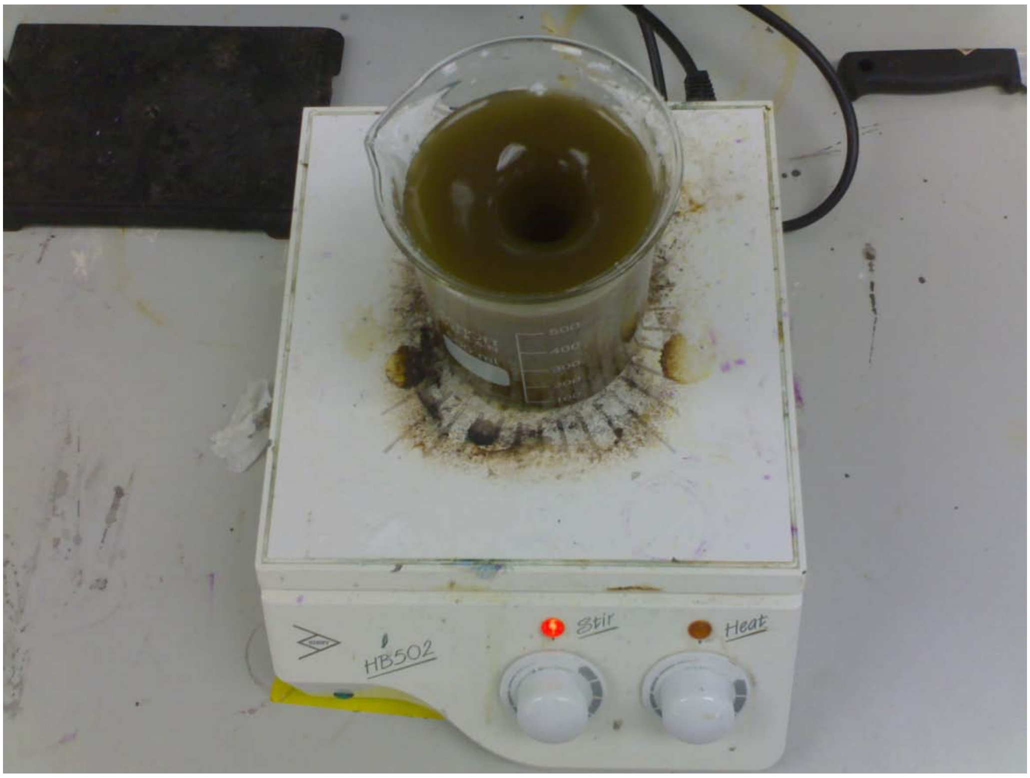

Figure 3.5: Mixing process using the magnetic stirrer

3.2.3 Anti-Caking Agent

Anti-caking agents are used in such things as table salt to keep the product from forming lumps, making it better for packaging, transport, and for the consumer. An anti-caking agent in salt is denoted in the ingredients for example as "anti-caking agent (554)", which is sodium aluminosilicate, a man-made product. This product is present in many commercial table salts as well as dried milks, egg mixes, sugar products, and flours. In Europe, sodium ferrocyanide (535) and potassiu ferrocyanide (536) are more common anti-caking agents in table salt. Natural anti-caking agents used in more expensive table salt include calcium carbonate and magnesium carbonate.[23] In this research project the natural anti-caking agent calcium carbonate is used. Table below shows the common food stuff and the amount of anti-caking agent used.

Food stuff	Anti-caking agent	Conditions and limit (mg / kg)
Meat tenderizer	Calcium Stearate, Silicon Dioxide, Amorphous	10000 *GMP
Milk powder	Aluminium silicate, Calcium Carbonate, Calcium Silicate, Calcium Phosphate, Magnesium Oxide, Magnesium Phosphate, Silicon Dioxide, Amorphous	10000
Salt (sodium chloride)	Aluminium Stearate, Calcium Stearate, Magnesium Oxide, Magnesium Silicate	20000
Salt substitute	Calcium silicate, Silicon dioxide, Amorphous	10000
Soft drink, powdered	Calcium carbonate, Calcium phosphate, Tribasic silicon dioxide, Magnesium carbonate,	5000, 10000, 15000, *GMP,
Soups and sauces, powdered	Silicon dioxide, Amorphous, Sodium silico-aluminate, Calcium carbonate, Magnesuim carbonate	10000, *GMP

Table 3.3: Anti-caking agent and it’s amount for common food stuff by ministry of health and welfare

3.2.3.1 Calcium Carbonate

Calcium carbonate is a chemical compound with the chemical formula $CaCO_3$. It is a common substance found as rock in all parts of the world, and is the main component of shells of marine organisms, snails, and eggshells. Calcium carbonate is the active ingredient in agricultural lime, and is usually the principal cause of hard water. It is commonly used medicinally as a calcium supplement or as an antacid, but high consumption can be hazardous. [24]

Calcium Carbonate added to finely powdered or crystalline food products to prevent caking, lumping, or agglomeration. The specification of the anti-caking agent (calcium carbonate) is shown below:

Specification of Calcium Carbonate	
Cas Number	471-34-1
Molar Mass	100.09 g/mol
Appearance	White powder
Density	2.71 g/cm^3 (calcite) 2.83 g/cm^3 (aragonite)
Solubility in Water	0.00015 mol/L (25°C)

Table 3.4: Specification of Calcium Carbonate

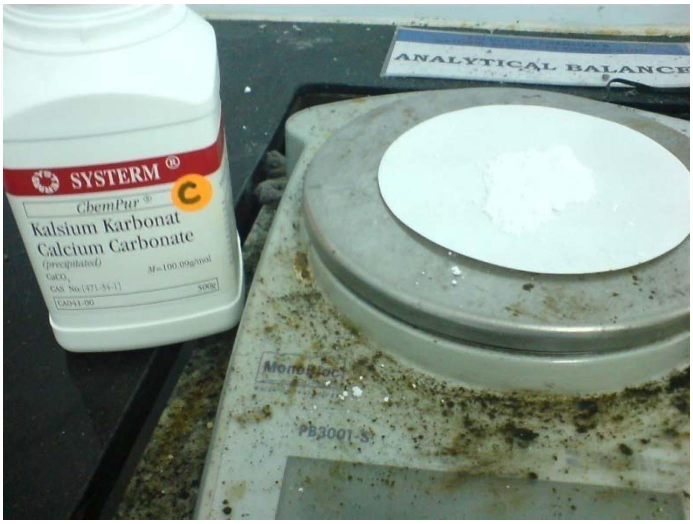

Figure 3.6: Calcium Carbonate

3.3 Equipment

3.3.1 Spray Dryer

The laboratory scale spray dryer used to spray dry the sugarcane juice. The powder is produced by continues process and free flow powder is produced. The picture of the spray dryer used is illustrated below:

