STANDARDIZATION OF PROCESS PROTOCOL FOR THE PRODUCTION OF BANANA PSEUDOSTEM JUICE POWDER

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PROJECT REPORT

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Department of Food and Agricultural Process Engineering
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TAVANUR - 679 573, MALAPPURAM

DECLARATION

We hereby declare that this project report entitled **"STANDARDIZATION OF PROCESS PROTOCOL FOR THE PRODUCTION OF BANANA PSEUDOSTEM JUICE POWDER"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Date: 13.2.2015

CERTIFICATE

Certified that this project report, entitled, **"STANDARDIZATION OF PROCESS PROTOCOL FOR THE PRODUCTION OF BANANA PSEUDOSTEM JUICE POWDER"** is a record of project work done jointly by Ms. Drishya Mohan, Ms. Nithya. C, Ms.Sunena T.P under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, associateship or other similar title of any other University or Society.

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DEDICATED TO THE

FOOD ENGINEERING PROFESSION

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Drishya Mohan
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SYMBOLS AND ABBREVIATIONS

%	percentage
=	equal to
±	plus or minus
cm	centimeter
CFU	colony forming unit
et al.,	and others
etc.	etcetera
Fig.	figure
g	gram(s)
i.e.	that is
KCAET	Kelappaji College of Agricultural Engineering and Technology
KAU	Kerala Agricultural University
kCal	kilocalorie
Kg	kilogram
$Kgcm^{-2}$	kilogram per square centimetre
m	meter
µm	micrometer
mg	milligram
mm	millimeter
Min	minute(s)
Ml	millilitre
MT	metric tons
MT/ha	metric ton per hectare
NHB	National Horticulture Board
NIIR	National Institute of Industrial Research
°B	degree Brix
°C	degree Celsius
rev/min	revolutions per minute

RH	relative humidity
Sec	second(s)
TSS	total soluble solids
viz.	namely
w.b	wet basis
wt	weight
SEM	Scanning electron microscopy

CHAPTER 1
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INTRODUCTION

Plants are important sources of many biologically active compounds. Plants used in traditional medicine provide an interesting and still largely unexplored source for the development of new drugs. Globally, about 85% of all medications for health care are derived from plants. A search for a safe and more effective agent from plants has continued to be an important area of active research since they can be selected on the basis of the ethno medicinal uses.

Musa paradisiaca (*M. Paradisiaca*) L. (Family: *Musaceae*), commonly known as "plantain" is a perennial tree-like herb widely distributed in the Tropics. Due to the enriched food value and versatile medicinal value, it is one of the most important fruits and vegetable crops of several countries. Banana is the fifth largest agricultural commodity in the world. In India, banana holds the first position in production and productivity among fruits with 29780 MT and 35.9 MT/ha respectively (NHB, 2011). Banana covers 13% of the total area under total fruit area, contributing nearly one third of total fruit production in the country. The highest productivity noted was 65.8 MT/ha in Tamil Nadu followed by Maharashtra (52.5 MT/ha) in the year 2010-2011 (NHB, 2011).

Banana Pseudostem (BPS) is an actively growing aerial stem with closely packed leaf sheaths. It functions as a vascular bridge for the flow of water and nutrients from roots to leaves and finally to the banana fruit bunch. It is often used as a vegetable for culinary purposes in India. Juice from BPS is a well-known remedy for urinary disorders. It helps in the treatment for removal of stones in the kidney, gall bladder, and prostate. The K, Ca, Mg, Si, and P contents of ashes of BPS were 33.4, 7.5, 4.34, 2.7, and 2.2%, respectively. Currently, <2% of PS production is used for human consumption and for production of fiber. This juice contains potassium which contributes in the effective functioning of muscles and maintains fluid balance with in the body. It is diuretic and helps in detoxification processes of the Body. It also contains Vitamin B6 which helps in

the production of Haemoglobin and insulin. It is also a source of calcium iron magnesium and phosphorus used as a laxative and in constipation.

After banana harvesting, the pseudostems are cut and left in the fields. In order to add value to banana plantation, the pseudostem could be processed into products. Nowadays, the pseudostem fiber has been used mainly in handicrafts. Although studies have shown that the cellulose fiber has suitable features to industry, the yield is low because pseudostem has about 90% of water. Once it contains potassium and sodium, the development of a sport drink seemed suitable (Feriotti *et al*). Banana central core Powder is calcium content health powder. It is used in food, pharmaceutical and medical drugs. It was found to be a potential source of polyphenols or natural antioxidants, which can be used as natural antioxidants in the food, nutraceutical and pharmaceutical industries (Saravanan *et al*).

After harvesting banana bunches from the trees over a tract of land, a large amount of waste biomass remains, because each banana plant cannot be used for the next harvest. These bare pseudo-stems are normally felled and usually abandoned in the soil plantation to become organic waste and cause environmental pollution. Therefore, exploitation of the waste banana pseudo-stems will be significantly beneficial to the environment and bring additional profits to farmers.

Nowadays, the fast economic development has changed the trend of food consumption from calories assurance to diet nutrient enrichment. The consumers today are well aware of the importance of vitamins. High moisture content in the food leads to having high water activity which leads the quality loss in foods by increasing the enzyme activity and microbial growth. Therefore, the reducing moisture content and water activity in fruits is always desirable to maintain the quality. Drying is used to preserve food by remove moisture content and water activity. Among the drying techniques, spray drying is usually applied to produce the fruit juice powder. Dehydration by spray drying is used in the wide range of products in food industries to produce dry powders and agglomerates. Economic considerations of this method include hygienic conditions during processing, operational costs, and short contact time (Sagar *et al*., 2010; Yousefi

et al., 2011). The quality of spray dried food depends on the different factors of spray dryer operating systems.

Microencapsulation is a technology that can improve the retention time of the nutrient in the food and allow controlled release at specific times, during food consumption or in the intestinal gut. It is relatively new to the food industry and is finding use in maximising the retention of the bioactivity of the components during the processing and storage of the formulated product and delivering the desired bioactive components to the target site of the body (Korhonen,2002).

Spray-drying is the most common and cheapest technique to produce microencapsulated food materials. Equipment is readily available and production costs are lower than most other methods. Compared to freeze-drying, the cost of spray-drying method is 30–50 times cheaper and efficient. During this drying process, the evaporation of solvent, that is most often water, is rapid and the entrapment of the interest compound occurs quasi-instantaneously. Spray-drying microencapsulation process must rather be considered as an art than a science because of the many factors to optimize and the complexity of the heat and mass transfer phenomena that take place during the microcapsule formation (Gharsallaoui *et al*., 2007).

Considering the above cited facts, a study was undertaken with the following objectives**:**

1) Development of process protocol for microencapsulated banana pseudostem juice powder

2) Quality analysis and shelf life studies of banana psuedostem juice powder

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

This chapter deals with comprehensive review of the research work done by various research workers related to the present studies that gives the general information on banana psuedostem, its physiochemical characteristics, drying and flour optimization and its storage studies.

2.1 Banana (*Musa paradisiaca*)

2.1.1 History and distribution

Historical report suggest banana as a native of the Papua, New Guinea. Bananas are a common herbaceous plant of the genus *Musa* (Arvanitoyannis, Mavromatis *et al*., 2008). Many species of bananas were traded over the last few centuries, and bananas are now cultivated in more than hundred countries around the world (Arvanitoyannis, *et al*., 2008). Among all the production countries, India, Brazil, Ecuador, Philippines, and China are the top 5 banana producers in the world (FAOSTAT, 2012). Major banana producing states in India are Tamil Nadu, Maharashtra, Karnataka, Kerala, Gujarat, Andhra Pradesh, Assam and Madhya Pradesh. Among this Tamil Nadu is the major banana producing state with 125.4 ha cultivating area and a productivity of 65.8 MT/ha (NHB, 2011).

2.1.2 Botanical aspects

Pseudostem is the pillar like structure on which the leaves hangs. Actually, the pseudostem is a column made through a number of tightly packed leaf sheaths. At the center of the pseudostem there is tube like structure called cambium. This layer acts as the connecting link between the rhizome and the bunch. And the translocation of food and nutrients take place through it. Thus, pseudostem also plays an important role in the plant body.

2.2 Banana pseudostem

The banana stem called the pseudo stem is a juicy material rich in fiber. It is one of the various other common foods in some regions of India. It has great medicinal value too. It is available in India as any other vegetable in the markets. Juice from banana

stem is a well-known remedy for urinary disorders. It improves the functional efficiency of kidney and liver thereby alleviating the discomforts and diseased condition in them. It helps in the dissolution of calcium oxalate, a cause for the formation of kidney stones. The product could be consumed for its medicinal value. Because of its high content of phenolics and tannins imparting an astringent taste to the beverage, its consumption is limited. The immediate browning of the extracted juice has been a problem for the commercial utilization of the juice.

2.2.1 *Nutrient composition*

Table 2.1 Pseudostem sap proximate composition

(Feriotti *et al*)

COMPONENT	**CONTENT(%)**
Total solid	0.308
Protein	0.0141
Lipid	0.005
Total sugar	0.191
Ash	0.104

Table 2.2 Pseudostem sap minerals and chlorides

COMPONENT	**CONTENT(mgL^{-1})**
Sodium	88
Potassium	874
Calcium	130
Magnesium	116
Chlorides	357.8

2.2.2 *Utility*

Prasobh et al. (2011) Conducted a study on use of *musa AAB* in kidney stone treatment and other diseases. By the three month invitro analysis it was proven that the Musa stem juice is effective to dissolve kidney stone. The stem of these plants are used as food but it has higher degree of medicinal value. There was a significant decrease in the size of kidney stone under *invitro* condition. This is due to the presence of inorganic

constituents like magnesium, potassium and nitrate.Magnesium nitrate and potassium nitrate are the major active constituents present in the *Musa AAB* stem juice and was confirmed by the *invitro s*tudies. Literature has proved the explosive and solubilizing property of potassium nitrate. The result from these experiment demonstrate the potential of concentrated *Musa AAB* stem juice extract was a good natural remedy against kidney stone. The *Musa AAB* stem juice may be useful to overcome the major drawback of surgical procedures which is recurrence of stones. *Invivo* studies can further confirm and revalidate the use of these agents in real time clinical settings.

Saravanan *et al*. (2011) conducted a study on Polyphenols of Pseudostem of different banana cultivars and their antioxidant activities. The investigation manifests clearly that BPS was found to be a potential source of polyphenols or natural antioxidants, which can be used as natural antioxidants in the food, nutraceutical, and pharmaceutical industries. The multiple antioxidant property may be an impetus to increase the consumption of BPS either in fresh or in processed form.

Ray *et al*. (2013) conducted a study on the Phytochemical characterization and antimicrobial property of banana(*Musa paridasiaca*) psuedostem juice. Characterization of preliminary phytochemical components of banana (*Musa paridasiaca*) Pseudostem juice was determined. Banana Pseudostem juice extracted from fresh banana Pseudostem was tested for antimicrobial activities. The level of antimicrobial effect was established using an invitro agar assay and standard broth dilution susceptibility test. Phytochemical screening revealed the presence of different minerals and tannins. The banana Pseudostem extract exhibited the strongest antimicrobial effect against *Staphylococcus aureus*. Other bacterial strains were also sensitive to the Banana Pseudostem juice.

Saravanan *et al.* (2011*)* conducted a study on potential nutraceutical food beverage with antioxidant properties from banana plant bio-waste (pseudostem and rhizome). Banana plant biomass waste, viz. pseudostem (BPS) and rhizome (BR), contribute 30.81% and 12.67% respectively. A negligible percentage of these were used for fresh consumption, otherwise they are waste and incinerated. In order to utilize these bio-wastes in a bioactive perspective, nutritional and nutraceutical components were studied from the juices and its Ready-To-Serve (RTS) beverage. Among the different concentrations of RTS beverages prepared, 25% BPS juice and 20% BR juice with 15

degree brix TSS and 0.3% acidity were adjudged as best by sensory panelists. Thus, BPS and BR juice can be effectively used to produce new generation functional beverage.

