APPLICATION OF OSMOTIC DEHYDRATION TECHNIQUE FOR PRODUCT DEVELOPMENT IN BANANA (MUSA (AAB GROUP) PALAYAMKODAN)

by

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THESIS

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Dedicated to

my beloved Grandfather

Mr ULLAHANNAN XAVIER

DECLARATION

I hereby declare that this thesis entitled "Application of osmotic dehydration technique for product development in banana (Musa (AAB group) Palayamkodan)" is a bonafide record of research work done by me during the course of research and that the thesis had not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society

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CERTIFICATE

Certified that this thesis entitled "Application of osmotic dehydration techn que for product development in banana (Musa (AAB group) Palayamkodan)" is a record of research work done independently by Ms DEENA GEORGE under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her

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INTRODUCTION

India is a sleeping giant which should realize its potential to export fruits and vegetables to Europe says an Israel expert Dan Cohen (1994)

Fruits and vegetables are regarded as excellent sources of various nutrients having carbohydrates vitamins minerals etc They are also considered as an important class of protective foods

Banana Is one of the most nutritions and oldest cultivated fruits in India which accounts for about 18 percent of the total fruit production occupying an area of 2 83 lakh hectors (Anon 1986) Production of banana in Kerala is 2 95 145 tons

Banana is not a seasonal fruit in nature like many other fruit crops and is available in fairly large quantities throughout the year But high fruit yields will be worthwhile only if the fruits reach the consumer in sound condition But a substantial quantity of the same is allowed to perish for want of adequate post harvest facil ties thus depreving the farmers the fruit for their labour This proves to be a loss not only in the field of export but also for domestic consumption Scientific approach is therefore required at all levels of operation including preservation to minimize this loss and extend the storage l fe of fruits

The principle of preservation is based on the man ,ulation of environmental factors Among which drying is a method Although preservation is still the principal reason for dehydration other important

factors like significant reduction of weight loss and bulk play an important part in the process

The accent today is increasingly on convenience foods in almost every field and the word Instant has a new connotation in our vocabulary

In the meantime advances in the food researches have led to the development of new processes for dehydration which retain a high percentage of the original color flavor and nutritional value Innovation of novel techniques technologies and development are taking place constatly in the existing methods of drying the ultimate aim of which is to keep the wholesomeness of the final product

Recently osmotic dehydration of foods got attention due to its great importance in the food processing industry Osmotic dehydration deals with the drying of the particular food stuff which is usually subjected to in a ripe form

This study entitled "Application of Osmotic Dehydration technique for the product development in Banana (Musa (AAB group) Palayamkodan)" has been selected with due focus on the food processing industries and for improving the export potential of the country The study is based on and outlined with the following objectives

1 To apply osmotic dehydration technique to develop shelf stable dehydrated banana products

2 To standardize the technique of osmotic dehydration for obtaining acceptable banana products

REVIEW OF LITERATURE

The pertinent research work in Application of osmotic dehydration techniqu for the product development in banana" is briefly reviewed under the following subt tles

2 1 Importance of banana as a fruit

2 2 Dehydration as a method of preservation and processing

2 3 Osmotic dehydration A recent trend in drying foods

2 4 Effect of pretreatments on drying

2 4 1 Sucrose concentration

2 4 2 Temperature of osmotic solution

2 4 3 Immersion time

2 5 Nutritional qual ties and shelf life changes in dried products on storage

2 6 Dehydrated foods in the commercial front

2 1 Importance of banana as a fruit

Banana fruit of the tropics is prized for its nutrit ve value and dessert qualities India is generally considered as the second home of banana CFTRI (1989)

Banana is not a seasonal fruit like many other fruit crops and is available throughout the year (Anon 1986) Aravindakshan *et al* (1992) stated that banana cultivat on in India is as old as Indian civil zation and though banana is considered as Poor man s apple it s liked and consumed by both poor and rich alike and hence necessary action needs to be taken to check

post harvest losses This can successfully be carried out by processing and preservation of the fru t

Bananas have a special value in the human diet as they are r ch sources of energy and contain nearly all the nutrients including minerals and vitamins About 24 bananas weighing 100 gms can provide the energy requiremeht (2400 cal/day) of a sedentary man according to Bose and Mitra (1990)

According to NIN (1989) banana is a good source of Carbohydrates 27 2 and β Carotene 78mg In addition it contains Calcium 17mg Phosphorous 13mg Thiamine 0 5mg Riboflavin 0 8mg Niacin 5mg and Vitamin C 7mg The total energy obtained from ripe banana is 116 K cal

Robusta Poovan Nendran Rasthali Mysore poovan Red banana are some of the varieties of banana that are commonly seen (Salunke 1984) Salunke and Desai (1984) reported that banana being a highly perishable fruit suffers from high post harvest losses to the extent of 30 40 percent The post harvest losses are high in a tropical country like India due to various reasons such as inadequate processing and improper storage facil ties (Anon 1986)

2 2 Dehydration as a method of preservation and processing

Dehydration involves the use of artificial heat to vapourize water and some special means of removing water vapour from

the system after it has separated from the fruit tissues as reported by Nuri *et al* (1963) When heat from any source other than sunlight is used to reduce moisture the process s called dehydration (Heid and Maynard 1963)

According to Nuri *et al* (1963) when fruits are dehydrated the soluble solid contents become great enough so the fruits will resist microbial spoilage for fairly extended periods of time Bender (1966) reported that dehydrated products undergo a wide variety of operat ons or pretreatments which can affect the nutrit onal value Dehydrated foods if store under proper conditions will not spoil from microbial attack as reported by Peter *et al* (1975) According to sharma and Nirankarnath (1991) when onion varieties were dehydrated it reduced pungency and ascorbic acid levels and induced browning

2 3 Osmotic dehydration A recent trend in drying foods

Osmotic dehydration has been the subject of scientific investigation as early as (1966)) by ponting *et al* Osmotic dehydration is rather a new innovation for producing better quality dehydrated products (Anon 1986) and has gained a sudden momentum during the last decade Le Maguer (1988)