Specification of spray dryer	
Type/Brand	Lab Plant SD 06
Capacity	50-200 g/hr
Vacuum Pressure	1 psig
Serial No.	399
Manufacturing Code	2504

Table 3.5: Specification of spray dryer

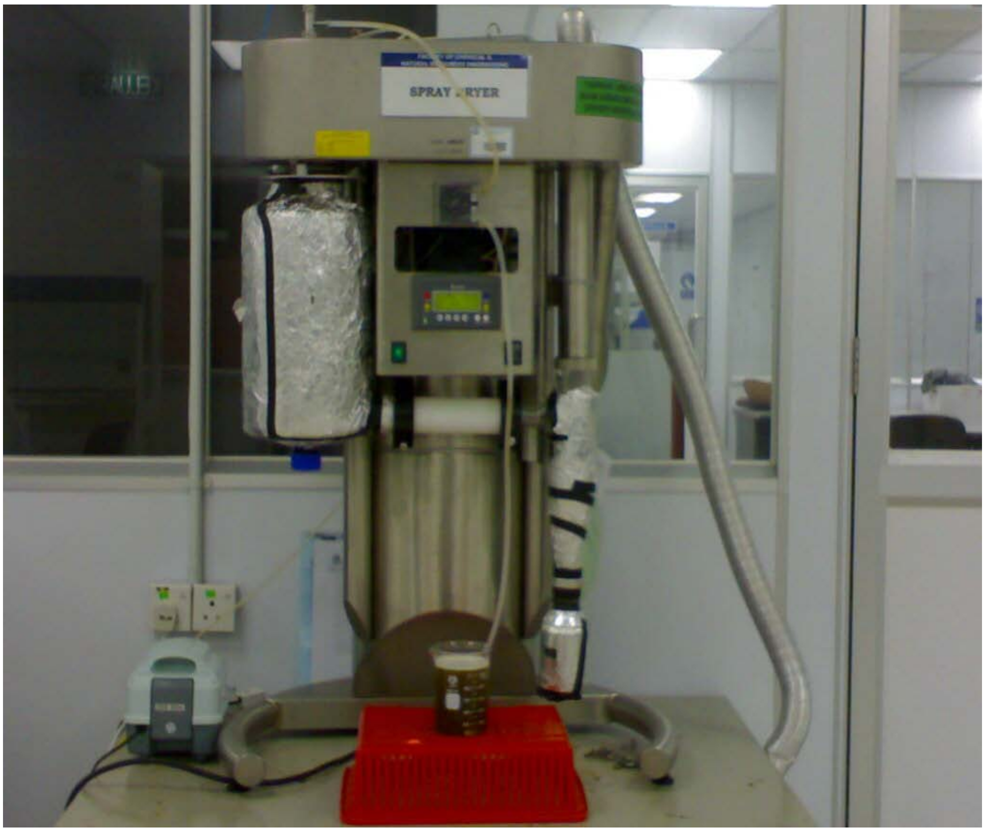

Figure 3.7: Spray dryer

3.4 Method of Research

3.4.1 Sample Preparation

The sugarcane puree bought from Sri Gading, Kuantan is filtered in the laboratory using sieve and coffee filter. All the cane particles and other suspended solids were removed in this process. Then, maltodextrin-10 were added in the solution and well mixed using the magnetic stirrer in different percentage. The sample is later spray dried to produce free flow powder at specific temperature.

3.4.2 Drying Process

Once the maltodextrin is well mixed with the sugar cane juice using the magnetic stirrer, the solution is dried using laboratory scale spray dryer in University Malaysia Pahang. Before running the sample, the equipment was run with distilled water, this is to make sure all the devices in the equipment is functioning well and also to dry the equipment, so that no moisture exists.

Switch on the main switch on the lab scale spray dryer and also press the "ON" button on the equipment, then set the parameters. The main parameters in this equipment are inlet temperature, outlet temperature, fan setting, pump setting and the de-blocker. In this experiment after the suitable amount of maltodextrin is determined the inlet temperature is manipulated to identify the best texture, odor, colour and taste. Other parameters are kept constant for every experiment. Once all the parameters are set wait for the word " SYSTEM READY" to appear on the equipment. The actual inlet temperature and outlet temperature displayed at all times on the set temperature screen.

Wait for the drying process until sugarcane powder is produced. Repeat the procedure using various amount of maltodextrin and once the suitable amount is determined use different temperatures to run the experiment. Total time to produce the sugarcane powder was taken. Once the best temperature and suitable amount of maltodextrin is determined, the procedure is repeated with adding anti-caking agent (Calcium Carbonate). This is to measure the caking ability of sugarcane powder. Both the powder with and without anti-caking agent is stored for two months.

3.4.3 Analytical Experiment

3.4.3.1 Solubility Analysis

Solubility is determined according to the Eastman and Moore method (1984) and modified by Cano-Chauca, Stringheta, Ramos, and Cal-Vidal (2005). According to method 1g of powder were added to the 100 mL distilled water and mixed at high velocity using the aid of stirrer for 5 minutes. Later the solution is placed in a centrifuge tube and centrifuged at 2600 rpm for 5 minutes. 25 mL of the centrifuged supernatant is placed in a previously weighed Petri dish and immediately oven dried at 105 ^{o}C for 5 hours. Solubility percentage is calculated by weight difference of the solid retained in the solution and mass of the powder added. The equation used to calculate the solubility of powder is shown below:

$$Solubility\ Percentage = \left(\frac{Mass\ of\ solid\ retained\ after\ drying}{Mass\ of\ Solid\ added\ X\,\frac{1}{4}}\right) X\ 100\%$$

Mass of the solids retained after drying is determined by the mass difference before and after drying. Mass of solids added is 1 g, which is added to the 100 mL distilled water. The one quarter is multiplied with the mass of solids added because only 25 mL of solution is used to be dried in oven. Thus, the solid retained indicates the amount of solids which soluble in 25mL of solution.