Abirami *et al*. (2014) conducted a work where pseudostem juice of Musa paradisiacal L was evaluated for its toxicity profiles. Toxicity studies were carried out using two methods, namely acute oral toxicity and Repeated dose 28-day oral toxicity as per OECD 425 and 407 respectively. During the entire period of study, behavioural changes, food intake, water intake and weekly body weight changes were evaluated. At the end of the treatment, serum samples were subjected to biochemical analysis. The data of the results obtained depicted that the pseudostem juice of Musa paradisiacal L is not toxic, hence can be used as an adjuvant in cancer and diabetic therapies to prevent toxic effects that might result due to the long term administration of chemo therapeutic agents.

2.3 Steam blanching

Blanching is a unit operation prior to freezing, canning, or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes, modifying texture, preserving colour, flavor and nutritional value and removing trapped air. Hot water and steam are the most commonly used heating media for blanching in industries. Blanching facilitates peeling and dicing, and is also accompanied by microbial load reduction. Fruits are usually not blanched, or blanched under mild (low temperature) conditions prior to freezing because blanching produces undesirable texture changes. Before drying, fruits and vegetables are sometimes blanched. After blanching, vegetables are quickly chilled by spraying with cold water, or by conveying them to a flume of cold water that often serves to transport them to the next part of the process.

In steam blanchers, a product is transported by a chain or belt conveyor through a chamber where ‘‘food-grade’’ steam at approximately 100°C is directly injected. Usually temperature in the headspace is measured and the flow rate of steam is controlled. Steam blanching is usually used for cut and small products, and requires less time than water blanching because the heat transfer coefficient of condensing steam is greater than that of hot water. However, because of the high-temperature gradients between the surface and the center of the product, larger products or pieces of product can be ‘‘over blanched’’ near the surface and ‘‘under blanched’’ at the center.

Steam blanching is more energy-efficient and produces lower BOD and hydraulic loads than water blanching. In addition, nutrient leaching is reduced compared to water blanching (Ralph *et al*).

2.4 Spray drying

Spray drying can be used to preserve food or simply as a quick drying method. The range of product applications continues to expand, so that today spray drying has connections with many things we use daily (Nath and Sathpathy, 1998).

Drying of fruit juices is a difficult operation, mainly because of the undesirable changes in the quality of the dried product. The high temperatures and long drying times required to remove the water from the sugar containing fruit material in conventional air-drying may cause serious damage to the flavour, colour, and nutrients of the product. Spray drying reduces these undesirable changes (Saravacos *et al*.,2002).

Spray drying belongs to the family of suspended particles systems as drying is accomplished while the particles are suspended in air. Spray drying is by definition the transformation of a feed from a fluid state into dry particulate form by spraying the feed into a hot drying medium (Barbosa-Canovas *et al*., 2005; Masters, 1991). It is a one-step, continuous particle processing involving drying. The drying of liquid food is often accomplished in a spray dryer. Moisture removal from a liquid food occurs after the liquid is atomized or sprayed into heated air within a drying chamber various configuration of the chamber are used.

In the spray drying process, due to the large surface area of the small droplets, drying takes place rapidly (1-10 seconds). As a result, it is highly recommended for heat sensitive foods (Fellows, 2000; Tang and Yang, 2004; Ramaswamy and Marcotte, 2006). Furthermore, several other advantages of spray drying can be found in that the drying process is continuous, easy and entirely automatically controlled. Importantly, the quality of final powders will not be variable from one batch to another when spray drying conditions remain unchanged (Masters, 1991). However, installation costs, thermal efficiency, waste heat and exhaust-air handling are the key drawbacks of the spray drying process (Barbosa-Cánovas and Vega-Mercado, 1996).

Among various methods of preparing dehydrated products, spray drying is the most important one. Spray drying delivers a powder of specific particle size and moisture content in relation to the drier capacity or product's heat sensitivity. In a continuous operation it delivers a highly controlled powder quality with relatively easy manipulation. Accordingly the objective of spray drying is to produce a spray of high surface to mass ratio droplets (ideally of equal size) and then to uniformly and quickly evaporate the water. Evaporation keeps the products temperature to a minimum, which in turn reduces the chance of high temperature deterioration of the products. Further, spray drying minimises loss of volatile flavours as against other dehydration techniques. Spray drying consists of four process stages.

1. Atomization of feed into a spray

2. Spray-air contact (mixing and flow)

3. Drying of spray (moisture/volatiles evaporation)

4. Separation of dried product from the air

Spray drying is used to produce a wide range of products including heat sensitive materials (Mahendran, 2010).

The flexibility of drier designs provides opportunities to produce the powders that consistently meet industrial specifications (Huntington, 2004; Sharma *et al.*, 2000). The production capacity can be expanded to over 25 tonnes of product per hour (Masters, 2004). The process is continuous and easily automated which can reduce labour costs (William, 1971; Sharma *et al.*, 2000). There are less sticking and corrosion problems in spray drying if the material does not come in contact with the equipment walls until it is dry (Gupta, 1978).

Masters (2004) in his study reported that the products produced by spray drying include: pharmaceutical, such as antibiotics, analgesics, vaccines, vitamins and catalysts; chemicals, such as, carbides, ferrite, nitrides, tannins, fine organic/inorganic chemicals detergent and dyestuffs; ceramic, including advanced ceramic formulations; and foods such as, milk and milk products, food colour, food supplement, soup mixes, spice and

herb extracts, coffee, tea and sweetener. Spray dried food products are appealing, retain nutritional qualities and are convenient to Consumer.

Masters (1997) Stated that spray drying is a powerful tool for delivering cost effective, high quality products.

Masters (2004) stated that spray drying is a technique widely used in many industries, as an effective method to obtain various dried products.

Spray-drying has been considered as a solution for conventional drying problems because the process has usually proved not only efficient but also economic (Masters, 2004). The main factors in spray-drying that must be optimized are feed temperature, inlet air temperature, and outlet air temperature (Liu *et al.,* 2006).

Chandrasekha *et al*. (1966) developed an infant food powder based on soyabean. Powdered barley malt was added to debittered soya dhal, centrifuged and the liquor from the centrifuge was warmed to 60°C. Weighed quantities of ground nut oil, skim milk powder, acid hydrolysed starch and buffer salts were added, homogenised and spray dried at 250°C inlet and 100°C outlet temperatures.

Spray drying is used for drying of solutions and paste especially for heat sensitive products (Mastres, 2004).

Hassan *et al*. (2006) studied about the spray drying of roselle extract. *Hibiscus sabdariffa* (Roselle) powder was produced by pilot scale spray drying using single strength and vacuum concentrated water extract of its calyces. The lowest inlet air temperature (198.5°C) resulted in the product with best protein content (12.43%), retention of vitamin C (82.76 mg/ 100 g), and solubility (dissolving in 97 sec); as well as the highest moisture content (3.78%) in the product. The powder showed a noticeable tendency to stick to internal surfaces of the drying chamber particularly with concentrated solutions at higher temperatures.

Brennan *et al*. (2007) studied about spray drying of concentrated orange juice, on a laboratory scale and some of the factors affecting the process. In his study concentrated orange juice (a) without additives and containing (b) sodium carboxymethyl cellulose, (c) Gum Acacia, and (d) liquid glucose as additives were spray dried in a laboratory drier. Liquid glucose was found to be the most satisfactory additive, producing a powder with good %, free-flowing characteristics and a minimum of wall deposition. Variations in air

inlet temperature, feed temperature and rate and atomizer speed, within a limited range, resulted in no significant changes in the bulk density and particle size of4 the product. The higher temperatures did result in some change in colour and an increase in insoluble solids. He concluded that Cooled plate experiments indicated that the problem of wall deposition is related to wall temperature and is minimized when the wall temperature is below the sticky point temperature of the product.

Jaya and Das (2007) studied relationship of moisture content, glass transition temperature and sticky point temperature of vacuum dried mango, pineapple and tomato with added maltodextrin and tricalcium phosphate). In that study, the ratios of maltodextrin (DE 38): fruit pulps were at 0.093:1, 0.065:1 and 0.033:1 respectively. The tricalcium phosphate at 0.015:1 was used for anti-caking in the three types of vacuum-dried powder. The difference between glass transition temperature and sticky point temperature however were found from 2.5 to 15.5°C depended on the nature of raw materials and amount of maltodextrin. The difference of these two temperatures was also found to vary with moisture contents. For pineapple powder, the glass transition and sticky point temperature appeared to be very close to each other (minimum difference of around 2.5°C).

Chegini *et al.* (2008) reported that the sticky point temperature of orange juice powder using maltodextrin, liquid glucose and methylcellulose as carriers was found to be at around 44°C at 2% moisture.

Coulter and Breene (2010) successfully spray dried wide variety of fruits and vegetables using condensed milk as carrier in conventional milk drying equipment after sieving though a 0.70 mm screen. The proportion of skim milk solids ranged from zero per cent with peas and corn, 50 per cent with crane berry and blue berry and 60 to 70 per cent with tomatoes and other highly hygroscopic fruits like apple, banana and pineapple.

Mahendran (2010) prepared guava juice powder using maltodextrin as an additive by using freeze drying, spray drying and tunnel drying and found that spray drying may be the best alternative for producing guava powder with good stability.

Souza *et al*. (2009) studied about the Influence of spray drying conditions on the physical properties of dried pulp tomato. In this study a complete factorial experimental design was applied to determinate the influence of the variable inlet air temperature, feed

flow rate, and atomizer speed on the physical properties of the tomato pulp powder. Results showed that these variables had a significant positive effect on the moisture content, apparent density, and particle size and no significant effects on the porosity and true density. The best spray drying conditions to produce lower moisture content and higher apparent density tomato powder were inlet air temperature of 200°C, feed flow rate of 276 g/min, and atomizer speed of 30000 rpm.

2.5 Microencapsulation by spray drying

Spray-drying is the most common and cheapest technique to produce microencapsulated food materials. Compared to freeze-drying, the cost of spray-drying method is 30–50 times cheaper (Desobry, Netto, & Labuza, 1997). Spray-drying has been considered as a solution for conventional drying problems because the process has usually proved not only efficient but also economic (Masters, 1968). The economics of spray-drying were discussed by Quinn (1965). However, Spray-drying is considered as an energy wasting operation because it is impossible to utilize all the heat going through the drying chamber.

The application of spray-drying process in microencapsulation involves three basic steps (Dziezak, 1988): preparation of the dispersion or emulsion to be processed; homogenization of the dispersion; and atomization of the mass into the drying chamber. However, and more detailing the third stage of the process, Shahidi and Han (1993) suggested that the microencapsulation by spray-drying involves four stages: preparation of the dispersion or emulsion; homogenization of the dispersion; atomization of the feed emulsion; and dehydration of the atomized particles.

J.M. Obon *et al*.,(2008) found that Spray-drying has been widely applied for microencapsulation of biological material. Fruit juices are a source of biomolecules as carbohydrates, proteins, as well as of nutraceutical compounds with interesting antioxidant properties. Red prickly pear juice has been used as an example for fruit juices microencapsulation studies because of its high antioxidant red pigment content which was used to evaluate spray drying performance. Spray drying conditions were optimized using glucose syrup as microencapsulating drying aid in order to obtain a non-sticky powder with high pigment content. A high color strength (4.0) fruit juice powder was obtained of low water content (4 %) and high bulk density (0.6 g/ml). Powder particles

average size were 2-4 μm. Spray drying conditions used and microencapsulation agent selected were compared with those used for spray drying different fruit juices in advance. Spray drying of fruit juices as the red prickly pear juice studied, allows obtaining free flowing microencapsulated juice powders useful for the food industry.

Currently maltodextrin is the most widely used additive to obtain fruit juice powders, since it satisfies the demands and is reasonably cheap (Bhandari *et al*., 1993). Stickiness is a major reason which has limited the use of spray drying for sugar-rich and acid rich foods. On the other hand, the stickiness was not encountered when less hydrolyzed starch derivatives such as maltodextrin were spray dried; instead, they facilitated the spray drying process of the sugar-rich foods. Hence, they are frequently used as drying aids.

Maltodextrins are digestible carbohydrates made from several different cereal sources, including corn, potato, rice and tapioca. The processes to produce maltodextrins involve cooking of starch followed by acid and/or enzymatic hydrolysis to break the starch into smaller chains. These chains are composed of several oligosaccharides molecules along with polysaccharides of larger molecular weight (Avaltroni *et al.*, 2004).