Lerici *et al* (1985) after studying d fferent osmotic solut on found that addition of a small amount of sodium chloride to the osmotic solution increased the driving force of the dry ng process

Angela *et al* (1987) stated that chemical treatment to reduce enzymatic browning could be avoided by osmotic process

Ponting (1973) pointed out that freezing prior to osmotic treatment is detrimental According to Islam and Flink (1982) osmotic dehydration increased nutrient retention during subsequent air drying Lerici *et al* (1984) reported that osmotically treated fru ts were better in texture and colour than untreated fruits The shrinkage of the material dur ng osmosis for characterization of the process was considered by Lenart and Fl nk (1984) Shahabuddin and Hawladaar (1990) reported that osmotic dehydration alone can remove 30 40 percent water content of pineapple fruit

Le Maguer (1988) has reported that the osmotic process will constitute in the future an important step in many processing operations

2 4 Effect of pretreatment on drying

2 4 1 Sucrose concentration

Lein (1987) found that the sugar solution was an effective agent for reducing the dry ng process and in connection it was also reported by Lein (1987) that glucose sucrose and fructose were the different sugars used as osmotic agents and the type of the sugar solution did not noticeably affect the product acceptance

In a p lot study Farkas and Lazar (1969) found a complete emperical relationship between percent mass reduction temperature

and sugar concentration and time in osmotic dehydration of golden delicious apple pieces Concentrated sucrose solutions (50 70° Brix) have been the most commonly used osmotic solution as reported by Contreras and Smyrl (1981) Fruits like apples pears peaches and plums when immersed in 65 percent sucrose solution showed a weight loss after osmosis as found by Lerici *et al* (1983) fifty percent weight loss was reported in banana slices when immersed in 70 percent sugar solution (Adambournou and Castaigne 1983) Lerici *et al* (1985) showed that weight loss in osmosed fruit increased with increasing solute concentration of the osmotic solution Osmotic dehydration in sugar syrup reduced moisture content of fruit the increase in the syrup concentration also caused an increased loss of moisture Kim and Toledo (1987) Rahman and Lamb (1989) reported that the water loss from pineapple increased with increase in the sugar solution and its concentration Videv *et al* (1990) opined that there was increase in the weight loss of the fruit with an increase in sugar concentration Sugar concentrat on of 60 75 percent was effective in removing moisture from the treated fruits as reported by Videv et al (1990) Beristeinetal (1990) reported that the amount of sugar absorbed by pineapple rings increased with increasing sugar concentrations At 50° Brix the sugar concentration increased by 10 percent at 60° Brix the increase was by 16 percent and at 70° Brix it was increased by 25 percent The rate of water loss increased with increased sugar

syrup concentration according to Beristein *et al* (1990) Rahman and Lamb (1990) revealed that water loss from pineapple fruit increased linearly with ncreased sucrose solution concentration

Different treatments before drying for various periods of time in hypertonic solution of sugar resulted in weight loss sugar penetration and increase in the shrinkage of the apple rings and a treatment in 70° Brix at 50° C for 30 minutes was adjudged to be the best treatment as reported by sharma *et al* (1991) Angela *et al* (1991) observed that the pineapple and papaya fruit immersed in sucrose 70° Brix syrup lowered the final water content of the fruits

Videv *et al* (1990) found that a high sugar concentration increased water transfer rates and use of different dehydration solutes (sucrose Sucrose/invert sugar glucose syrup) had little effect on the mass transfer Yang and Maguer (1992) reported that when strawberr es were osmotically dehydrated more than 40 percent of moisture and less than 1 percent of sucrose in strawberries were removed by 63 percent sucrose solution

Hough *et al* (1993) found in a simple model of osmotic dehydration of apples in 55/100 gms of sugar syrup a diffussability rate of 1 5x10 ^{0} m^2

2 4 2 Temperature of osmotic solution

Videv *et al* (1990) found that high temperature and high sugar concentrations ncreased water transfer rates They had also

reported that processing above 50°C adversely affected colour and Vitamin C content and chlorophyll concentration whereas processing at or below 40° C gave satisfactory results in the product The variables that exert the greatest influence on the osmotic concentrations were the processing time and temperature as reported by Raul *et al* (1992)

Rabbit eye blue berries were dried using an experimental high temperature fluidized bed (HTFB) at 170° C the moisture content was reduced to 0 7 from 5 8 and after osmotic dehydration in sucrose the moisture content was 1 3 and when dried in a drier at 150° C it reduced to 0 28 (Kim and Toledo 1987) Analysis of the various parameters of the canned apple rings revealed that the pretreatment in sugar solution at 50° C prior to canning was adjudged to be the best treatment among the various treatments tried by Sharma *et al* (1991)

Sivakumar *et al* (1989) observed that blanching of bitter gourd rings in 5 percent Sodium Chloride and drying them in tray drier at 70° C followed by 60° C at intervals gave dark green soft textured slightly salty and less bitter product According to Raul *et al* (1992) pears and apple cubes when osmotically treated solid gains were similar at 5° C and 25° C in both pear and apple cubes reaching a value of about 11 percent and found that water diffusion was greater at 25° C than at 50° C making it possible to obtain a weight loss of approximately 30 percent Hough *et*

al (1993) reported that temperature of 45° C was suitable for developing osmotically dehydrated products using apple slices Kanawadi and Maharaj (1993) suggested a temperature of 60° 90° C for dehydrating pear based on the assessment of the dehydrated samples for texture and flavor Elizabeth (1993) observed that pear fruits when hand peeled and canned in sugar syrup (20 Brix) at 100° C the fruit firmness decreased

Water loss from pineapple as reported by Rahman & Lamb (1989) increased with increase in the sucrose solution temperature the sugar gain increased up to 50° C and then fell rapidly According to Videv *et al* (1990) an administration of a temperature above 50° C causes internal browning in the apple rings and also a loss of the fruity flavor