Figure 3.8: Centrifuge machine used

3.4.3.2 Effect of Anti-Caking

Anti-caking agent is very essential in all kind of powder production. This is to prevent the lump or flocculation of the powder in the future. This also will increase the shelve life of the produce sugarcane powder. Once the optimum temperature and suitable amount of maltodextrin is identified, the experiment is rerun with adding the anti-caking agent which is Calcium Carbonate. The amount of Calcium Carbonate added was referred to the journal created by the ministry of health and welfare. In that journal no specification for powdered fruit juice were given, so with the advice of our final year project supervisor, we chose the anti-caking agent used in soft drinks. The suggested amount of anti-caking agent was 5000mg/kg per solution. The weight of 500 mL sugarcane sample was determined. Referring to the ratio of 5000mg/kg solution, the amount of the anti-caking agent was added to the prepared sample and stirred well. All the usual procedures to prepare the spray dried sugarcane powder was followed. Now both the sample with and without anti-caking agent is stored for two months to check its caking ability. Later the texture and properties of the powder is analysed.

3.4.3.3 Sensory Evaluation

Sensory evaluation is the final part in this research. This is to identify the commercial value of produced sugarcane powder. [25] The evaluation is done by random probability. The important criteria of the powder which should be evaluated are determined and a sensory evaluation form is constructed. From the Sensory Evaluation Manual by Associate Professor Richard Mason from The University of Queensland, the sensory evaluation criteria are determined. The criteria are dividing into three parts which are appearance, texture and flavor. [26] The sensory evaluation is conducted randomly at Universiti Malaysia Pahang KK1 cafeteria. The sugarcane powder and the reconstituted juice is given to the people at cafeteria and asked to evaluate the product according to criteria stated in the evaluation form. 10 people were selected and evaluation is conducted. All the results are collected for further analysis. The evaluation form of the Sensory Evaluation is attached in the appendix.

3.5 General Advice to Get Optimum Product

Always start a trial with a low to medium temperature. Maximum air flow, and a slow pump rate. Observe the bottom of the main chamber for wetting and either reduce the pumping rate or increase the temperature if the product is not completely dried.[27] The optimum pumping or temperature rates are achieved when no wet spotting of the product is observed.

If the sample is a liquid with solid in suspension it may be necessary to keep it continually agitated with the magnetic or overheat stirrer. Heavy suspension are best pumped from the sample container when the positioned on the side shelf as this shelf, the pump and the jet are all at a similar weight. [28] If the sample is pumped from the bench top the product may separate as it is being pumped upwards in the silicon tube.

3.6 EXPERIMENT FLOW CHART

500 ml of sugarcane puree is bought from nearest retailer

The puree is poured into 1000ml of conical flask then filtered to remove any solid particle in order to ensure the smooth running of spray dryer

The filtered puree were added with maltodextrin 10 in various ratios for 500ml of prepared sugarcane puree. Magnetic stirrer used to avoid flocculation of maltodextrin during the mixing process.

Firstly the spray drier operated under 170 °C and 100g of maltodextrin to convert 500ml of sugarcane puree to powder. The time for the complete spray drying process was taken.

The spray drying was continued for various amount of maltodextrin and temperatures. Time were taken for every experiment.

Once the suitable amount of maltodextrin and optimum temperature were identified, one more experiment were conducted with anti-caking agent which is calcium carbonate. After the spray drying process the powder was further analysed for solubility test using centrifugation and sensory analysis

Figure 3.9: Schematic diagram for the process to convert sugarcane puree to powder

CHAPTER 4

RESULT AND DISCUSSION

4.1 Spray Drying

By using spray dryer, two major analysis was done. The first one is the change in the amount of maltodextrin and the second on the various temperatures. The other parameters were kept constant during this analysis. The analysis was done based on the product which is the amount of sugarcane powder produced.

4.1.1 Change in maltodextrin

The first objective of this experiment is to determine the suitable amount of maltodextrin to be added in 500ml of sugarcane puree. By using spray dryer to convert sugarcane puree to powder; all the parameters or condition in the operation had been kept constant except for the amount of maltodextrin added. The first sets of experiments were done to find the suitable amount of maltodextrin for 500ml of sugarcane juice. In this case the temperature was kept constant at 170°C. The condition and result are given in the next page:

Run	Juice (ml)	Maltodextrin (grams)	Inlet temperature (°C)	Outlet temperature (°C)	Fan setting	Pump setting	De-blocker
1	500	50	170	100	20	7	Fast
2	500	75	170	99	20	7	Fast
3	500	100	170	101	20	7	Fast
4	500	125	170	102	20	7	Fast
5	500	150	170	100	20	7	Fast

Table 4.1: Condition in spray dryer using various amount of maltodextrin

Run	Sugarcane juice (ml)	Percentage of maltodextrin 10 added (%)	Net weight of sugarcane powder (g)	Time taken (min)
1	500	10	48.05	135
2	500	15	83.76	139
3	500	20	110.38	132
4	500	25	157.86	130
5	500	30	167.03	133

Table 4.2: Net weight of sugarcane powder for various amount of maltodextrin

In this research of adding different amount of maltodextrin in 500ml of sugarcane juice, the prediction of sugarcane powder amount which will be produced, is the challenge of the study. This is because we need to go for a lot of assumption to predict the amount of final product. Prediction of the amount of final spray dried product can depended on the composition of maltodexrin 10 added to the puree. As we know maltodextrin is the main source of the end product. Maltodextrin act as a carrier agent in this experiment. It absorbs the taste and colour of the sugarcane juice and appear as the powder once it has been spray dried. So, the more the amount of maltodextrin we add to the sugarcane juice, the more powder will be produced. But in this experiment the amount of the powder produced is not the only concern. The taste, colour, odor and texture are also taken into account. The problem with more maltodextrin is, it mightl reduce the taste and colour of the sugarcane powder. The texture could be better with the increase amount of maltodextrin.because more amount of powder to absorb the taste, if less maltodextrin is used the amount of taste it can carry is limited therefore the shape of the powder could be affected Since we. are producing drink, the colour, odor and taste is very essential. Below is the result of adding various amount maltodextrin to 500ml sugarcane juice.