Dolinsky *et al*., (2000) suggested that 30-55% maltodextrin should be added to the fruit and vegetable juice in order to obtain the powder.

Adhikari *et al.*, (2003) reported that the addition of maltodextrins significantly reduced the stickiness of fructose solutions, showing its use as an effective drying aid.

2.6 Quality characteristics

Poduval (2002) opined that quality standards are of great importance in facilitating both national and international trade. Quality of the product is determined by its chemical and nutritional composition.

2.6.1 Moisture content

Drying is the standard method for determining the moisture content of materials. The material is heated under carefully specified conditions and the loss of weight is taken as a measure of the moisture content of the sample. Drying methods are simple, relatively rapid, and provide the simultaneous analyses of large numbers of samples (Pomeranz and Meloan, 1994).

The residual moisture content of spray-dried samples was determined by oven-drying the powders at 102 °C, determining the difference in weight, and expressing the weight loss as a per cent of the initial powder weight ((IS: SP: 18(part XI), 1981).

2.6.2 pH and titrable acidity

pH values give a measure of the acidity or alkalinity of a product, while titrable acidity gives a measure of the amount of acid present. Assessment of pH and titrable acidity of banana, cooked banana and plantain are used primarily to estimate consumption quality and hidden attributes. They could be considered as indicators of fruit maturity or ripeness.

Dadzie and Orchard (1996) reported that acids make an important contribution to the post-harvest quality of the fruit, as taste is mainly a balance between the sugar and acid contents, hence post-harvest assessment of acidity is important in the evaluation of the taste of the fruit.

Wills *et al*. (1998) reported that acids are one of the energy reserves of the fruit, therefore theses are used in the respiration process and converted to more simple molecules such as carbon dioxide and water.

Ingham and Uljas (1999) reported that temperature and pH interact to form barriers to the survival of certain pathogens.

Marupadi *et al.* (2011) studied the enhancement of storage life in quality maintenance of papaya fruit using aloevera based anti-microbial coating. The results showed that the titrable acidity in the fruit sample decreased with the storage time in both controlled and treated fruits.

2.6.3 Total soluble solids

TSS indicates soluble solid content of banana flour, and high TSS has been associated with high sucrose content in banana pulp.

Luong *et al*. (1973) reported that the average starch content drops from 80% to 70% in the pre climacteric period to less than 1% at the end of the climacteric period, while sugars, mainly sucrose accumulate to more than 10% of the fresh weight of the fruit.

Luh and Woodrff (1975) reported that the increase in TSS during storage may be due to acid hydrolysis of poly saccharides especially gums and pectin.

Singh *et al*. (1984) determined the TSS of fruits in controlled atmosphere storage using refractometer. It was observed that TSS decreased with increase in carbon dioxide composition and storage period.

Naik *et al*. (1993) observed that TSS of tomatoes increased up to 14 days of storage in polyethylene bags and thereafter gradually decreased. The control showed very rapid decrease in TSS.

Gill *et al.* (2006) reported that fresh cut mango cubes maintained good visual quality and there were no significant change in soluble solid content.

2.6.4 Water activity

Water activity is defined as the ratio of vapour pressure of water in a system to the vapour pressure of pure water or the equilibrium relative humidity of the air surrounding the system at the same temperature. It is a function of moisture and temperature of food. Most fresh foods can be considered as high-moisture foods and their shelf life is largely controlled by the growth of microorganisms. High-moisture foods have a a_w of 0.90 to 0.999 and they usually contain more than 50% w/w water (Guzman *et al.,* 1974).

Eskin and Robinson (2000) reported that most bacteria, molds, and yeasts are likely to grow in high-moisture foods. However, the types of spoilage microorganisms and their species are highly dependent on both aw and pH as well as other hurdles.

Eskin and Robinson (2000) found that intermediate moisture foods (IMF) have a a_w of 0.60 to 0.90 and the water content is 10 to 50%. These foods include many traditional low-moisture foods, such as grains, nuts and dehydrated fruits and a number of processed foods. The traditional and novel IMF products consumed after dehydration included some fruit cakes/pies/puddings and pop-tarts, respectively.

2.6.5 ***Bulk density***

Bhandari *et al.* (1993) described a method for the determination of bulk density in which measuring cylinder of known volume was tapped (50 times) after the powder was poured into it. The cylinder containing the powder was tapped on a flat surface to a constant volume. The final volume of the powder was recorded and the bulk density was calculated by dividing the sample weight by volume.

Goula and Adamapoulos (2008) described a method for the bulk density in which Bulk density (g/mL) was determined by gently adding 2 g of powder into an empty 10

mL graduated cylinder and holding the cylinder on a vortex vibrator for 1 minute. The ratio of the mass of the powder and the volume occupied in the cylinder determines the bulk density value.

2.6.6 Wettability

The reconstitution properties (wettability, solubility and dispersibility) of skim milk powder is having particular importance to manufacturers and consumers as a benchmark of consumption quality and also has a direct impact on their perception of the overall product quality.

In the research study conducted by Fang *et al*. (2008) it was reported that the wettability of skim milk powder increased with lactose and protein content and decreased with fat content. The solubility decline of skim milk powder was due to denaturation of protein under drying.

Wettability (or wetting time) was determined by placing 3 g of dried powder around a pestle inside a funnel so that the pestle blocks the funnel opening. Then, the pestle was lifted to allow the powder to flow though the stem into a beaker of water. As soon as all the powder had flown into the beaker of water, a stop watch was started. The time (s) taken for complete wetting of the powder was noted as the wetting time. The experiment was done in triplicate (Falade and Omojola, 2010; Desousa *et al*., 2008).

2.6.7 Particle size

Ozkan *et al*. (2002) reported the scanning electron microscopy (SEM) of the milk powders, which gave an impression of the types of agglomerates that existed in the whole and skim milk powders. The differences between the SMP and WMP were mainly due to the significant variation in the surface composition of these milk powders.

Ji *et al*. (2008) studied the microstructure by Cryo-SEM and showed that casein/k-carrageenan aggregates were composed of many spherical subunits. These subunits were tightly connected with each other. No individual caseins or k-carrageenans were distinguishable. The FE-SEM after critical point drying showed the presence of individual casein micelles and k-carrageenan strands. Casein micelles appeared to be spherical with some protuberances on the surface.

2.6.8 Packaging and storage studies of spray dried products

Some of the findings on packaging and storage by other scientist on guava powder are furnished below:

Sharma *et al*. (2004) conducted the storage studies on foam mat dried hill lemon powder in poly propylene and aluminium laminated pouches. It was found that the moisture content increased from 19 to 133 per cent on dry basis, 2.86 times of browning with consequent losses of 20.98 per cent ascorbic acid, 1.72 per cent acidity and 0.63 per cent total sugar during the storage period of 6 months. However, powders packaged in aluminium laminated pouches experienced minimum changes in quality compared to those packaged in polypropylene pouches. The equilibrium relative humidity (ERH) studies of hill lemon powder showed that the powder was highly hygroscopic and therefore required to be stored in the RH of 18 to 25 per cent.

Mary *et al*. (2007) studied the packaging and storage studies on spray dried ripe banana powder under ambient conditions and concluded that banana powder could be successfully stored under ambient conditions for one year by packing in nitrogen flushed aluminium foil laminated pouches with minimum changes in colour, flavour, texture, microbial load and organoleptic qualities.

Pua *et al.* (2008) had conducted an experiment on storage stability of jackfruit powder packaged in aluminium laminated polyethylene and metalized co-extruded biaxially oriented poly propylene. The total colour difference (ΔE), rates of adsorbed moisture and sensory attributes of drum-dried jackfruit powder packaged in aluminium laminated polyethylene (ALP) and metalized co-extruded biaxially oriented polypropylene (BOPP/MCPP) pouches stored at accelerated storage (380C, with 50%, 75% and 90% relative humidity (RH)) were determined over 12 weeks period. The changes intotal colour followed zero order reaction kinetics. The powder packaged in ALP significantly ($p < 0.05$) reduced total colour change, rates of adsorbed moisture, lumpiness intensity of jackfruit powder and was rated higher in terms of overall acceptability over BOPP/MCPP.

2.6.9 Sensory Evaluation

Sensory evaluation is the scientific discipline used to evoke measures to analyse and interpret reactions to those characteristics of food as they are perceived by the senses of sight, smell, taste, touch and hearing. Sensory attribute of quality, guide the consumer in his selection of foods, also for determining the conformity of a food with established government or trade standard and food grade.

As the final criterion of food quality is human evaluation, the value of objective measurements must be evaluated by their correlation with sensory measurements. A successful implementation of sensory evaluation programme requires major components like proper laboratory facilities, sensory panels and rigorous training programme (Reece, 1979).

The selection, acceptance, and digestibility of a food are largely determined by its sensory properties. Evaluation of sensory properties, is, however, affected by personal preference. To minimize the effect of factor on personal preference, different procedure for safety evaluation has been devised and the results are evaluated by statistical methods (Zeuthen *et al*., 1990).

According to Bodyfelt *et al.* (1998) the panelist should be trained for desirable and undesirable sensory attributes of the concerned product. Before starting, the panelists should feel that they are going to do an important activity and their contribution is very important.

Anonymous (1999) stated that organoleptic evaluation is a scientific discipline to evolve measures, analysis and interpret reactions to those characteristics of food and materials, as they are perceived by the sense of sight, taste, smell, etc. Quality is a measure of the degree of excellence or degree of acceptability by consumer. Quality characteristic are classified into Sensory (colour, size, shape and defect, texture and %), Hidden (Nutritive value and Toxicity) and Quantitative (crop yield and finished product yield).

Rao and Gupta (2002) developed a spray dried orange juice blended skim milk powder. From the various samples that were obtained during the process Optimisation trials, representative samples of the 4 proportions with the best attributes were selected, based on organoleptic and quantitative observations. These representative powder samples were subjected to various physico-chemical and sensory attributes. A panel of five trained judges performed sensory evaluation.

Rao and Kumar (2005) studied the spray drying of mango juice-buttermilk blends. The sensory evaluation of resultant powder was judged by an in-house panel consisting of 5 experienced judges. The panelists were supplied with both powder as well as reconstituted form of mango-buttermilk blends. In case of reconstituted form, the

powder was fully dispersed in warm water at 40°C to a solid level of 10 per cent and supplied to judges.

Falade and Aworh (2005) reported the study of sensory evaluation and consumer acceptance of osmosed and oven dried African star apple and African mango. It was found that there are no significant differences in all the sensory attributes of oven dried African star apple slices preosmosed in the sucrose solutions. However unosmosed and dried samples received consistent poor scores for all the sensory attributes. There was no significant differences in the quality attributes of preosmosed oven dried African mango except the taste.

Materials and Method

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the methodology adopted for satisfying the objectives of the study on preparation of banana pseudostem powder.

3.1 Collection of sample

The fresh banana pseudostems were collected from the farm of KCAET campus, Tavanur.

3.2 Pretreatment before drying

The pseudostems were cut into pieces and dipped in citric acid (3%) solution to avoid discoloration.

3.3 Steam blanching

The cut pseudostems were kept in steam blancher on trays and the chamber was closed tightly. Then the food grade steam at approximately 100˚C is directly injected in to the chamber. The blanching trials were carried out at 30 seconds and 1 minute separately.

Plate 3.1 steam blancher

3.4 Standardisation of blanching time

Blanching time was standardized based on peroxidase test by using guaiacol solution and hydrogen peroxide.

3.5 Extraction and preparation of juice

The blanched samples were crushed and pressed to squeeze out the juice. Then the juice was filtered and mixed with ginger juice, sugar and maltodextrin. Maltodextrin was used as an encapsulating agent.

3.6 Micro encapsulation by Spray drying

The Microencapsulation was Carried out in Tall type spray dryer with two fluid nozzle. The slurry or solution is introduced in the main chamber and sprayed by means of a two –fluid nozzle from the ceiling of main chamber facing downward. Compressed air is introduced in the two fluid nozzle.