Adambournou and Castaigne (1983) on conducting dehydration experiments using osmosis at 60° C and 40° C found that sucrose gain and water loss was faster at 60° C than at 40° C It was noted by Beristein *et al* (1990) that higher temperature increased the rate at which sugar was transported into the ring equilibrium was reached faster and higher temperature also promoted faster water migration from the fruit

2 4 3 Immersion time

In osmotic dehydration as the immersion time of fruit slices in the osmotic solution increased there was increase in the weight

loss from the final slices as reported by Videv *et al* (1990) Berlstein *et al* (1990) found that water loss and sugar gain increased exponentially with the immersion time

50 gms of apple pears and peaches when immersed n sucrose solution for 12 15 hours the weight losses after osmosis were 34 6 43 0 and 36 2 percent respectively (Lerici *et al* 1983) Adambournou and Castaigne (1983) found that the sucrose gain and water loss in dehydration experiments were faster in the first 20 minutes at 40° C and 60° C According to Elizabeth (1993) when hand peeled pears were immersed for 15 minutes after treatment at 100° C it lost its firmness (i e) the fruit firmness decreased with increasing processing time

After the osmotic dehydration of blue berries in sucrose the moisture content was 1 3 and 4 minutes in the drier at 150° C reduced the mo sture content to 0 28 as reported by Kim and Toledo (1987) Sivakumar et al (1989) reported that immersion of 1 cm thick ring of bitter gourd in boiling water for 2 minutes inactivated all the enzymes present in the rings Raul *et al* (1992) repoted that on treatment of pear & apple cubes in a sucrose solution solid gains were similar at 50° C reaching a value of about 11 percent in 4 hours According to Yang and Maguer (1992) about 40 percent of moisture and less than one percent of sucrose in strawberries were removed in a period of 2 hours from the treated fruit

Sharma *et al* (1991) opined that pretreatment in 70 percent sugar solution and at 50° C and 30 minutes immersion time was the bes for canning

2 5 Nutritional qualities and shelf life changes in dried products on storage

Lerici *et al* (1984) on conducting experiments in the dehydration of fruits such as plums pears and peaches found that treated fruits were better in flavour texture and color than the untreated fruits

Conway *et al* (1983) pointed out that dehydration minimized the heat damage to color and flavor Videv *et al* (1990) observed that when high temperature was used for dehydration it caused internal browning of the pieces textural changes and loss of fruit flavor

Dehydrated raw mango slices (with salt) could be used for the preparation of mango chutney pickles and raw mango powder shown by chemical and organoleptic data reported by CFTRI (1982) According to kaur & Bhatia (1982) mustard greens when dehydrated yielded good products based on the physico chem cal and organoleptic studies

Ranganath and Dubash (1981) studied changed in carotenoid pigment in spinach leaves as a result of dehydration and found that it was reduced by 50 percent at 55° C and after storage

at 24° C for 4 months there was a loss of 18 percent of carotenoid pigment and 48 5 percent of ascorbic acid Sarbjit and Bhatia (1982) proved that certain varieties of dehydrated seeds has a shelf life of about 6 months at room temperature with adequate retention of chlorophyll and β carotene According to Hsu *et al* (1989) the total soluble proteins decreased with storage time of fruits

According to Angela et al (1987) dehydrated blue berry products had a good texture flavor and overall acceptability and a predicated shelf life of 16 to 64 months depending on the storage temperature Vegetables dehydrated to y eld vegetable curry mix had a shelf life of about 18 months under ambient conditions as reported in Food packer (1990) In Kiwi fruits dehydration temperature above 50° C adversely affected color and ascorbic acid and its chlorophyll concentration Processing below 40° C gave a satisfactory ascorbic acid and chlorophyll content in the finished product as reported by Vial *et al* (1990) The osmotic dehydration preserves the flavor and nutritional characteristics and provides a final product o' good quality which has better attributes with appearance color taste and flavor compared to sun dried fruits (Anon 1991)

Accord ng to Mukhtha *et al* (1982) dehydrated pineapple slices stored at room temperature gave good products based on the chemical composition and organoleptic qualities According to Mir and Nirankarnath (1993) storage of the mango bars for

90 days increased the reducing sugar significantly but it decreased the overall acceptability and textural changes Sharma et al (1993) found that browning occurred in dried apricots which were both treated and untreated Kanawad and Maharaj (1993) reported that sensory characters of dehydrated peas showed that temperature affected flavor and texture According to Mukthi *et al* (1993) six months storage with retention of ascorbic acid was possible in unblanched fenugreek leaves Mahajan and Chopra (1994) found that Total soluble solids (T S S) content which was fairly low initially increased as the storage period advanced reaching a peak of 150 days and declined thereafter in the case of stored apple fruits The titrable acidity gradually declined linearly with advance in storage period Mahajan *et al* (1994)

On storage of dehydrated fruits the first indiscernible change occurred was in colour before change in flavor as found by Nuri (1962) According to Nuri (1963) when fruits are dehydrated the soluble solid contents become great enough so the fruit will resist microbial spoilage for fairly extended periods of time

Islam & Flink (1982) finally concluded that osmotic dehydration increased nutrient retention

2 6 Dehydrated foods In the commercial front

India can make a substantial contribution for the export of horticultural products to fetch foreign exchange and India still predominantly

an agricultural country can fruitfully use this status to step up in the world market with its horticultural processed products as per Vijay Sethi (1992) According to Anvila (1993) the consumption of processed foods is likely to increase n the future

The osmovac process was proposed by Ponting *et al* (1966) as a method for producing dehydrated products su table for consumption directly in the dry stage Farkas and Lazar (1969) concluded that an increased sugar content in the concentrated fruits produce a sweeter flavor in the processed fruit and when dried they form the candy of the food industry Canned pineapples do not rank as one of the important sources of food for mankind provided by the industry and at times it has been classified as luxury food rather than an essential one by Collins (1979) Bolin *et al* (1983) opined that the osmotic syrups would make a suitable ingredient for such products as table syrups concentrates wine fruit roll ups jellies etc Yang and Atallah (1985) stated that the ready to eat texture and easier dehydration have made the berries a processing product in the snack and convenience food industries Nabtisi and Movoghan (1989) reported that fruits and vegetables could be dehydrated to produce crispy but tender puffed food products having the color and appearance of the orig nal Jayaram *et al* (1991) developed a quick cooking dehydrated ready mix for avail using a combination of dehyralid vegetables Carrots rich in carotene vitamins and minerals is widely used for the preparation of juice

powder flakes and sweet meats like halwa and muraba by preserving them through dehydration (Indian food packer 1992) Dried osmotically dehydrated products which are more sweeter ensure a higher quality and have a great demand in the market as reported by Lovino *et al* (1993)