After getting the result it has clearly known that, increase in the amount of maltodextrin will yield more powder. A graph is plotted for the percentage of maltodextrin versus amount of powder yield. This is because the amount of maltodextrin is what we producing as the powder in the end, the more the amount of maltodextrin we add the more sugarcane powder we get. The texture of powder become more fine with the increase of maltodextrin. Compare to less amount of maltodextrin, carrying the taste of sugarcane juice, more maltodextrin has the capacity to carry more taste yet remain as more fine particle. The colour of sugarcane powder turns from more green to white or become more pale with the increase of maltodextrin. The original colour of the maltodextrin is pure white so the more we add the amount of maltodextrin the more will the effect of it’s colour on the produced sugarcane powder. The odor also become less strong when more maltodextrin is added.

A trial experiment also had been carried out to prove the significant of maltodextrin on the sugarcane powder. In this experiment pure sugarcane juice without the addition of maltodextrin is spray dried using the lab scale spray dryer. During these initial trials of spray drying clear juice, no powder was collected due to the low solids content of the feed and high hygroscopic level. Therefore, the higher solids of sugarcane puree concentrated were selected for spray drying. Spray drying was difficult due to high sucrose content and burn-on the equipment resulting from the high temperatures used can also contributes to high vitamin loss. When Maltodextrin was added to the concentrated puree, it formed a film around the solids in the feed that facilitated the production of a non-hygroscopic, free flowing, and flour-like powder.[29] All the powders produced by spray drying were mix of bright white and little greenish in appearance, irrespective of the color of the feed material. The produced sugarcane powder and it's reconstituted juice is shown in next page:

Figure 4.1: Sugarcane powder arranged in the increase amount of maltodextrin from the left to the right

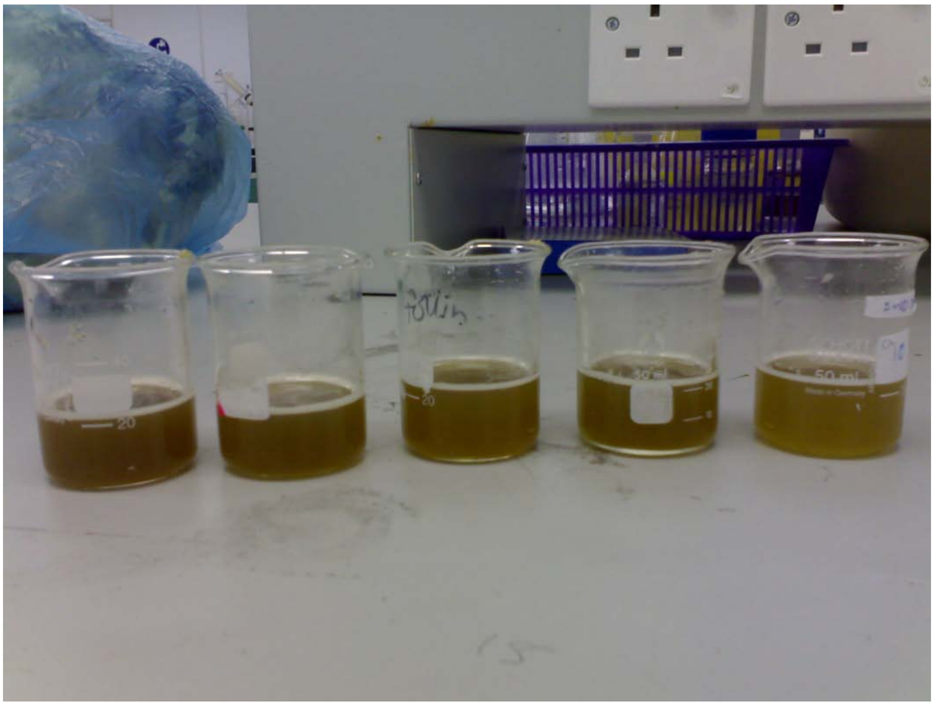

Figure 4.2: Reconstituted sugarcane juice arranged in the increase amount of maltodextrin from the left to the right

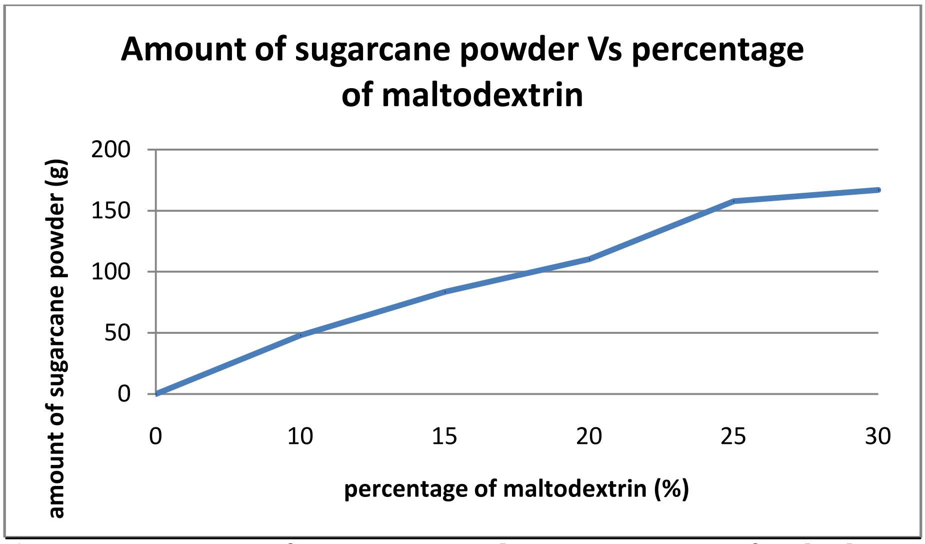

Figure 4.3: Amount of sugarcane powder Vs percentage of maltodextrin

Though we know that the amount of sugarcane powder increase with the amount of maltodextrin added , we need to choose the best suitable amount of maltodextrin for the sugarcane drink. From the analysis of taste odor and colour, 20% of maltodextrin is found to be the best amount to add in sugarcane juice. 30% and 25% of maltodextrin were found hard to dissolve in the sugarcane puree. The colour of this reconstituted juice gave pale green and the odor is not so strong, where else 10% and 15% of maltodextrin exists to be a little more hygroscopic and viscous. The amount of powder produce were also very little compare to 20% of maltodextrin. Due to commercial value and high amount of yield, 20% of maltodextrin were chose as the best suited amount to be added in sugaecane juice.