The function of compressed air is to disperse the solution or slurry in fine mist. Hot air is sucked by blower through the main chamber from the ceiling which is intermixed with the mist resulting in evaporation of water and formation of dry particles. The tiny dried particles during its moist stage agglomerates to larger particles and drop in the bottom. Smaller particles is collected in the cyclone and collected in the glass product jar placed below the cyclone. Moist humid air is finally sucked by the blower and exits to atmosphere. The relative collection of dried powder at the main chamber bottom glass jar and cyclone bottom glass jar depends upon density of powder and its other characteristics which can only be evaluated by laboratory testing in spray dryer.

plate 3.2 Spray dryer

3.7 Physicochemical analysis

3.7.1 Moisture content

Moisture content of the sample was determined by weighing accurately about 5g of powder into a flat bottomed glass or aluminium dish (with a cover) previously dried and weighed and heat the dish containing the material (after uncovering) in an electric oven maintained at 1000C for about 3h. Cool the sample in a dessiccator and weigh with the cover on. Repeat the process of drying, cooling and weighing at 30 min intervals until the difference between two consecutive weighing is less than 1mg. Preserve the dish containing this dried material in a dessicator for the determination of other contents (Diamante *et al*., 2009). The moisture content of the samples was calculated on a per cent wet basis, and the average value of the triplicate measurements was used.

$$\text{Moisture content in \% wet basis} = \frac{\text{M initial} - \text{M dried}}{\text{M initial}} \times 100 \qquad (3.1)$$

3.7.2 pH

pH being the logarithm of the reciprocal of hydrogen ion concentration, is a measure of active acidity which influence the flavour or palatability of a product and also affects its processing requirements. The pH of the pseudostem powder samples was determined using a digital pH meter. The pH meter was standardized with buffer solutions of different pH (4.0, 7.0, and 9.2). Each sample was replicated three times and its mean value was taken as pH of the sample.

Plate 3.3 YORCO pH meter, model: YSI – 601

3.7.3 Total soluble solids

Total soluble solid (TSS) was measured using a hand refractometer. Pseudostem powder was mixed with water and allows the sample to settle. One or two drops of the prepared sample were placed on the hand refractometer for TSS measurement. It was expressed in degree Brix (Ranganna, 1995).

Plate 3.4 Hand refractometer for TSS measurement

3.7.4 Water activity

Aqua lab water activity meter (Plate 3.5) was used for the measurement of water activity of the prepared sample. It is the fastest instrument for measuring water activity, giving readings in five minutes or less. Its readings are precise, providing ±0.003 accuracy. The instrument is easy to clean and checking calibration is simple (Chirife *et*

al., 1992). For the water activity determination, pseudostem powder is filled in the disposable cups of the water activity meter and the sample drawer knob is turned to OPEN position and the drawer is opened. The prepared sample is then placed in the drawer. Checked the top lip of the cup to make sure it is free from sample residue (an over-filled sample cup may contaminate the chamber‘s sensors). After placing the sample, turned the sample drawer knob to the READ position. The a_w sample was noted from the LCD display of the water activity meter.

plate 3.5 Aqua lab water activity meter

3.7.5 *Wettability*

Wettability (or wetting time) was determined by placing 3 g of dried powder around a pestle inside a funnel so that the pestle blocks the funnel opening. Thereafter the powder was allowed to flow into a beaker of water by lifting the pestle and the time taken for the complete wetting of the powder in the beaker was noted and recorded as the wetting time. The experiment was done in triplicate (Falade and Omojola, 2010; Desousa *et al*., 2008).

3.7.6 *Bulk density*

Bulk density of the pseudo stem powder was determined by tapping method (Gong *et al*., 2008). Two grams of powder was loosely weighed into 10 ml graduated cylinder. The cylinder containing the powder was tapped on a flat surface to a constant volume. The final volume of the powder was recorded and the bulk density was calculated by dividing the sample weight by volume.

$$\text{Bulk density } (g/cm^3) = \frac{\text{weight of the powder}}{\text{volume of the powder}} \qquad (3.2)$$

3.8 Particle size analysis by Scanning Electron Microscopy (SEM)

The morphology of powder was determined using Scanning Electron Microscope (SEM). The scanning electron microscope (SEM) determines the particle size of a powder by using a beam of high energy electrons and electromagnet. The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. SEM can produce a largely magnified image by using electrons.

Scanning Electron Microscopy analysis of the samples were carried out using, JSM-6400 scanning electron microscope (JEOL, Tokyo, Japan). Prior to examination, the samples were uniformly spread on a sample holding stub made of aluminium. A carbon tape was stuck to the sample holding side of the stub and then a thin uniform layer of samples were coated. These samples being non-conductive were sputtercoated with gold to render them electrically conductive by using HUMMLE VII Sputter Coating Device (Anatech Electronics, Garfield, N.J., USA). The sputter coated samples were examined at 15 kV. The micrographs were taken at magnification of 500x and 200x .

3.9 Proximate analysis

3.9.1 Determination of Total Carbohydrate by Anthrone Method

Carbohydrates are the important components of storage and structural materials in the plants. The carbohydrate content can be measured by hydrolysing the polysaccharides into simple sugars by acid hydrolysis and estimating the resultant monosaccharides. Carbohydrates are first hydrolysed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxyl methyl furfural. This compound forms with anthrone a green coloured product with an absorption maximum at 630 nm.(Ranganna, S. 1991)

Procedure

1. Weigh 100 mg of the sample into a boiling tube.

2. Hydrolyse by keeping it in a boiling water bath for three hours with 5 mL of 2.5 N HCl and cool to room temperature.

3. Neutralise it with solid sodium carbonate until the effervescence ceases.

4. Make up the volume to 100 mL and centrifuge.

5. Collect the supernatant and take 0.5 and 1 mL aliquots for analysis.

6. Prepare the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard. '0' serves as blank.

7. Make up the volume to 1 mL in all the tubes including the sample tubes by adding distilled water.

8. Then add 4 mL of anthrone reagent.

9. Heat for eight minutes in a boiling water bath.

10. Cool rapidly and read the green to dark green colour at 630 nm.

11. Draw a standard graph by plotting concentration of the standard on the X-axis *versus* absorbance on the Y-axis.

12. From the graph calculate the amount of carbohydrate present in the sample tube.

Calculation

Amount of carbohydrate present in 100 mg of the sample= $\frac{mg\ of\ glucose}{volume\ of\ test\ sample} \times 100$ (3.3)

3.9.2 Determination of protein

The protein content was determined from the organic nitrogen content by Micro-Kjeldal method. The KEL PLUS Automatic Nitrogen /protein estimation system by pelican equipments, Trivandrum, India was used for this estimation .The various nitrogenous compounds were used for this estimation. The various nitrogenous compounds were converted into ammonium sulphate by boiling with concentrated sulphuric acid .The ammonium sulphate formed was decomposed with concentrated sulphuric acid . The ammonium sulphate formed was decomposed with an alkali (NaOH) and the ammonia liberated was absorbed in excess of standard solution of acid and then back titrated with standard alkali. The nitrogen value was multiplied by 6.25 to obtain the protein content. (Ranganna, S. 1991)

The protein content was calculated as:

$$\text{Protien}(\%) = \frac{(14 \times \text{titre value} \times \text{Normality of alkali} \times 6.25)}{\text{Sample weight}} \quad (3.4)$$

The percent nitrogen was multiplied by a factor of 6.25 to obtain percent "protein" on a total nitrogen basis.

3.9.3 Total ash

Note the tare weight of three silica dishes (7-8cm dia).Weigh 5-10g (or more if minerals are to be estimated, see under Minerals) of the sample into each. If moist, dry on a water bath.(After determination of moisture content, the same dishes may be used for ashing) ignite the dish and the content on a Bunsen burner. Ash the material at not more than 525^0C for 4 to 6 hr. If need be, ash overnight. Cool the dishes and weigh. The difference in weights-gives the total ash content and is expressed as percentage.

3.9.4 Vitamin C

The direct colorimetric method is based on measurement of extent to which a 2,6-dichloophenol –indophenol solution is decolorized by ascorbic acid in sample extracts and in standard ascorbic acid solutions. Since inferring substances reduce the dye slowly, rapid determination would be measuring mainly the ascorbic acid.

Procedure

Preparation of sample: prepare the sample as in visual dye titration method but using 2% HPO_3 . If the sample is solid ,to blend 50 to 100 g of the sample with an equal weight of 6% HPO_3 and make an aliquot of the macerate to 100ml.

Standard curve: to dry cuvettes or test tubes, pipette the requisite volume of standard ascorbic acid solution- 1,2,2.5,3,4and 5ml and make upto 5ml with the requisite amount of 2% HPO_3 . Add 10ml of dye with a rapid delivery pipette ,shake and take the reading within 15 to 20 sec. Set the instrument to 100% transmission using a blank consisting of5ml of 2% HPO_3 solution and 10ml of water . Measure the red colour at 518 nm or a

wavelength nearest to the required wavelength using a suitable filter. Plot absorbance against concentration.

Sample : place 5 ml of extract in dry cuvette or test tube, add 10 ml of dye and measure as in standard.

3.10 Packaging

The powder obtained spray dryer is packed for shelf life studies. The samples were packed using a hand sealing machine and stored in ambient condition (temp 29-30˚C with 40-50% RH) and the different quality parameters of the powder were evaluated. The powder was packed in Aluminium foil.

3.11 Storage studies

The most acceptable treatment was selected for storage studies at room temperature. Bio-chemical analysis of powder obtained by spray drying were carried out to evaluate the quality deterioration during drying and storage. The moisture content, total solids, pH, bulk density, and wettability were estimated in every week using the standard procedures.

3.12 Microbiological Analysis

Microbiological analysis of prepared samples included determination of total viable count. Ten grams of samples were homogenized by a stirrer with 90 ml sterile distilled water to obtain a 10^{-1} dilution. Further tenfold serial dilution was made using the same diluents till a dilution of 10^{-2} was obtained. Aliquot of (1ml) suitable dilution was pour plated in triplicates onto prepared, sterile and dried Petridishes. The prepared media was added to the petridishes . Total number of viable microbes per gram of was obtained by multiplying the number of colony forming units (CFU) on the plate with respective dilution factor and then was converted into logarithmic form. Experiments were conducted in triplicate.

3.13 Sensory evaluation

The drink prepared from powder were assessed for their sensory attributes like appearance, odour, flavour, taste and overall acceptability by using a 5-point scale with 18 panelists to find out the consumer acceptability. The fresh Pseudostem juice with

ginger, lime and sugar added to it was kept as control.The juice prepared T5 kept as sample 1.The juice with T2 kept as sample 3.Lemon juice was added in every samples for flavor.

SENSORY EVALUATION CARD

Name of the panelist: Date:

SAMPLE NO	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTABILITY

5-Like very much

4-Like

3-Nither like nor dislike

2-Dislike

1-Dislike very much Signature of the panelist

3.14 Standardisation of drying temperature and treatment

About 500 ml of juice was taken for spray drying. The drying was carried out at two different inlet temperatures and at different concentrations of sugar, Ginger juice and maltodextrin.