MATERIALS AND METHODS

The study entitled Application of Osmotic Dehydration technique for product development in banana (Musa (AAB group) Palayamkodan) is a comprehensive study aimed at applying osmotic dehydration technique to develop shelf stable dehydrated banana products and also to standardize the technique of osmotic dehydration for obtaining acceptable banana products

3 1 Selection of Fruits

Banana is one of the most important fruit crops of India This fruit is available throughout the year unlike other fruits which are seasonal

Palayamkodan is one among the many varieties of banana This variety is very cheap and is readily available in abundance Not much processing techniques have been applied for this fruit Moreover once these fruits start ripening the whole bunch gets ripened within a day or two making the fruit unacceptable for consumption due to over ripening Because of these reasons palayamkodan variety was selected for this study

The fruits for the study was brought from the Instructional farm College of Agriculture Vellayani and from adjacent private farms

3 2 Treatments

Treatments to which the fruits were subjected were based on the following factors

Table - 1

The various treatments applied to the banana fruit

C_1		C_2		C_3	
1	C T_1 P_1	13	C_2 T_1 P_1	25	C_3 T P
2	C T P_2	14	C_2 T P_2	26	C_3 T_1 P_2
3	C T P_3	15	C_2 T_1 P_3	27	C_3 T P_3
4	C T_2 P_1	16	C_2 T_2 P	28	C_3 T_2 P
5	C T_2 P_2	17	C_2 T_2 P_2	29	C_3 T_2 P_2
6	C T_2 P_3	18	C_2 T_2 P_3	30	C_3 T_2 P_3
7	C T_3 P	19	C_2 T_3 P_1	31	C_3 T_3 P
8	C T_3 P_2	20	C_2 T_3 P_2	32	C_3 T_3 P_2
9	C T_3 P_3	21	C_2 T_3 P_3	33	C_3 T_3 P_3
10	C T_4 P	22	C_2 T_4 P	34	C_3 T_4 P
11	C T_4 P_2	23	C_2 T_4 P_2	35	C_3 T_4 P_2
12	C T_4 P_3	24	C_2 T_4 P_3	36	C_3 T_4 P_3

Key C Sugar concentrat on T Tempe ature of Osmot c Solut on P Immers on t me

C	60° Brix	T	0°C	P	30 m nutes
C_2	65° Brix	T_2	40°C	P_2	45 minutes
C_3	70° Br x	T_3	50°C	P_3	60 m nutes
		T_4	60°C		

3 2 1 Concentration of sucrose solution viz 60°Brix 65° Brix and 70°Brix

3 2 2 Temperature of osmotic solution viz 0°C 40°C 50°C and 60°C

3 2 3 Immersion t me viz 30 minutes 45 m nutes and 60 minutes The treatments applied are given in Table 1

The treatments provided a preliminary dewatering of the fresh fruits and this assumed to hasten the drying process Treated fru ts were subjected to sun drying Advantage of osmotic dehydration over the conventional method of drying were conservation of flavor and nutritive value decrease in polyphenol oxidase activity and reduction in energy consumption Lerici *et al* (1984) had pointed out that osmotically dehydrated fruits had a better flavor texture and color than untreated ones

3 2 4 The Control group

Fruits sun dried without any treatments was maintained as the control sample in the study

3 3 The processing technique

Ripened fruits (1kg each) taken for processing were peeled and cut into round slices These were subjected to initial dewatering by applying the treatments proposed The we ght of the banana sl ces before and after dewatering was noted The same was then

subjected to open sun drying till the desired moisture level (below 10 percent) was obtained

3 3 1 Method of Drying

Drying is one of the oldest and cheapest methods of preservation Maini (1982) has reported that more fruits were preserved by drying than by any other method as they had more advantages like greater concentration in dried form cheaper to produce with minimal labour processing equipment storage and distribution cost

Plain sun drying was applied in this study The treated banana slices were spread out in aluminium trays and put under direct sunlight The slices were turned over at intervals to get an even rate of drying The time taken for drymg the slices to the required moisture level was also noted (in hours)

3 3 2 Sealing of dried products

The net weight of the dried product was assessed for each treatment The products were then packed in polypropylene covers each weighing 100 gms The covers were steril zed before packing They were then sealed using a heat sealer and stored in room temperature

3 4 Tests conducted on the dried products

Tests for analysis conducted on the fresh samples and the dried products were moisture acidity reducing sugar and vitamin C

All the samples (in duplicate) were drawn randomly in required quantities for analysis The organoleptic assessment of the dried banana products were carried out For the conduct of the organoleptic assessment a panel of judges were screened from a group of 25 healthy women in the age group of 20 25 through triangle test as suggested by Swami Nathan (1984) A small highly sensitive panel would usually give more reliable results than a large less sensitive group Hence from among the screened panel 10 judges were selected for the organoleptic assessment of the product

The products were evaluated based on quality attributes viz appearance color flavor texture and taste Scores were assigned for each quality parameter ranging from 1 5 (i e) from very good to very poor and the scores were summed up to obtain the overall acceptability of the product

The maximum score that can be acheived for overall acceptability will be 25 The mean of the same was taken for convenience in execution The score card evolved for the conduct of the organoleptic study is presented in Appendix 2

3 5 Tests conducted to ascertain shelf life qualities of dried banana products

As per FPO specifications routine tests recommended to ascertain shelf life qualities of dried banana products are acidity pH reducing sugars organoleptic qualities and microbial infestation Hence these tests were conducted on the products using the procedures as suggested by AOAC (1960) and Renganna (1977)