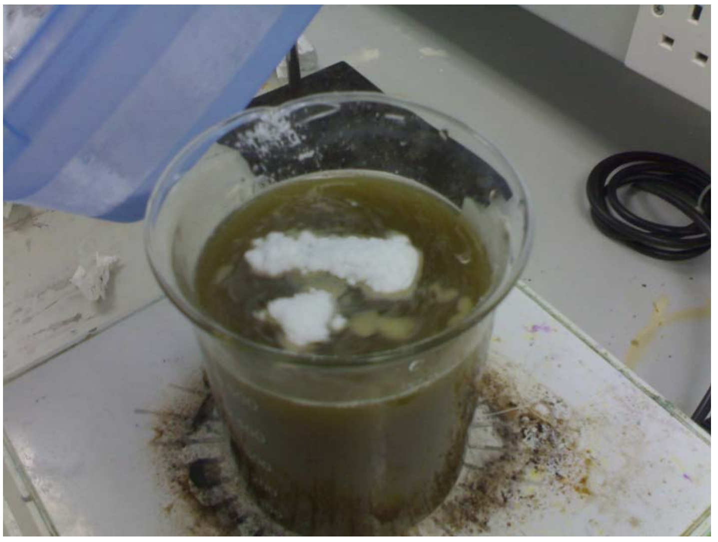

Figure 4.4: Difficulty of 30% maltodextrin to dissolve in sugarcane puree

4.1.2 Change in temperature

The second objective of this experiment is to find the optimum temperature for commercial sugarcane juice production by lab scale spray dryer. In this experiment all the other parameters are kept constant. 20% of maltodextrin were added to 500ml of sugarcane juice, as it were found to be the best suited amount of maltodextrin can be added to sugarcane juice. The condition and result of this experiment are given in the following page;

Run	Juice (ml)	Maltodextrin (grams)	Inlet temperature (°C)	Outlet temperature (°C)	Fan setting	Pump setting	De-blocker
1	500	100	160	112	20	7	Fast
2	500	100	170	110	20	7	Fast
3	500	100	180	107	20	7	Fast
4	500	100	190	114	20	7	Fast
5	500	100	200	112	20	7	Fast

Table 4.3: Condition in spray dryer using different temperatures

In this second set of experiment, the value of temperature has been manipulated for the constant value of maltodextrin. 100 grams of maltodextrin added for every 500 ml of sugarcane juice. The set temperature was started from 160°C to 200°C. In this experiment the temperature were manipulated to check whether it has any effects on the amount of powder produced or it taste, texture and odor. Higher temperature will reduce the effect of hygroscopic. More dried powder with low moisture content will be produced. Below is the result of varying the temperature with constant amount of maltodextrin.

Run	Sugarcane juice (ml)	Temperature (°C)	Percentage of maltodextrin 10 added (%)	Net weight of sugarcane powder (g)	Time taken (min)
1	500	160	20	0	30
2	500	170	20	107.6	130
3	500	180	20	105.8	132
4	500	190	20	109.6	127
5	500	200	20	54	123

Table 4.4: Net weight of powder for different amount of temperature

There was no significant difference between the powders produced using temperatures of 170°C, 180°C and 190°C in term of physical look, odor, taste and even the amount produced. This proves that the temperature does not affect much on all these characters. [30] The amount of produced powder in this three different temperatures are almost same. This also shows that the moisture content of all produced powder is almost same, though different temperature is being applied.

At temperature of 160°C, no powders were produced. This is because the heat is not sufficient to dry the sugarcane puree. At 200°C only 54grams of powder produced. This is because at 200°C most of the powders were burnt. This temperature is simply too high for the production of sugarcane powder using lab scale spray dryer. Minimum 170°C is needed to convert the sugarcane juice to powder. The powder produced in 170°C looks fine and has a good aroma of sugarcane. Though there were no significant differences among all the powders produced in various temperatures, 170°C chosen as the optimum temperature for drying sugarcane juice. This is because as we know nutrient lost is proportional to temperature, so to prevent nutrient lost from sugarcane juice we took the minimum temperature as optimum. [31] The nutrient content of sugarcane is vitamin B2 and antioxidant. These nutrients cannot be analysed since there were only little amount of it present. There are no sophisticated equipment to analyse this nutrient in UMP. These valuable nutrients do get denatured with very high temperature. To prevent from this to happen, we chose 170°C as the optimum temperature to produce sugarcane powder and with minimal lose of nutrients.