Table 4.1 Standardisation of drying temperature and treatment

TREATMENT	**MALTODEXTRIN (%)**	**GINGER (%)**	**SUGAR (%)**	**INLET TEMPERATURE (°C)**
T1	25	4%	12	185
T2	25	4%	15	185
T3	25	4%	20	185
T4	20	2%	12	180
T5	20	2%	15	180
T6	20	2%	20	180

Standardisation was done on the basis of quality analysis of different treatments and sensory analysis.

process protocol for pseudostem juice powder

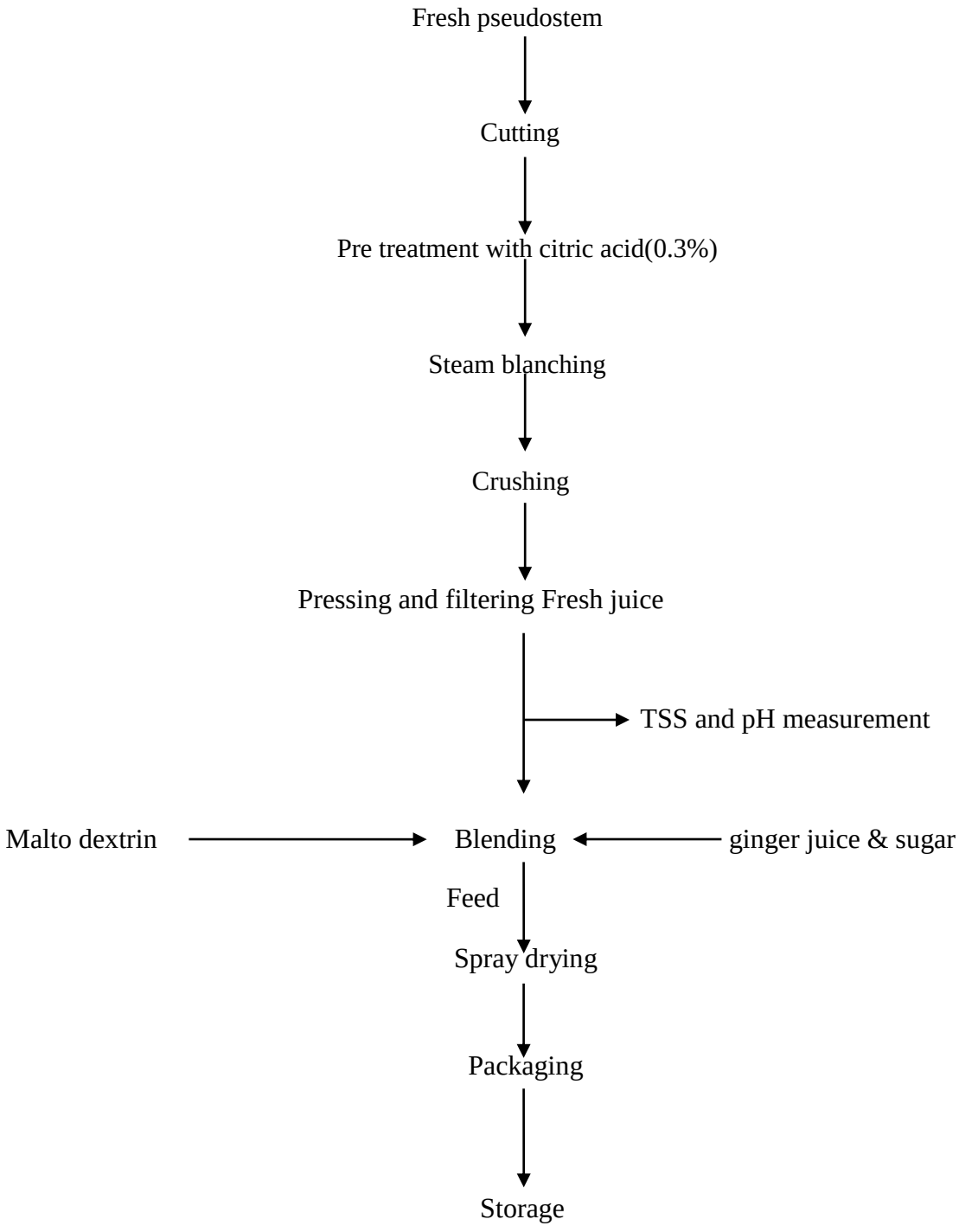

Fig 3.1 Flow chart for psuedostem powder preparation

Results and Discussions

CHAPTER 4

RESULTS AND DISCUSSION

This chapter enunciates the experiments conducted to standardize the various parameters in the drying process. The chapter also discusses in detail the storage of the powder and its quality.

4.1 Steam Blanching

The steam blanching done at 1 min interval was found to be effective to prevent enzymatic browning. So the blanching time is standardized as 1 minute. The standardization was on the basis of colour change of sample during peroxidase test. At 30 seconds , a brown colour was observed in the sample which indicated that enzymes were not inactivated. But at 1 minute , no colour change was observed, that is complete inactivation was taken place.

Plate 4.1 Peroxidase test at 30 sec

Plate 4.2 Peroxidase test at 1 minute

4.2 Standardisation of treatments

4.2.1 water activity

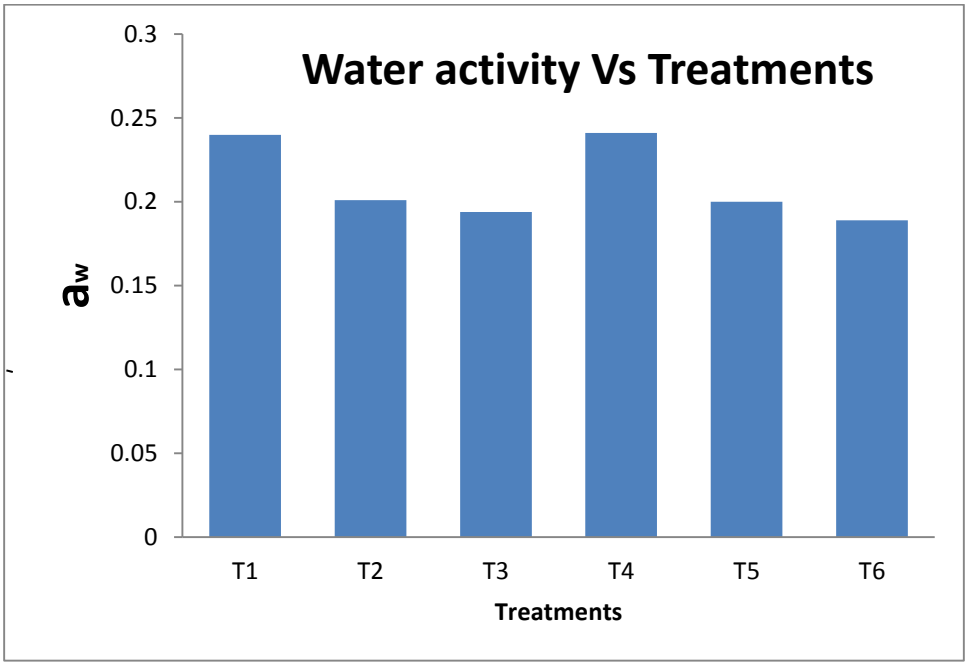

Fig 4.1 variation of water activity in various treatments

From the fig.4.1 it is obsereved that with increase in sugar content, water activity of the powder decreases. Food stability usually decreases with increase in water activity. From the figure it is evident that the water activity is maximum for T4 treatment (spray drying with 12% sugar and 20% maltodextrin) and minimum for T6 treatment (spray drying with addition of 20% maltodextrin and 20% sugar).

In general the water activity is in the permissible limit. Microorganisms respond differently to water activity depending on a number of factors. Microbial growth, and in some cases the production of microbial metabolites, may be particularly sensitive to alteration in water activity. An increase in temperature usually decreases microbial growth.

4.2.2 pH

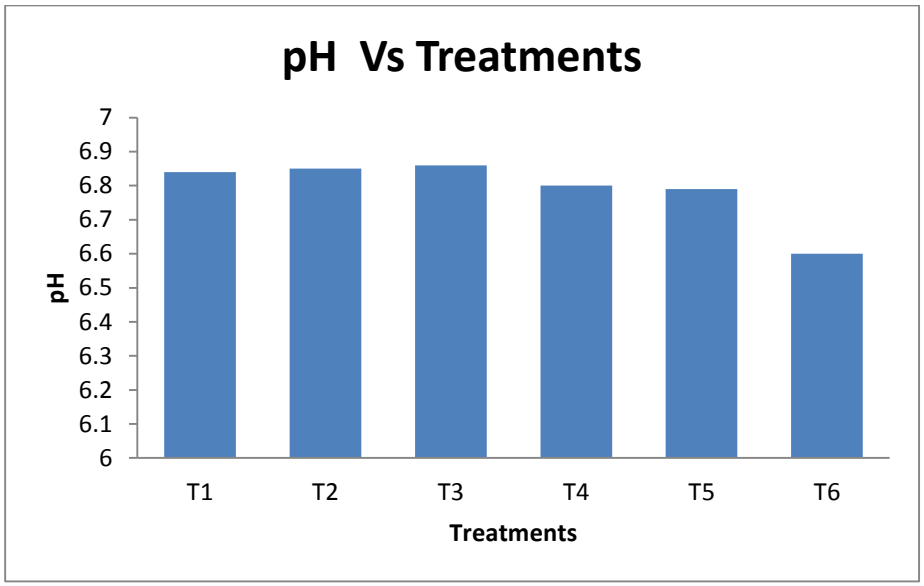

Fig.4.2 variation of pH in various treatments

The change in pH with treatment is shown in fig.4.2. From the figure it was observed that with increase in ginger juice concentration pH of the powder also increases. The highest pH was observed for T3 treatment and minimum for T6 treatment.

4.2.3 Total soluble solids

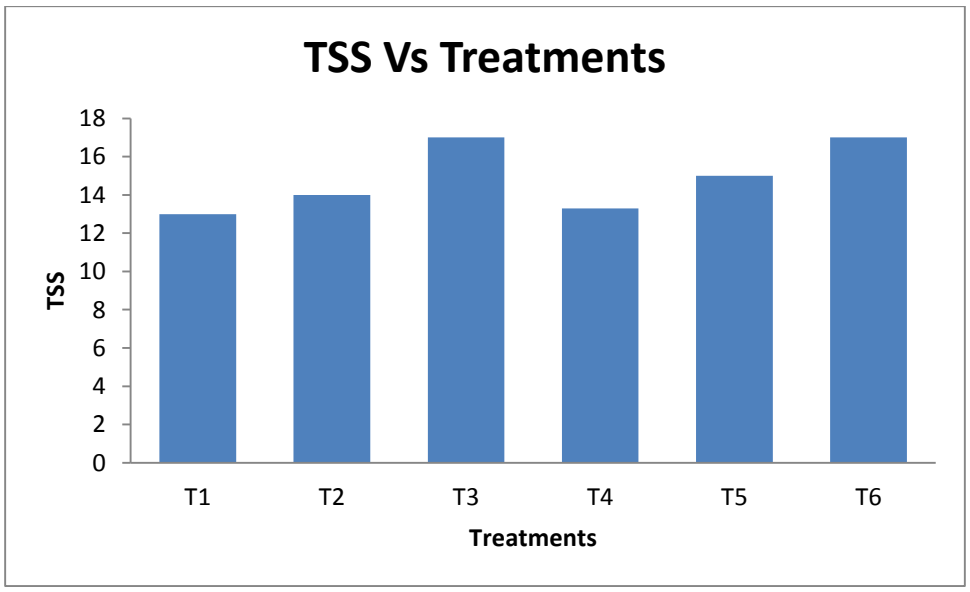

Fig:4.3 variation of total soluble solids in various treatments

The TSS for different treatments is shown in Figure 4.3. The results showed that there was no significant change in the amount of TSS among various treatments. There was a slight increase in TSS for T3 and T6 treatments. It may be due to increase in sugar content of the powder.

4.3 Standardised parameters of spray drying

The spray drying parameters were optimized based on the yield and external appearance of the powder. Temperature and other process parameters were adjusted by considering above attributes. At 180°C more yield and better appearance were observed.

The time required for the spray drying was significantly high at low feed rate. Whereas a substantial reduction in powder was observed at higher pump feed rate (>12 rpm). The pressure and blower speed of spray dryer were adjusted to 2 kg/cm^2 and 1600 rpm, respectively inorder to obtain good quality powder with above attributes.

From these observations spray drying parameters were optimized as shown in the table 4.1.

Table 4.1 Standardised parameters of spray drying

Spray drying parameters	Result
Feed pump rpm	12
Main blower rpm	1600
Inlet temperature(˚C)	180
Outlet temperature(˚C)	68
Pressure	2kg/ cm^2

Plate 4.3 Psuedostem juice powder

4.4 Sensory analysis

Sensory quality is the ultimate measure of product quality and success. Sensory analysis comprises a variety of powerful and sensitive tools to measure human responses to foods and other products. The fresh Pseudostem juice with ginger, lime and sugar was kept as control. The juice prepared from spray dried powder with 2% ginger and 20% malto dextrin (T5) was kept as sample 1. The juice prepared from powder with 4% ginger

and 25% maltodextrin (T2) kept as sample 3. Lemon juice was added in all samples, irrespective of treatments, for flavor.