3 6 Cost Benefit Analysis

Cost benef t was analysed considering the major food mater als that contr bu te to the expense namely banana and sugar Fuel used and labour charges were cons dered to work out the overl ead charges for each treated sample

RESULTS AND DISCUSSION

Salient findings of the study entitled Application of osmotic dehydration technique for the product development in banana (Musa (AAB group) Palayamkodan) are presented and discussed under the following headings

4.1 Effect of treatments on the weight loss Moisture loss and drying time

4.2 Nutritional and chemical analysis of the dried banana products

4.3 Influence of treatments on the organoleptic qualities and changes during storage

4.4 Assessment of microbial contamination of the products

4.5 Cost benefit analysis of the dried banana products

4 1 Effect of treatments on weight loss moisture loss and drying time

Pretreatments help is improving the quality of the products and to extend their shelf life Islam and flink (1982) pointed out that pretreatments like direct osmosis increased nutrient retention during subsequent drying

When the fruit slices were treated n a sucrose solution with higher concentrations the flow of water from the fruit ncreased with increased temperature sim larly absorption of sucrose by the fruit increased linearly w th increased temperature

Effect of treatments on the weight loss moisture loss and drying time was analysed in the products and the results are presented below

4 1 1 Weight loss during dehydration

Dehydrated products as the name indicates have a markedly lower weight than the fresh products Bolin *et al* (1983) pointed out that dehydrated products provide a consistent product which is an important modern marketing requirement The dried products are of light weight and hence are convenient in packaging and transportation

4 1 1a Weight loss during initial dewatering

Rahman and Lamb (1989) pointed out that weight lost from fruits ncreased with increase in sugar concentration temperature

Table 2

Influence of osmosis on the weight loss of banana fruits before drying

S No	Treatments	Weight after straining	Percentage of Weight Loss	S No	Treatments	Weight after straining	Percentage of Weight Loss	S No	Treatments	Weight after straining	Percentage of Weight Loss
1	C T P	940	6	13	C_2 T P	940	6	25	C_3 T P	935	6 5
2	C T P_2	940	6	14	C_2 T P_2	940	6	26	C_3 T P_2	930	7
3	C T P_3	940	6	15	C_2 T P_3	940	6	27	C_3 T P_3	930	7
4	C T_2 P	900	10	16	C_2 T_2 P	900	10	28	C_3 T_2 P	890	11
5	C T_2 P_2	900	10 5	17	C_2 T_2 P_2	895	10 5	29	C_3 T_2 P_2	895	11 5
6	C T_2 P_3	900	10 5	18	C_2 T_2 P_3	895	10 5	30	C_3 T_2 P_3	890	11
7	C T_3 P	830	17	19	C_2 T_3 P	830	17	31	C_3 T_3 P	830	17
8	C T_3 P_2	825	18	20	C_2 T_3 P_2	820	18	32	C_3 T_3 P_2	820	28
9	C T_3 P_3	825	17 5	21	C_2 T_3 P_3	820	18	33	C_3 T_3 P_3	820	18
10	C T_4 P	830	17	22	C_2 T_4 P	830	17	34	C_3 T_4 P	825	18 5
11	C T_4 P_2	800	20	23	C_2 T_4 P_2	800	20	35	C_3 T_4 P_2	800	20
12	C T_4 P_3	800	20	24	C_2 T_4 P_3	800	20	36	C_3 T_4 P_3	800	20

and immersion time The weight lost by the products after initial dewatering was assessed and the results are giving in Table 2

As indicated in table 2 treatments with 60° Brix sugar concentration had a weight loss ranging from 6 to 20 percent and that with 70° Brix had a weight loss of 6 5 to 20 percent

Osmotic dehydration alone is reported to remove 30 to 40 percent water from the treated fruits as reported Ponting et al (1966) In this study there has been a decrease of 6 20 percent in the weight of the fruit products

In a fruit like banana with 70 percent moisture (NIN 1989) drying or dehydration trends to cause tremendous fall in the weight of the final product In this study effect of different pretreatments on weight loss of the products were analysed It was found that the weight loss of the pretreated foods accounted to be 75 percent When 1kg of the fruit was treated and dried approximately 250 gms of the dried product was obtained as shown in Table 2 1

4 1 2 Percentage of Moisture loss

The fresh banana fruit contains a mo sture of 70 percent (NIN 1989) When fruit s dried or dehydrated the soluble solid content becomes concentrated so the fruit will resist microbial spoilage for fairly extended periods of storage

Table 2 1 gives a detailed descr ption of the moisture loss after dehydration of the dried products As depicted in the table

Table 21

Effect of treatments on weight loss, moisture loss and drying time

Sl No	Treatments	Time taken in hrs	Moisture in Percentage		Initial Wight (Kg)	Final Weight (gms / Kg)	Weight loss (gms / Kg)
			Fresh	Dried			
1	C T P	60	70	9 2	1 00	255	745
2	C T P_2	60	70	9 2	1 00	255	745
3	C T P_3	60	70	9 2	1 00	250	750
4	C T_2 P	60	70	9 2	1 00	255	745
5	C T_2 P_2	54	70	9 0	1 00	250	750
6	C T_2 P_3	54	70	9 2	1 00	253	747
7	C T_3 P	54	70	9 2	1 00	255	745
8	C T_3 P_2	54	70	9 2	1 00	255	745
9	C T_3 P_3	54	70	9 0	1 00	250	750
10	C T_4 P	54	70	8 9	1 00	246	754
11	C T_4 P_2	54	70	8 9	1 00	240	760
12	C T_4 P_3	54	70	9 0	1 00	250	750
13	C_2 T P	54	70	8 9	1 00	245	755
14	C_2 T P_2	54	70	9 2	1 00	255	745
15	C_2 T P_3	48	70	9 2	1 00	255	745
16	C_2 T_2 P	54	70	8 9	1 00	240	760
17	C_2 T_2 P_2	54	70	8 6	1 00	240	760
18	C_2 T_2 P_3	54	70	9 2	1 00	255	745