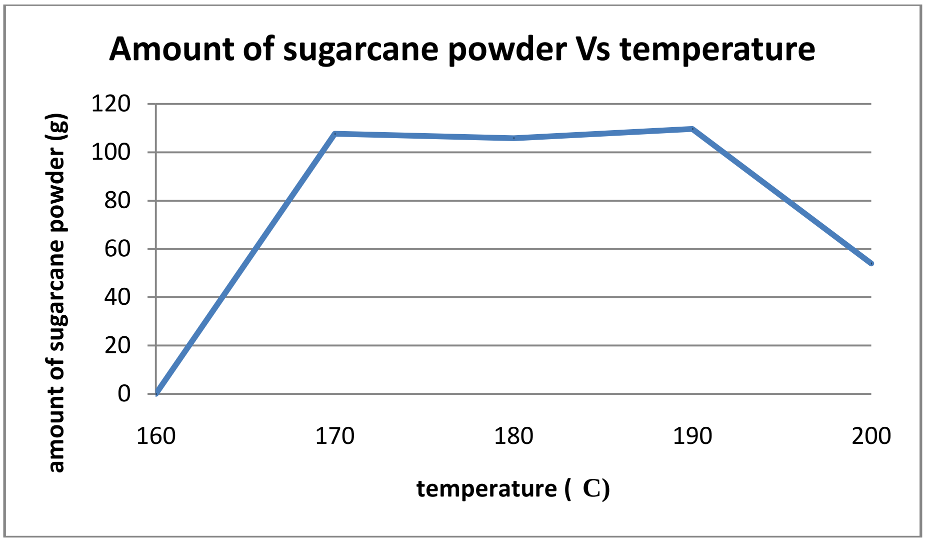

Figure 4.5: Graph of amount of sugarcane powder vs temperature

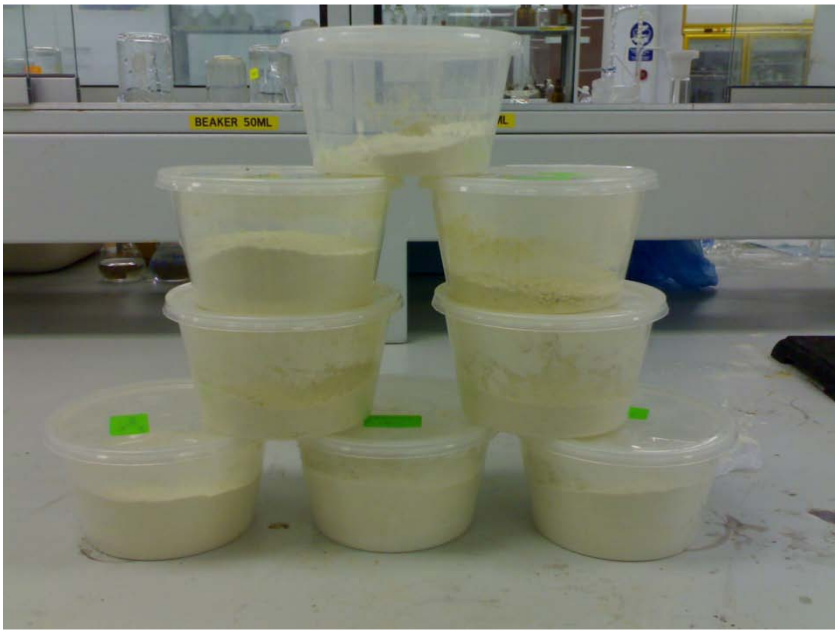

Figure 4.6: Sugarcane powder produced at various temperature

4.2 Analytical Experiment

Analytical experiments were done on the produced sugarcane powder. Once the best parameter on the amount of maltodextrin and temperature has been chosen, the powder is further analysed. In the analytical experiment the solubility analysis, anti-caking analysis and sensory analysis were done.

4.2.1 Solubility Analysis

Solubility analysis is conducted for the sugar powder produced using the different percentage of the Maltodextrine. As we know maltodextrin itself is highly soluble. Increasing the amount of maltodextrin should increase the solubility. The solubility test is conducted to evaluate the ability of the powder to dissolve in the water. This test was found essential in order to produce ready to dissolve powder. This test was conducted in University Malaysia Pahang laboratory using the centrifugation equipment. The results of the solubility analysis are illustrated in the following table;

Sample (percentage of Maltodextrine) %	Weight of boat	Weight of boat + weight of supernatant after drying	Weight of solids retained after drying
10	1.288	1.477	0.189
15	1.279	1.472	0.193
20	1.285	1.480	0.195
25	1.286	1.482	0.196
30	1.284	1.483	0.199

Table 4.5: Results of solubility analysis

The results shows that with the increase in the amount of maltodextrin, more weight of solid is gained. This proves that the solubility increases with the amount of maltodextrin. This is because, maltodextrin has the ability to change the microstructure of the produced powder, from crystalline structure maltodextrin can change to amorphous structure which has higher solubility due to the arrangement of atoms itself.[32] The percentage of the solubility is calculated using the Eastman and Moore method (1984). The percentage of solubility for different amount of Maltodextrine 10 is illustrated in the table below.

Sample (percentage of Maltodextrine 10) %	Weight of boat + weight of supernatant after drying	Weight of solids retained after drying	Percentage of solubility %
10	1.477	0.189	75.6
15	1.472	0.193	77.2
20	1.480	0.195	78
25	1.482	0.196	78.4
30	1.483	0.199	79.6