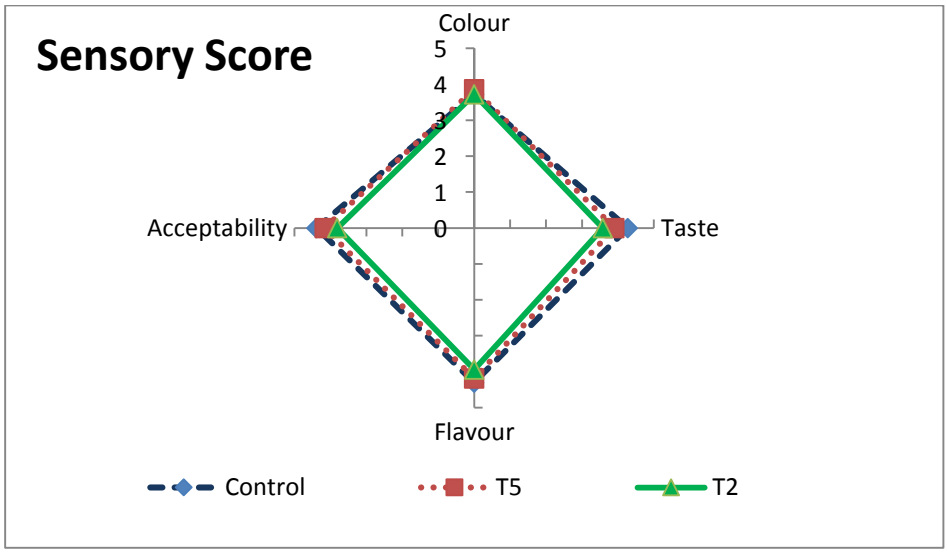

Fig 4.4 Sensory analysis of spray dried banana pseudostem powder

It was observed that taste, flavor and overall acceptability were high for the control. However, the colour of juice prepared from the powder T5 was marked as better by sensory panelists. Based on quality analysis and sensory analysis, T5 (powder with 2% ginger juice, 15% sugar and 20% maltodextrin) sample was optimized as best powder.

4.5 Physicochemical analysis

Moisture content of optimized spray dried powder was found to be 4%. This moisture content was found to be safe for storage and further processing. The pH of fresh juice and the spray dried powder was found to be 6.8 and 6.4, respectively. TSS of fresh juice was found to be 7˚Brix and the spray dried powder was 15˚Brix. Water activity of the powder was found to be 0.2 which is in the permissible limit. It indicate that the powder is safe for storage. The wetting time of the powder should be low for good reconstitution. The wetting time of the powder was 80 Sec. It can be seen that as the temperature increases, the time required for wetting of the powder increases which implies the wettability of the powder decreases. This may be due to reduced product

residual moisture content. Similar results were found by Bhandari *et al*., (1993) and Jumah *et al*., (2000). The bulk density of powder was found to be 0.47 g/ml.

The results of various physicochemical analysis of optimized sample (T5) is shown in the table 4.2.

Table 4.2 Physicochemical analysis

PHYSICOCHEMICAL ANALYSIS	POWDER	JUICE
pH	6.8	6.4
TSS	15° brix	7° brix
Moisture content	4%	-
Bulk density	0.47g/ml	-
Wettability	80 sec	-
Water activity	0.2	0.9

4.6 Proximate composition of the powder

Table 4.3 shows the proximate composition of pseudostem powder. The carbohydrate content of powder was found to be 78%. The powder contain 3.8% protein, 312 kcal of energy and 4.1% of total ash. The result shows that the powder is rich in nutrients. The result of the proximate analysis is shown in Table 4.3.

Table 4.3 Proximate composition of the powder

Sl No	COMPOSITION	%
1	Carbohydrate(g/100g)	78
2	Protein(g/100g)	3.2
3	Vitamin c	10.24
4	Energy(Kcal)	312
5	Total ash(%)	4.1

4.7 Particle size analysis

The morphology of the spray dried powder which was produced at optimized process conditions was analysed with the help of Scanning Electron Microscope (SEM) and the observed images are presented in Plate .The spray dried powder sample was having an average particle size of 17.5 ± 11.2µm.

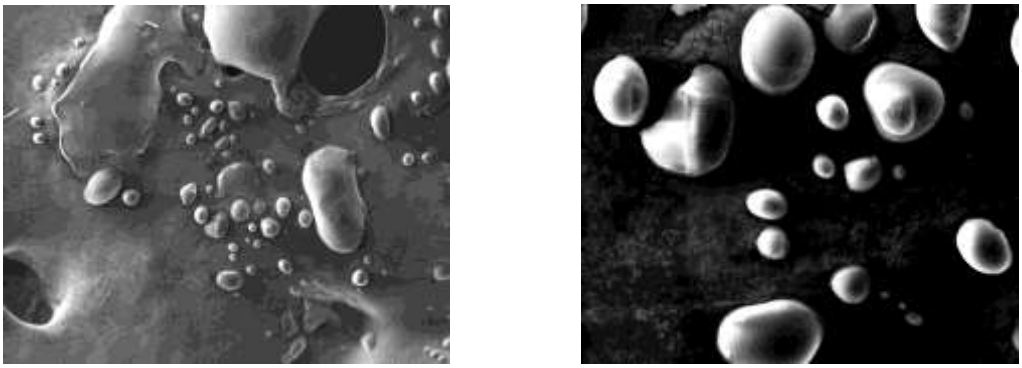

Plate 4.3

a **b**

Scanned microscopic image of spray dried powder

(a.500x, b.200x)

4.8 Shelf life study of the powder

The optimized sample was further subjected to shelf life study of storage. The results obtained are discussed below.

4.8.1 Changes of Moisture content on storage

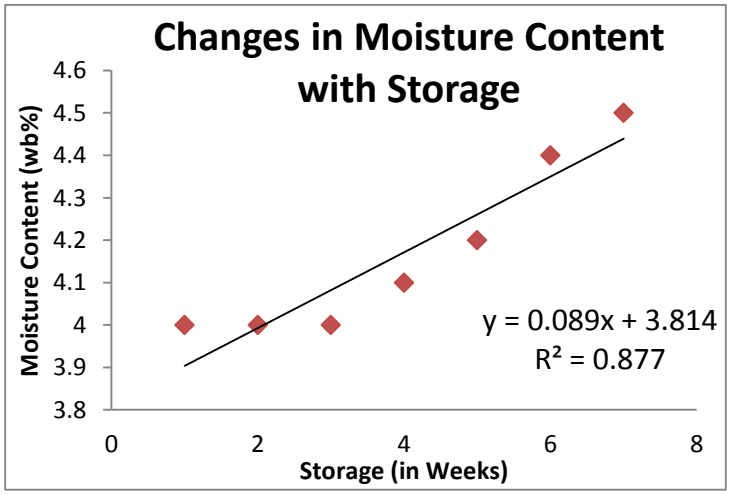

Fig.4.5 Changes of moisture content on storage

The change in moisture content with storage is shown in Figure. 4.5. The moisture content of spray dried powder slightly increased with storage which could be expressed using the linear equation given below.

$$\text{Moisture content} = 0.089x + 3.814 \ (R^2 = 0.877)$$

Where, x is the storage period in weeks.This increase in moisture content could be due to the water vapour permeability of packaging material during storage. Similar results of increase in moisture content were reported by Mishra *et.al*,(2002) for apple powder.

4.8.2 Change of pH on storage

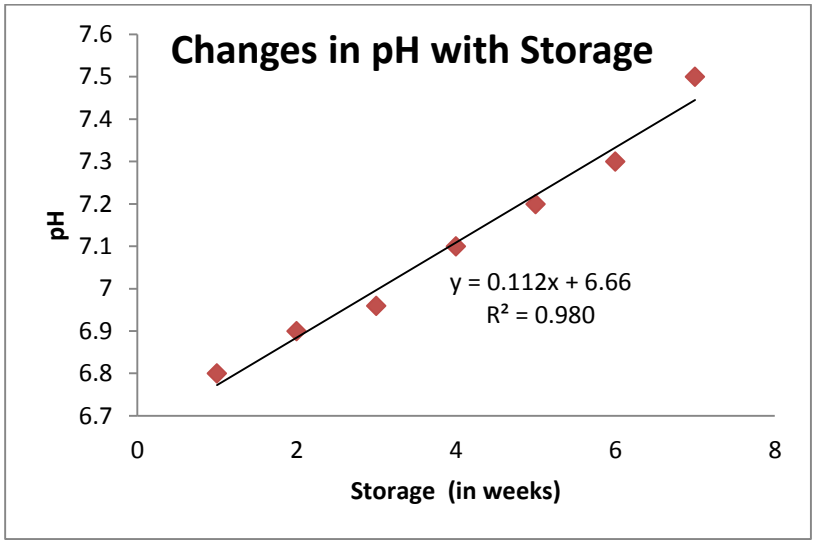

Fig 4.6 Change of pH on storage

The pH of spray dried powder slightly increased with storage which could be expressed using the linear equation given below.

$$pH = 0.112x+6.66 \ (R^2=0.980)$$

Where, x is the storage period in weeks. The increase in pH may be due to the acid hydrolysis of polysaccharides (Luh and Woodrff, 1975).

4.8.3 *Change of TSS on storage*

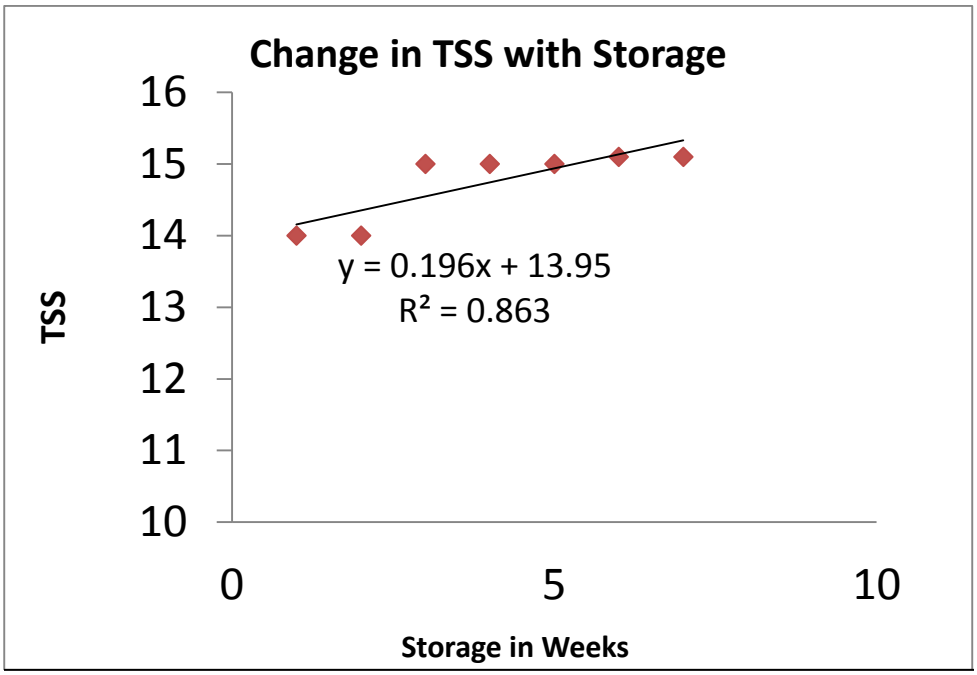

Fig.4.7 Change of TSS on storage

The pH of spray dried powder slightly increased with storage which could be expressed using the linear equation given below.

$$TSS = 0.196x+13.95(R^2=0.863)$$

Where, x is the storage period in weeks. It is clear from the figure that there is an increase in TSS concentration during storage. The increase in TSS during storage may be due to acid hydrolysis of poly saccharides especially gums and pectin (Luh and Woodruff, 1975).