Table 21

Effect of treatments on weight loss, moisture loss and drying time (Contd)

Sl No	Treatments	Time taken in hrs	Moisture in Percentage		Initial Wight (Kg)	Final Weight (gms / Kg)	Weight loss (gms / Kg)
			Fresh	Dried			
19	C_2 T_3 P	54	70	9 2	1 00	260	740
20	C_2 T_3 P_2	54	70	8 9	1 00	240	760
21	C_2 T_3 P_3	50	70	8 7	1 00	235	765
22	C_2 T_4 P	50	70	8 8	1 00	240	760
23	C_2 T_4 P_2	54	70	8 9	1 00	250	750
24	C_2 T_4 P_3	54	70	9 0	1 00	250	750
25	C_3 T P	48	70	8 7	1 00	250	750
26	C_3 T P_2	48	70	8 7	1 00	250	750
27	C_3 T P_3	48	70	8 7	1 00	255	745
28	C_3 T_2 P	48	70	8 6	1 00	255	745
29	C_3 T_2 P_2	48	70	8 7	1 00	250	750
30	C_3 T_2 P_3	48	70	8 5	1 00	260	740
31	C_3 T_3 P	48	70	8 7	1 00	255	745
32	C_3 T_3 P_2	48	70	8 7	1 00	250	750
33	C_3 T_3 P_3	48	70	8 6	1 00	260	740
34	C_3 T_4 P	48	70	8 7	1 00	260	740
35	C_3 T_4 P_2	48	70	8 6	1 00	265	735
36	C_3 T_4 P_3	48	70	8 7	1 00	255	745
Control Sample		60	70	9 4	1 00	250	750

the moisture content for the different treated products ranged from 8 5 to 9 5 percent from that of 70 percent as observed in the fresh fruit The moisture content of the treatments C T P $C T P_2$ and $C T P_3$ which were dried for 60 hours had a moisture level of 9 2 However treatments C_3T_1P $C_3T P_2$ $C_3T P_3$ and all other treatments with a higher sugar concentration of 70° Brix with 48 hours of drying attained a moisture level between 8 5 and 8 7 This reduction in the moisture level within a shorter drying time is assumed to be due to the effect of the osmotic agent as pointed out by Angela *et al* (1987)

4 1 3 Drying time

The drying time is directly related to the moisture content such that higher moisture level increased the drying time and when the moisture content is less the time required for drying is also less

Angela *et al* (1982) had reported that treatment with osmotic dehydration would reduce processing time

Among the various treatments the samples treated with 70° Brix the highest of the sugar concentration applied was found to take the least time for drying This may be due to the fact that the water lost from the fruit increased with increased sugar concentration temperature and immersion time Though there was a difference in the time taken for drying between certain treatments with the same sugar concentration it was not very

significant as the moisture level was below the 10 percent level Maynard and Heid (1963) suggested a moisture level below 10 percent for storing dried fruits to reduce microbial contamination

4 2 Nutritional and Chemical analysis of dried banana products

Bananas fit well with the recommendations of the select committee of the senate of nutrition and home needs for increased consumption of foods low in fats cholesterol and salt (Anon 1986)

During dehydration due to the loss of water nutrients already present in the fruit get concentrated Dried banana products subjected to 36 different treatments were assessed for their chemical composition The major components assessed were acidity reducing sugar and Vitamic C the results of which have been tabulated from Tables 3 10

The vitamin C content of the dried banana products were found to be very neglible when analysed (0 2 mg)

4 2 1 Acidity in the fruit

Early work reviewed by Palmer (1971) showed that malic acid was the main acid found in banana with substantial quantities of oxalic and citric acids The malic acid increases on ripening whereas oxalic acid was decreased

pH value of banana is observed to be 5 0 This pH needs to be lowered for the adequate preservation of dried fruit products

Table - 3

Changes in the acidic content in the products on storage - First Month

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P	55	13	C_2 T P	53	25	C_3 T P	55
2	C T P_2	58	14	C_2 T P_2	54	26	C_3 T P_2	52
3	C T P_3	58	15	C_2T P_3	53	27	C_3 T P_3	54
4	C T_2 P	55	16	C_2 T_2 P	58	28	C_3 T_2 P	54
5	C T_2 P_2	56	17	C_2 T_2 P_2	55	29	C_3 T_2 P_2	55
6	C T_2 P_3	50	18	C_2 T_2 P_3	56	30	C_3 T_2 P_3	58
7	C T_3 P	52	19	C_2 T_3 P	58	31	C_3 T_3 P	48
8	C T_3 P_2	58	20	C_2 T_3 P_2	54	32	C_3 T_3 P_2	48
9	C T_3 P_3	59	21	C_2 T_3 P_3	58	33	C_3 T_3 P_3	50
10	C T_4 P	57	22	C_2 T_4 P	52	34	C_3 T_4 P	47
11	C T_4 P_2	58	23	C_2 T_4 P_2	53	35	C_3 T_4 P_2	47
12	C T_4 P_3	56	24	C_2 T_4 P_3	52	36	C_3 T_4 P_3	45

Control Sample 52

and sugar is added to mask the acidity to quite an extent as stated by Tonaki *et al* as early as (1973)

The acidity of the treated dried banana products was analysed every month of storage the values obtained for which are given in table 3 6

The acidity of the other products ranged from 59 45 as indicated in the table The highest acidic value was obtained by the treatment $C T_3P_3$ (59) (60° Brix with a heating temperature of 50° centigrade and an immersion time of 60 minutes)

It is noted that the acidity content was lower in the products which had a higher concentration of sugar This proves the fact that increased sugar concentration reduces acidity

The lowest value of acidity ie 45 was found in treatment $C_3T_4P_2$ (70° Brix an heating temperature of 60° centigrade and an immersion time of 60 minitues)

Acidity obtained for the samples with 70° Brix sugar concetrations was found to be less than products treated with 65° Brix sugar concentration 60° Brix treated samples were still lower in acidity From this it can be stated that concetration of the sugar influences the acidity content of the dried products