Table 4.6: Percentage of solubility for different amount of Maltodextrine

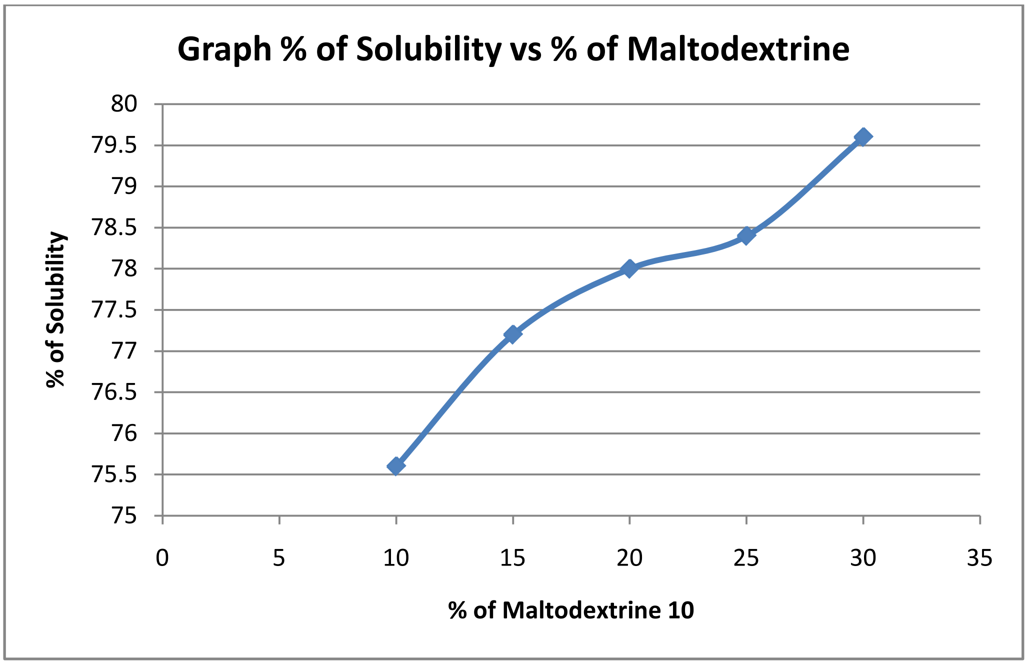

Figure 4.7: Graph percentage of solubility versus percentage of Maltodextrine

From the above graph, we could see that with the increase of percentage in maltodextrin, the percentage of solubility increases. More maltodextrin added in the solution will make it more easier to dissolve in water. This is because, the maltodextrin itself posses very high rate of solubility when dissolve in water. As we know the amount of maltodextrin affects the production of sugarcane powder. The amount of maltodextrin is directly proportional to the amount of sugarcane produced. The more amount of maltodextrin added to the juice the more the powder of sugarcane produced. Since maltodextrin has high rate of solubility, the higher amount of maltodextrin will make the powder to dissolve easily. This is why the the juice which contains high percentage of maltodextrin has produced high amount of solid, which means juice with high amount of maltodextrin has higher dissolving rate. Maltodextrin plays an essential part in the solubility of sugarcane powder.

4.2.2 Anti-Caking analysis

Once the optimum temperature and the suitable amount of maltodextrin to be added in the sugarcane juice were determined, the experiment was rerun with the addition of anti-caking. The suitable anti caking for fruit juices is Calcium Carbonate. Amount of Calcium Carbonate were added in the solution referring to the journal published by the ministry of health. This analysis does not involve any experiment. Only the process of storage is done. Two experiments with the same parameters were done, one was added with the anti-caking agent and the other was not. Both powders were stored in a dry place for one month. Observation was done, and the following pictures were taken after one month of storage.

Figure 4.8: Sugarcane powder with anti-caking agent

Figure 4.9: Sugarcane powder without anti-caking agent

According to this analysis, the powder added with anti-caking agent has not undergone any changes physically, whereas the powder produced without anti-caking agent become solid. This physical change is very essential for powders. [33] The powder which has not undergone any physical changes can be stored longer and has high shelf life. [34] Whereas the powder without anti-caking agent was found to be very hygroscopic, this powder cannot be stored long and very sensitive to humidity. However the suitable anti-caking agent should be chosen in order to get the best effect. Most of the commercial powder in the market is added with anti-caking agent.

4.2.3 Sensory Evaluation

Sensory evaluation is another major part in this experiment. Once the best parameter of producing sugarcane powder has been chosen, the experiment was done again with anti-caking agent to conduct a sensory evaluation. This sensory evaluation was done on both the powder and its reconstitute solution. This evaluation was divided into three main criteria, which are appearance, flavor and the texture. In the appearance section, colour, size and the shape of the powder was evaluated. In the flavor section odor and taste were analysed. In the section of texture, viscosity and mouth feel were evaluated. All these categories were evaluated from the scale of 1 to 5. Five different facial expressions were represented, to evaluate from the best to worst. This sensory evaluation was done among the students of University Malaysia Pahang. This survey was taken place in the cafeteria. 10 Students were randomly chose and given explanation on the research done. They were briefed about the criteria of evaluation as well. The students were given the form of evaluation and a little amount of reconstituted sugarcane juice to taste. The sample powder was also shown to them to be evaluated. The results from the random sensory evaluation were collected and all the results are illustrated in the table given. [35]

Criteria	Score Frequency				
					
Appearance					
Color			4	6	
Size			2	8	
Shape				10	
Flavor					
Odor			5	5	
Taste				1	9
Texture					
Mouth Feel				2	8
Viscosity				10	
Total			11	42	17

Table 4.7: Result of sensory analysis

When the survey from students were analysed, most of them has given good response for the taste of the juice. Only the colour and odor were given less marks. This is because the smell of sugarcane is not so strong, may be due to storage process and the colour is not very green. Overall this survey shows that, the produced sugarcane powder has a very good commercial value and it will have very good potential in the market. The odor and colour can be added synthetically if this product is happened to be marketed to increase the commercial value.

Figure 4.10: Sensory analysis in cafe

Figure 4.11: Sensory analysis in cafe

Figure 4.12: Sensory analysis in cafeteria

Figure 4.13: Sensory analysis in cafeteria

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this chapter, the chosen final parameters for all the variables are discussed. Justification for choosing such parameters are also given. The effect of every variable are also elaborated in detail.

5.2 Spray drying process

Spray dried powder is very stable at room temperature. The perfect amount of maltodextrin resulted in better colour, taste and odor retention in the final powder. The reconstituted juice retains original color of sugarcane juice. The suitable temperature is chose to prevent the nutrient loses

The produced spray dried product has very good commercial value in our neighborhood seeing that fruit powders immensely utilized to make blended juice and as a infant product in western countries.

5.3 Effect of Maltodextrine

Maltodextrine is very essential element in any powder making technology. This maltodextrin will absorp the taste and odor of the original fruit juice and will form as the powder at the end of the experiment. There are various type of maltodextrin available in the market such as maltodextrin 10, maltodextrin 15 and maltodextrin 20. Maltodextrin 10 is the most suitable for producing fruit powders. Without maltodextrin no powder can be produced. Even in this experiment, to check the effect of maltodextrin an experiment with just pure sugarcane juice without maltodextrin were spray dried. In this experiment no powder were produced.

Once we found out the effectiveness of maltodextrin, next we need figure the suitable amount of maltodextrin that need to be added in the sugarcane juice. To identify this, five various experiment were done with constant temperature. In this experiment temperature was set to be 170°C, the component of maltodextrin were manipulated from 10%, 15%, 20%, 25% and 30%. From this variation we found out that the amount of sugarcane powder produced will increase with the amount of maltodextrin added. The more maltodextrin we add the more powder we produce. Anyhow there were difficulty in dissolving 25% and 30% of maltodextrin in sugarcane juice due to high concentration. The colour and odor also depreciate with addition of maltodextrin. From all these variation of maltodextrin, 20% of maltodextrin were found to be suitable due to its taste colour and texture.