4.8.4 *Changes of Water activity on storage*

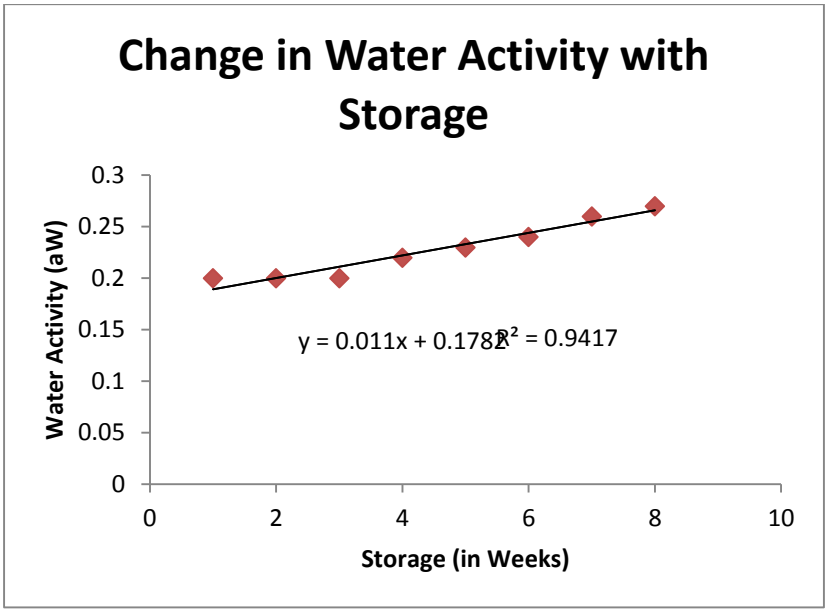

Fig 4.8 Change of water activity on storage

The water activity of spray dried powder slightly increased with storage which could be expressed using the linear equation given below.

$$\text{Water activity} = 0.011x+0.178 \ (R^2=0.941)$$

Where, x is the storage period in weeks

From the figure it is clear that water activity was constant up to 3 weeks of storage and further increase in storage period resulted in slight increase of water activity. It may be due to improper sealing and water vapour migration through packaging material during storage.

4.8.5 *Microbiological Analysis*

The total number of viable microbes per gram of sample was obtained by multiplying the number of colony forming units (CFU) on the plate with respective dilution factor and then was converted into logarithmic form. Microbial load of standardized sample was found to be $1X10^3$CFU/ml which is very small. So the powder was found to be safe.

Summary and Conclusions

CHAPTER 5

SUMMARY AND CONCLUSION

Banana stem, appearing as a waste of the banana plant is very good for health. One can use banana stem for its high nutritive value in different ways. It is also a source of energy and can be used in treatment of kidney stone. It forms an integral part of most South Indian health conscious families. Juice from banana stem is a well-known remedy for urinary disorders. It improves the functional efficiency of kidney and liver thereby alleviating the discomforts and diseased condition in them. It helps in the dissolution of calcium oxalate, a cause for the formation of kidney stones. But the major problem associated with the pseudostem juice is its perishability and immediate browning reactions. It leads to the reduction of its acceptability by consumers. Considering the above cited facts a study was undertaken to obtain powdered product from pseudostem juice.

In this study we used spray drying technology along with micro encapsulation to obtain the powder. Further quality analysis of the powder and storage studies were also conducted. The quality of the powder was expressed in terms of moisture content, water activity, pH, total soluble solids , bulk density, wettability and consumer acceptability of the juice prepared from the powder was determined by sensory analysis.

In the light of above literature, results obtained in present study are summarized below:

- Pre-treatment such as steam blanching at 1 minute gives better colour retention by preventing enzymatic browning effectively.
- The pseudostem juice with ginger juice and sugar was subjected to microencapsulation by maltodextrin in spray dryer.
- At 180°C inlet temperature, 68ºC outlet temperature, feed pump rpm of12, main blower rpm- 1600, good quality powder was obtained.
- By sensory analysis powder with 20% maltodextrin, 15%sugar, 2% ginger juice was optimized.
- The moisture content of 4% and water activity of 0.2 were found to be safe for storage.

- Storage studies indicated that there are no significant differences in quality parameters.
- From proximate analysis it was observed that there were no much nutrient losses in the powder.

References

CHAPTER 4
REFERENCE

Abirami,J., Brindha,P. and David,R. 2014. Evaluation of toxicity profile of Musa Paradisiaca (Pseudostem) juice. *Int J Pharm Pharm Sci*. 6:9-11

Adhikari, B., Howes, T., Bhandari, B. R., and Troung, V. 2003. Characterization of the surface stickiness of fructose-maltodextrin solutions during drying. *Int. J. Fd. Properties.* 21: 17-34.

Adhikari, B., Howes, T., Bhandari, B. R., and Troung, V. 2003. Characterization of the surface stickiness of fructose-maltodextrin solutions during drying. *Int. J. Fd. Properties.* 21: 17-34.

Arvanitoyannis, I.S., Mavromatis, A.G., and Sakellariou, M. 2008. Banana cultivars, biotechnological approaches and genetic transformation. *Int. J. Food Sci. Technol.* 43(10): 1871-1879.

Athanasia, G., Adamopoulos., and Konstantinos. 2008. Effect of Maltodextrin addition during spray drying of tomato pulp in dehumidified Air: II- Powder properties. *Drying Technol*. 26(6): 726-737

Avaltroni, F., Bouquerand, P. E. and Normand, V. 2004. Maltodextrin molecular weight distribution influence on the glass transition temperature and viscosity in aqueous solutions. *Carbohydrate polym.* 58(3): 323-334.

Avaltroni, F., Bouquerand, P. E. and Normand, V. 2004. Maltodextrin molecular weight distribution influence on the glass transition temperature and viscosity in aqueous solutions. *Carbohydrate polym.* 58(3): 323-334.

Bakan, J.A. 1973. Microencapsulation of food and related products. *Food Technology*, 27(11):34–38.

Baker, C. G. J. and. Masters, K. 1997. Industrial drying of foods: Spray Drying. Blackie Academic and Professional, London, 234p.

Barbosa-Cánovas, G. V., Ortega-Rivas, E., Juliano, P., and Yan, H. 2005. Drying in food powders - physical properties, processing and functionality (1st Ed.). Kluwer Academic / Plenum Publishers., N.Y, pp.271-304.

Barbosa-Canovas. G. and Vega-Mercado, H. 1996. Dehydration of foods, Chapman and Hall International. Thomson Publishing, N.Y., pp212-217.

Bates, T., Hatashi, H., and Ohashi, T. 2001. Some of the additives used in spray drying of food liquid. *Drying Technol.* 12 (2): 151–177.

Bhandari, B. R., Datta, N., and Howes, T. 1997. Problems associated with spray drying of sugar rich foods. *Drying Technol*. 15: 671-684.

Bhandari, B. R., Senoussi, A., Dumoulin, E. D., and Lebert, A. 1993. Spray drying of concentrated fruit juices. *Drying Technol*. 11(5): 1081-1092.

Bhandari, B. R., Senoussi, A., Dumoulin, E. D., and Lebert, A. 1993. Spray drying of concentrated fruit juices. *Drying Technol*. 11(5): 1081-1092.

Bodyfelt, F. W., Tobias, J. and Trout, G. M.1998. Sensory evaluation of cheese. In: Sensory evaluation of dairy products, AVI/Van Nostrand Reinhold, N.Y., pp.300–375.

Brennan, J. G., Herrera, J., and Jowitt, R. 2007. A study of some of the factors affecting the spray drying of concentrated orange juice. *J. Fd. Technol*. 6(3): 295–307.

Chandrasekha, M. R., Ramasree, G., and Leela, N. 1966. Processing of groundnut in India as a source of foods. *Indian Fd. Packer*.24:15-24.

Chegini, G. R., and Ghobadian, B. 2008. Effect of spray-drying conditions on physical properties of orange juice powder. *Drying Technol.* 23(3): 657-668.

Chegini, G. R., and Ghobadian, B. 2008. Effect of spray-drying conditions on physical properties of orange juice powder. *Drying Technol.* 23(3): 657-668.

Chegini, G.R., Khazaei, J., Ghobadian, B. and Goudarzi, A. M., 2008. Prediction of process and product parameters in an orange juice spray dryer using artificial neural networks. *J. Fd. Engng*.84: 534-543.

Cheuyglintase, K.2009. Spray drying of fruit juice with vegetable fibre as a carrier. Phd (Chemical and Process Engineering) thesis, University of Canterbury, Chistchurch, N. Z., pp. 56-59.

Cordeiro, N., Belgacem, M. N., Torres, I. C. and Moura, J. C. V. P. 2004. Chemical composition and pulping of banana pseudo-stems. *J. Crops and Products* 19: 147-154.

Dadzie, B. K., and Ochard, J. E. 1996. *Post-harvest criteria and methods for the routine screening of banana/plantain hybrids.* Montpellier publishers , Montpellier, 544p.

Desobry, S.A., Netto, F.M., and labuza, T.P. (1999) Influence of maltodextrin systems at an equivalent 25DE on encapsulated β-carotene loss during storage. *J. of Food Processing Preservation* **23**, 39–55.

Desousa, A. S., S. V. Borges, N. F. Magalhaes, H. V. Ricardo and A. D. Azevedo. 2008. Spray-dried tomato powder: reconstitution properties and colour. *Braz. Arch. Biol. Tech*. 51(4): 807-814

Desousa, A. S., S. V. Borges, N. F. Magalhaes, H. V. Ricardo and A. D. Azevedo. 2008. Spray-dried tomato powder: reconstitution properties and colour. *Braz. Arch. Biol. Tech*. 51(4): 807-814.

Dhopeshwarkar, G.A., and Magar, N.G. 1952. Effect of blanching on nutrient loss of banana puree. *J. Sci. Int.* 11:p.264.

Diamante, L.M. 2009. Vacuum fried jackfruit: effect of maturity, pretreatment and processing on the physicochemical and sensory qualities. *Proceedings of the Nutritional Society of N. Z*, pp. 138–142.

Dolinsky, A., Maletskaya, K. and Snezhkin, Y. 2000. Fruit and vegetable powders production Technology on the bases of spray and convective drying methods. *Drying Technol.* 18(3): 747-758.

Dolinsky, A., Maletskaya, K. and Snezhkin, Y. 2000. Fruit and vegetable powders production Technology on the bases of spray and convective drying methods. *Drying Technol.* 18(3): 747-758.

Falade, K. O. and Aworh, O. C. 2005.Sensory evaluation and consumer acceptance of osmosed and oven dried African star apple and African mango. *J. Fd. Agric. Environ.* 3 (1): 91-96

Falade, K. O. and Aworh, O. C. 2005.Sensory evaluation and consumer acceptance of osmosed and oven dried African star apple and African mango. *J. Fd. Agric. Environ.* 3 (1): 91-96.

Falade, K. O. and Omojola, B. S. 2010. Effect of processing methods on physical, chemical, rheological, and sensory properties of okra (*Abelmoschus esculentus*). *Fd. Bioprocess Technol.* 3: 387–394.

Falade, K. O. and Omojola, B. S. 2010. Effect of processing methods on physical, chemical, rheological, and sensory properties of okra (*Abelmoschus esculentus*). *Fd. Bioprocess Technol.* 3: 387–394.

Felllows, P.J. 2000. Food processing Technol. principles and practices. Ellis Horwood Publications, 67p.

Feriotti, D.G.,Igutti, A.M.2011. Proposal for Use of Pseudostem from Banana Tree (*Musa cavendish*). Thesis. Maua Institute of Technology, Sao Caetano do Sul, Brazil.

Francisconi, A. D. 2003. Effect of atomization speed and maltodextrin concentration. *J. Fd. Engg*. 7(2): 97-100.

Garcia, R, Leal, F. and Rolz, C. 1988. Drying of banana using microwave and air oven. *Int. J. Food Sci. Technol*. 23: 73-80.

Gharsallaoui, A., Roudaut, G., Chamban, O., Boilley, A., Saurel, R.2007. Applications of spray drying in microencapsulation of food ingredients. An overview. *Food research international*. 40(9):1107-1121.

Gong, Z., Zhang, M., and Sun, J. 2008. Physico-chemical properties of cabbage powder as affected by drying methods. *Drying Technol. 25* (5): 913-916.

Goula, A. M. and Adamopoulos, K. G. 2008. Influence of spray drying conditions on tomato powder properties. *Drying Technol*. 22 (5): 1129–1151.

Gupta, A. S. 1978. Spray drying of citrus juice. *American Inst. of Chemical Engineers,* 7th Annual meeting; 3-5pp. paper no.55f.

Hassan, A., Al-kahtani., Bakri, H., and Hassan. 2006. Spray Drying of Roselle (*Hibiscus sabdariffa* L.) Extract. *J. Fd. Sci.* 55 (4): 1073–1076.

Huntington, D. H., 2004. The influence of the spray drying process on product properties. *Drying Technol.* 22(6): 1261-1287.