There was no stated criteria or factors that could claim for the difference between values obtained for the various treatments with the same sugar concentration The products were stored at room temperature

Table - 4

Changes in the acidic content in the product on storage - Second month of storage

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P	545	13	C_2 T P	505	25	C_3 T P	515
2	C T P_2	555	14	C_2 T P_2	525	26	C_3 T P_2	505
3	C T P_3	565	15	C_2 T P_3	5	27	C_3 T P_3	515
4	C T_2 P_1	525	16	C_2 T_2 P	555	28	C_3 T_2 P	51
5	C T_2 P_2	535	17	C_2 T_2 P_2	53	29	C_3 T_2 P_2	495
6	C T_2 P_3	49	18	C_2 T_2 P_3	565	30	C_3 T_2 P_3	545
7	C T_3 P	515	19	C_2 T_3 P	535	31	C_3 T_3 P	47
8	C T_3 P_2	565	20	C_2 T_3 P	525	32	C_3 T_3 P_2	46
9	C T_3 P_3	525	21	C_2 T_3 P_3	515	33	C_3 T_3 P_2	475
10	C T_4 P	405	22	C_2 T_4 P	485	34	C_3 T_4 P	45
11	C T_4 P_2	535	23	C_2 T_4 P_2	51	35	C_3 T_4 P_2	445
12	C T_4 P_3	535	24	C_2 T_4 P_3	505	36	C_3 T_4 P_3	435

Control Sample 525

Table - 5

Changes in acidic content in the products on storage - Third month of storage

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P_1	49	13	C_2 T P	46	25	C_3 T P	50
2	C T P_2	46	14	C_2 T P_2	50	26	C_3 T P_2	48
3	C T P_3	52	15	C_2 T P_3	50	27	C_3 T_1 P_3	45
4	C T_2 P	50	16	C_2 T_2 P_1	51	28	C_3 T_2 P_1	50
5	C_1 T_2 P_2	51	17	C_2 T_2 P_2	50	29	C_3 T_2 P_2	45
6	C T_2 P_3	50	18	C_2 T_2 P_3	52	30	C_3 T_2 P_3	49
7	C T_3 P	51	19	C_2 T_5 P	50	31	C_3 T_3 P	46
8	C T_3 P_2	51	20	C_2 T_3 P_2	51	32	C_3 T_3 P_2	47
9	C T_3 P_3	51	21	C_2 T_3 P_3	49	33	C_3 T_3 P_3	43
10	C T_4 P	49	22	C_2 T_4 P	45	35	C_3 T_4 P	43
11	C T_4 P_2	50	23	C_2 T_4 P_2	50	36	C_3 T_4 P_2	41
12	C T_4 P_3	51	24	C_2 T_4 P_3	50	37	C_3 T_4 P_3	40

Control Sample 52

They were further analysed after a per od of one month and it was found that the values had decreased a little but there was no significant difference in the values obtained Two samples secured the same value 56 treatment C T P_3 (60° Brix without heating and an immersion time of 60 minutes) & $C_2T_2P_3$ (65° Brix 50 degree centigrade and an immersion time of 60 minutes) when analysed during the second month

Acidity value obtained for the samples had reduced a little It was also found that most of the treatments with a higher sugar concentrat on had a comparatively lower level of acid ty

There was no significant difference when compared to the values dur ng first month The lowest value for acidity was found in $C_3T_4P_3$ (70° Brix with a heating temperature of 60 degree centigrade and an immersion time of 60 minutes)

The third month analysis also indicated that acidity value does not decrease drastically but there was a slight decrease in the acidity level It has been stated by Ranganath and Dubash (1981) that acidity decreases on storage This statement stands right as seen by the linear decrease in the acidity in this study

Values of the fourth month analysis showed a significant difference thus prov ng that the ac dity level of osmotically dehydrated fru t samples decreased with storage (Table 6)

Table - 6

Changes in the acidic content in the products on storage - Fourth month of storage

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P	48	13	C_2 T P	43	25	C_3 T P	48
2	C_1 T P	47	14	C_2 T P_2	42	26	C_3 T_1 P_2	47
3	C T P_3	48	15	C_2 T_1 P_3	47	27	C_3 T P_3	45
4	C T_2 P	46	16	C_2 T_2 P	48	28	C_3 T_2 P_1	48
5	C T_2 P_2	46	17	C_2 T_2 P_2	48	29	C_3 T_2 P_1	45
6	C_1 T_2 P_3	46	18	C_3 T_2 P_3	50	30	C_3 T_2 P_2	47
7	C_1 T_3 P	46	19	C_3 T_3 P	48	31	C_3 T_3 P	43
8	C_1 T_3 P_2	47	20	C_3 T_3 P_2	49	32	C_3 T_3 P_2	45
9	C T_3 P_3	46	21	C_3 T_3 P_3	45	33	C_3 T_3 P_3	45
10	C_1 T_4 P	45	22	C_3 T_4 P	43	34	C_3 T_4 P	42
11	C T_4 P_2	50	23	C_3 T_4 P_2	48	35	C_3 T_4 P_2	40
12	C_1 T_4 P_3	41	24	C_3 T_4 P_3	46	36	C_3 T_4 P_3	39

Control Sample 52

It can clearly be understood that though there is no significant difference between the values obtained for two consecutive months there is a significant difference between values obtained for the 1st and 4th month of analysis

The acidity level of the $C T P_3$ (60^0 Brix without heating osmotic solution and an immersion time of 60 minutes) for the first four months were 58 56 52 & 48 resp

It was found that the control sample had a greater acidity than the treated fruit products making it more succeptable to microbial growth than the treated ones proving with the storage point of view that treated fruits are better than untreated ones

4 2 3 Effect of treatments on reducing sugar

One of the less thought of procedures for foods is that involving the use of high sugar concentrations as stated by Harris (1975) Generally speaking sugar treated products are usually considered to be "Fun foods" Their usage is very small in the daily consumption Further more the levels of Vitamins and Minerals in such type of products are not usually significant from a nutritional stand point (Harris and Karmas 1975)