5.4 Effect of temperature

After determine the suitable amount of maltodextrin that should be added to sugarcane juice, next the optimum temperature were found out. In this experiment all the parameters were kept constant. 20% of maltodextrin were added to 500ml of sugarcane powder. The temperature were manipulated from 160°C, 170°C, 180°C, 190°C and 200°C.

There were no powders produced in 160°C. This is because the temperature is not enough to heat up the sugarcane juice. At 200°C only 54grams of powder produced. This is because at 200°C most of the powders were burnt. This temperature is simply too high for the production of sugarcane powder using lab scale spray dryer. The other temperature differences did not give any significance to the amount of sugarcane powder produce and neither the taste nor odor. It was difficult to identify the differences, even the reconstituted juice were all in almost same colour. However higher temperature has the tendency to denature the nutrients, though the nutrient losses were not calculated, since there were only limited amount of vitamin B2 in sugarcane juice, it is assumed that 170°C which is the minimum amount of temperature to produce will be the optimum temperature for this experiment with minimal lose of nutrients. [36]

5.5 Solubility analysis

For the sensory analysis, one gram of sugarcane powder from various percentage of maltodextrin were taken. This amount of powder were dissolved in 100ml of distilled water. Then, 25 ml of water were taken from that solution and centrifuged. After five minutes the supernatant were collected and dried for five hours. The dried sample after five hours were weighed in a weighing machine in the laboratory and the result were taken.

In this analysis, the juice with higher amount of maltodextrin produced high amount of solid. In a nutshell, the solubility increases with increase of the amount of maltodextrin in the juice. This is because as we know maltodextrin itself is a good dissolving agent. More maltodextrin will facilitate higher solubility in the sugarcane juice.

5.6 Anti-caking analysis

In this analysis Calcium Carbonate were chose as the anti-caking agent. The amount of anti-caking agent added according to the journal published by the ministry of health. Once the optimum temperature and the suitable amount of maltodextrin for sugarcane powder were identified, two different experiments were done on this parameters. one with the addition of anti-caking agent and another without the addition of anti-caking agent. Both powders were stored for 1 month in dry place and the caking ability of both powders were observed.

The powder with anti-caking agent did not undergo any change in physical but the powder without anti-caking agent became solid. This shows that Calcium Carbonate is the suitable agent for prevent caking in sugarcane powder. This agent need to be added in the sugarcane juice before spray drying it in order to increase the shelf life and commercial value of sugarcane powder

5.7 Sensory evaluation

After all the analysis is being done, to study the commercial value of produced sugarcane powder, sensory evaluation is done in the form of survey. In this evaluation appearance, flavor and texture were given importance. Students were chosen randomly in the cafeteria. They were given the sugarcane juice to taste and showed the produced powder.

The result from the sensory analysis shows that the produced sugarcane powder has good commercial value. 90% of the students were agreed that the taste is very similar to real sugarcane juice. The only problem was the odor and the colour. They find the odor not so strong and the colour not so green as sugarcane powder. This problem can be easily solved in the real world where synthetic colouring and aroma exist in the market. We only need to add those elements to look more commercial. From this analysis it can be concluded that the produced sugarcane powder is success and can be commercialized

5.8 Recommendation

Food is one of very important human basic needs. Food preservation is an important method to increase the shelf life of the food. The main challenge in this food preservation technique is retaining the nutrient values. Most of the techniques due to overheat or extra chemical ingredient loses its nutrient values. There are varieties of methods available for the preservation purposes. Spray drying is one of the effective methods to produce powders from fresh fruit juices.

Maltodextrin is very crucial element in producing sugarcane powder. The addition of maltodextrin should not be very more since it might affect the colour and taste of sugarcane powder. Very less amount of maltodextrin also will cause the powder to be more hygroscopic. In the case of sugarcane, 20% of maltodextrin will be the best amount to add to get the best product. Temperature naturally has the tendency to reduce the nutrient value in any food. High temperature will cause the vitamins to denature. In this case 170°C is the minimum amount to produce sugarcane powder. So, 170°C is taken as the optimum temperature to produce powder. The powder produced in this temperature looks fine and not very hygroscopic.

Solubility is also very essential for powder drinks. Since this powder is going to be mixed in the water, its level of solubility is very essential for commercial value. Furthermore in this research the main purpose is to produce ready to dilute sugarcane powder. Solubility is directly proportional to the amount of maltodextrin added. Very little amount of maltodextrin could affect the solubility rate of sugarcane powder. 20% of maltodextrin were found to most suitable, higher than this could affect the taste and colour of sugarcane powder. Another important analysis done on this sugarcane powder is anti-caking ability. Anti-caking agent is very important for this powder in order to increase its shelf life. The suitable anti-caking agent for sugarcane powder is not found. Calcium Carbonate, which is the anti-caking agent for the soft drink were chosen, since it is the nearest best comparison. The analysis on the stored sugarcane powder shows that Calcium Carbonate does reduces the caking ability of sugarcane powder. The sugarcane powder without the addition of Calcium Carbonate loses its physical form and became hard like a solid. Anyhow it is also found that too much of Calcium Carbonate could affect the colour of the sugarcane powder. So, the amount of anti-caking agent added should be proportional. Therefore further research should be done to identify more suitable anti-caking agent to increase the quality of the sugarcane powder and to increase its shelf life.

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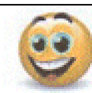
APPENDIX

SENSORY EVALUATION FORM

SENSORY EVALUATION

SUGAR CANE JUICE POWDER

Instruction: Tick (√) in the relevant column.

CRITERIA	SCORE				
					

APPEARANCE					
1) COLOUR					
2) SIZE					
3) SHAPE					

FLAVOUR					
1) ODOUR					
2) TASTE					

TEXTURE					
1) MOUTH FEEL					
2) VISCOSITY					