Ingham, S.C., and Uljas, H.E. 1999. Combinations of intervention treatments on acidic behaiviour of food. *Appl. Environ. Microbiol*. 65: 1924-1929.

IS: SP: 18 (Part XI). 1981. Hand book of food analysis. Part XI. Dairy Products. Beuro of Indian standards, Manak Bhavan, New Delhi.

Jaya, S. and Das, H. 2007. Glass transition and sticky point temperatures and stability/mobility diagram of fruit powders. *Fd. Bioprocess Technol.* 1-7p.

Ji, S., Corredig, M. and Goff, H. D. 2008. Production and functional properties of micellar casein/k-carrageenan aggregates. *Int. Dairy J*. 18: 64-71.

Jumah, R.Y., Tashtoush, B., Shaker, R.R., and Zraiy, A.F. 2000. Manufacturing parameters and quality characteristics of spray dried jameed. *Drying Technol.* 18 (5): 967–984.

Li, K., S. Fu, H. Zhan, Y. Zhan, and L. A. Lucia. 2010. Banana pseudostem chemistry,structure. *Bioresources* 5(2): 576–585.

Liu, Z., Zhou, J., Zeng, Y. and Ouyang, X. 2006. The enhancement and encapsulation of *Agaricus bisporus* flavour. *J. Fd. Engng.*.6: 391–396.

Liu, Z., Zhou, J., Zeng, Y. and Ouyang, X. 2006. The enhancement and encapsulation of *Agaricus bisporus* flavour. *J. Fd. Engng.*.6: 391–396

Luh, B. S. and Woodrff, J. G. 1975. *Commercial Vegetable Processing*. AVI Publishing Company, Westport, Connecticut, USA. 650p.

Luh, B. S. and Woodrff, J. G. 1975. *Commercial Vegetable Processing*. AVI Publishing Company, Westport, Connecticut, USA. 650p.

Mahendran, T. 2010. Quality of instant guava drink powder: Physico-chemical properties and sensory characteristics of dehydrated guava concentrate: Effect of drying method and maltodextrin concentration. Department of Agricultural Chemistry, Faculty of Agric., Eastern University of Sri Lanka, Chenkalady. *Trop. Agric. Res. and Ext.* 13(2): 48-54.

Mary, A. E., John, P. J., and Vijayanand, D. 2007. Packaging and storage studies on spray dried ripe banana powder under ambient conditions. *J. Fd. Sci. Technol.* 44(1): 16-21.

Masters, K. 1991. Spray drying handbook (5th Ed.). Longman Scientific and Technical, Harlow, 616–617p.

Masters, K. 1997. Industrial drying of foods; Spray drying. In: Baker, C G J. (Ed.), Blackie Academic and Professional, London, 25p.

Masters, K. 2004. Applying spray drying to customize powder manufacture. *Chinese J. Chemical Engng.* 12(6): 744-749.

Naik, D.M., Oulekar, V.G., Phandel, G.C., and Sapse, B.M. 1993. Effect of prepackaging on physico-chemical changes in tomato during storage. *J. Indian Food Packer*. 42(2): 9-13.

Nath, S. and Satpathy, G. R. 1998. A systematic approach for investigation of spray drying processes. Tomato Pulp in Dehumidified Air: II. Powder Properties. *Drying Technol.* 16: 1173–1193.

Ozkan, N., Walisingheand, N. and Chen, X. D. 2002. Characterization of stickiness and cake formation in whole and skim milk powders. *J. Fd. Engg*. 55: 293-303.

Pal, D., Sachdeva S., and Singh, S.1995. Methods for determination of sensory quality of foods: A critical appraisal. *J. Fd. Sci. Technol.* 32(5): 357-367.

Poduval, S. 2002. *Diversification and value addition in coconut- Sustainable Production and Utilisation of Coconut*. Coconut Development Board, Cochi, pp.43-44.

Pomeranz, Y. and Meloan, C.E. 1994. Food Analysis Theory and Practice (3rd Ed.). Chapman and Hall, One Penn Plaza, N.Y., 34p

Pua, C. K., Tan, C. P., Mirlosseini, H., Abdul, R. R. and Russel, G. 2008. Storage stability of jackfruit (*Artocarpus heterophyllus*) powder packaged in aluminium laminated polythene and metalized co extruded biaxially orienyed polypropylene during storage. *J. Fd. Engng.* 89: 419-428.

Raiph, P., Jose,I., Joseph,R. 2004. Blanching of foods. *Encyclopedia of Agricultural, Food, and Biological Engineering.*

Ramaswamy, H. and Marcotte, M. 2006. Food processing: Principles and applications. FLA: CRC Press, Boca Raton , 78p.

Ranganna, S. 1991. Handbook of analysis and quality control for fruit and vegetable products. Tata Mc-Graw Hill Publishing Co. Ltd, New Delhi, 56p.

Rao, R. H. G and Gupta, P. M. 2002. Development of spray dried orange juice blended skim milk powder. *Drying Technol.* 82: 523-529.

Rao, R. H. G. and Kumar, A. H. 2005. Spray drying of mango juice - buttermilk blends. *J. Fd. Tech*.85: 395-404.

Ray,P.R. and Ghatak,P.K.2013. Phytoschemical characterization and antimicrobial property of Banana(Musa paridasiaca) psuedostem juice. *International journal of agricultural science and veterinary medicine*.1:4

Reece. 1979. Grocery trade; Food industry and trade; Food; Vocational guidance; Marketing. Gregg Division, Mc Graw-Hill., N.Y, 202p.

Saravacos, G. D., Tsiourvas, D.A. and Tsami, E.2002. Effect of temperature on the water adsorption isotherms of sultana raisins. *J. Fd. Sci.* 51(2): 381-383.

Saravanan, K., Aradhya, S.M.2011. Polyphenols of Pseudostem of different Banana Cultivars and their antioxidant activities. *J. Agric. Food Chem.* 59: 3613–3623.

Shahidi, F. and Han, X. Q. 1993. Encapsulation of food ingredients. *Crit. Rev. Fd. Sci. Nutri.* 33(6): 501-547.Ultra, V. U., Mendozam D. M., and Briones, A. M. (2005). Chemical changes under aerobic composting and nutrient supplying potential of banana residue compost. *Renewable Agriculture and Food Systems.* 20(2): 113-125.

Shahidi, F. and Han, X. Q. 1993. Encapsulation of food ingredients. *Crit. Rev. Fd. Sci. Nutri.* 33(6): 501-547.

Sharma, S. K., Sharma, P. C and Lalkanshal, B. B. 2004. Storage studies of foam mat dried hill lemon juice powder. *J. Fd. Sci. Technol.* 41(1): 9-13.

Sharma, S.K., Mulvaney. S.J., and Rizvi, S.S. 2000. Food process engineering: Theory and laboratory experiments. Wiley-interscience, N.Y., US, 34p.

Singh, M., Panesar, P. S. and Marwaha, S. S. 1984. Studies on the suitability of Kinnowfrutis for the production of wine. *J. Food. Sci. Technol.* 35(5): 455-457.

Souza, A. S., Borges, S.V ., Magalhaes, N. F., Ricardo, H. V., Cereda.M. P. and Daiut, E. R. 2009. Influence of spray drying conditions on the physical properties of dried pulp tomato. *Cienc. Tecnol. Aliment. Campinas*. 29(2): 291-294.

Tang, J. and Yang, T. 2004. Dehydrated vegetables: Principles and systems. Handbook of vegetable preservation and processing, Marcel Dekker, N.Y. pp.335-372.

Tayo N. F., 2004. Effect of blanching and ripening on functional properties of plantain (Musa AAB) flour. *J. Pl. Food Hum. Nutr.* 54: 261-269.

William, G. A. 1971. *Industrial Drying*. Chemical and Process Engng. Series. Leonardo Hill. London, UK, pp.23-37.

William, G. A. 1971. *Industrial Drying*. Chemical and Process Engng. Series. Leonardo Hill. London, UK, pp.23-37.

Yu,W., Shu, B.and shi-ying, X . 2007. Study on microencapsulation of lycopene by spray drying. *J. Fd. Engng. 76*(4): 664-669.

Zeuthen, P., Cheftel, J. C., Efiksson, C., Gormley, T. R., Linko, P., and Paulus, K. 1990. *Processing and quality of foods: High temperature/short time (HTST) processing (Volume 1):- Guarantee for high quality foods with a long shelf life*. *Elsevier Appl. Sci.* 1(2): 355–361.

APPENDIX I

Variation of quality parameters of different treatments

TREATMENTS	WATER ACTIVITY(a_w)	pH	TSS
T1	0.240	6.84	13
T2	0.201	6.85	14
T3	0.194	6.86	17
T4	0.241	6.80	13.3
T5	0.200	6.79	15
T6	0.189	6.60	17

APPENDIX II

Sensory analysis of banana pseudostem juice powder

TREATMENTS	COLOR	TASTE	FLAVOUR	ACCEPTABILITY
Control	3.722	4.277	4.305	4.388
T5	3.861	3.905	4.188	4.161
T2	3.722	3.583	3.944	3.811

APPENDIX III

Variation of quality parameters during storage of pseudostem powder

WEEK	MOISTURE CONTENT (M.C)	pH	TSS	WATER ACTIVITY(a_w)
1	4.0	6.80	14.0	0.20
2	4.0	6.90	14.0	0.20
3	4.0	6.96	15.0	0.22
4	4.1	7.10	15.0	0.23
5	4.2	7.20	15.0	0.24
6	4.4	7.30	15.1	0.26
7	4.5	7.50	15.1	0.27

APPENDIX IV

Media composition

Nutrient agar media

- Peptone extract = 0.3 g
- Peptone = 5 g
- Sodium chloride = 5 g
- Agar = 18 g
- Distilled water = 1000 ml

STANDARDIZATION OF PROCESS PROTOCOL FOR THE PRODUCTION OF BANANA PSEUDOSTEM JUICE POWDER

By

DRISHYA MOHAN
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SUNENA. T.P

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree

Bachelor of Technology
In
Food Engineering

Faculty of Agricultural Engineering and Technology
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ABSTRACT

Banana stem, appearing as a waste of the banana plant is very good for health. One can use banana stem for its high nutritive value in different ways. It is also a source of energy and can be used in treatment of kidney stone. It forms an integral part of most South Indian health conscious families. Juice from banana stem is a well-known remedy for urinary disorders. It improves the functional efficiency of kidney and liver thereby alleviating the discomforts and diseased condition in them. It helps in the dissolution of calcium oxalate, a cause for the formation of kidney stones. But the major problem associated with the pseudostem juice is its perishability and immediate browning reactions. It leads to the reduction of its acceptability by consumers. Considering the above cited facts a study was undertaken to obtain powdered product from pseudostem juice.

The objectives of the study were to develop a process protocol for microencapsulated banana pseudostem juice powder and quality analysis and storage studies of the powder. Microencapsulation was done with pseudo stem juice as the core material and maltodextrin as the wall material. The pieces of pseudostem was treated was treated with 0.3% citric acid and steam blanched at two different temperatures for 30 sec and 1min. By peroxidase test, the time for steam blanching was standardized as 1min. The substance to be encapsulated (the filtered juice) and a carrier (maltodextrin) is homogenized as a suspension in water (the slurry). The slurry is then fed into a spray drier. The composition of filtered juice was ginger juice (2% and 4%), maltodextrin (20% & 25%) and two concentrations of sugar (12% and 15%). The process parameters were optimized as inlet temperature of 180ºC, outlet temperature of 68ºC, feed pump rpm as 12, main blower rpm- 1600. The physicochemical characteristics such as pH, total soluble solids, bulk density, wettability and moisture content of powder were determined. The pH of powder was found to be 6.8, TSS as 15ºBrix, moisture content was found to be 4% w.b, bulk density as 0.47 g/ml, wettability as 80 seconds.. Based on sensory analysis, maltodextrin concentration of 20% and ginger juice concentration of 2% and sugar concentration of 15% was standardized for the production of microencapsulated pseudostem ginger juice powder by spray drying. The results indicated that moderate wall material concentration (20%), low inlet air temperature (180ºC), and moderate feed flow rate are the best spray drying conditions. The study suggests that banana pseudostem powder can be taken as a ready to drink beverage as a food supplement for diabetes and kidney stones.