For the various processing methods sugar syrups are used and mainly syrup of sugar glucose or corn is used for fruits The strength of the syrup usually depends on the kind and variety of the fruit the more acidic fruits require denser syrup (Girdharilal 1986)

Table - 7

Effect of pretreatments on the reducing sugar of dried banana products - First month of storage

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T_1 P	14 05	13	C_2 T P	14 15	25	C_3 T P	16 15
2	C T_2 P_2	14 05	14	C_2 T_1 P_2	15 25	26	C_3 T P_2	16 35
3	C T P_3	14 10	15	C_2 T_1 P_3	15 25	27	C_3 T P_3	16 55
4	C T_2 P	14 20	16	C_2 T_2 P	15 55	28	C_3 T_2 P	16 25
5	C T_2 P_2	14 45	17	C_2 T_2 P_2	15 45	29	C_3 T_2 P_2	16 25
6	C T_2 P_3	14 65	18	C_2 T_2 P_3	15 15	30	C_3 T_2 P_3	16 20
7	C T_3 P	14 65	19	C_2 T_3 P	15 55	31	C_3 T_3 P	16 15
8	C T_3 P_2	14 65	20	C_2 T_3 P_2	15 35	32	C_3 T_3 P_2	16 55
9	C T_3 P_3	14 55	21	C_2 T_3 P_3	15 80	33	C_3 T_3 P_3	16 55
10	C T_4 P	14 60	22	C_2 T_4 P_1	15 55	34	C_3 T_4 P	16 55
11	C T_4 P_2	14 80	23	C_2 T_4 P_2	15 65	35	C_3 T_4 P_2	16 65
12	C T_4 P_3	14 55	24	C_2 T_4 P_3	15 85	36	C_3 T_4 P_3	16 8
					14 5			

Control Sample 13 85

Fruits consist of fairly large amount of sugars when they are ripe and ready for consumption which accounts for the sweetness in the ripe fruit when compared to that of the unripe ones

Range of the reducing sugar of the thirty six samples of dehydrated banana products were analysed for every month of storage and the values obtained based on the analysis are given in the tables 12 15

The highest value (16 8) for reducing sugar was obtained by $C_3T_4P_3$ (70° Brix 60 degree centigrade and an immersion time of 60 minutes) this may be due to the higher sugar concentration immersion time and the osmotic temperature

Based on reducing sugar level $C_3T_4P_3$ was followed by treatments which were treated with 70 percent sucrose solution though the immersion time and osmotic solution varied Other treatments with higher levels of reducing sugar were $C_3T_4P_2$ (70° Brix 60 degree centigrade and an immersion time of 45 minutes) (16 65) the treatments C_3T_4P $C_3T_3P_3$ and $C_3T_3P_2$ had a reducing sugar level of 16 55 percent

It is seen from table 12 that reducing sugar levels increased gradually with the increase in the sugar concentration (i e) osmotic solution temperature and the immersion time of the fruit So the samples with highest sugar concentration immersion time and osmotic temperature had the highest reducing sugar content

Table 8

Effect of treatment on the reducing sugar of dried banana products Second month of storage

C			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P	14 30	13	C_2 T P	14 35	25	C_3 T P	14 85
2	C T P_2	14 10	14	C_2 T P_2	15 30	26	C_3 T P_2	16 35
3	C T P_3	14 20	15	C_2 T P_3	15 45	27	C_3 T P_3	16 45
4	C T_2 P	14 40	16	C_2 T_2 P	15 75	28	C_3 T_2 P	16 45
5	C T_2 P_2	14 55	17	C_2 T_2 P	15 55	29	C_3 T_2 P_2	16 35
6	C T_2 P_3	14 75	18	C_2 T_2 P_3	15 35	30	C_3 T_2 P_3	16 25
7	C T_3 P	14 65	19	C_2 T_3 P	15 75	31	C_3 T_3 P	16 30
8	C T_3 P_2	14 85	20	C_2 T_3 P_2	15 55	32	C_3 T_2 P_2	16 65
9	C T_3 P_3	14 80	21	C_2 T_3 P_3	15 90	33	C_3 T_3 P_3	16 60
10	C T_4 P	14 65	22	C_2 T_4 P	15 85	34	C_3 T_4 P	16 65
11	C T_4 P_2	15 05	23	C_2 T_4 P_2	15 75	35	C_3 T_4 P_2	16 85
12	C T_4 P_3	14 85	24	C_2 T_4 P_3	16	36	C_3 T_4 P_3	16 90

Control Sample 13 9

The treatment C T P had the lowest level of reducing sugar among the treated samples C T P (60° Brix without heating the osmotic solution and an immersion time of 30 minutes) had a reducing sugar level of 14 05 The same level of reducing sugar was not ced for treatment $C T P_2$ (60° Brix w th an immersion time of 45 minutes leaving the osmotic solution unheated) also

This may be due to the fact that heating of th osmotic solution helps more absorption of sucrose from the sugar solution which was proved by Berıstein *et al* (1990)

The control sample which was dried without any treatments had a very low level of reducing sugar (13 85) accounting for the statement that treatment with sucrose solution increased the reducing sugar content of the fruit by Berıstein *et al* (1990)

The dried banana products were further analysed after a period of one month and it was found that the reducing sugar level remained constant for certain treatments but otherwise there was a l ttle increase in the value of the same And although there was an increase in the value of the reducing sugar there was no noticable difference in the values between the two consecutive months (Table 8)

Treatment $C_3T_4P_3$ (60° Brix 60 degree centigrade with an immersion time of 60 minutes) had the maximum level of reducing sugar as in the case of the first month It had a value of 16 90 which was higher when compared to the reducing sugar

Table 9

Effect of treatment on reducing sugar of dried banana products - Third month of storage

C_1			C_2			C_3		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C_1 T_1 P_1	14 25	13	C_2 T P	15 35	25	C_3 T P	14 95
2	C T P_2	14 35	14	C_2 T_1 P_2	16 35	26	C_3 T P_2	16 55
3	C T P_3	14 3	15	C_2 T P_3	15 75	27	C_3 T P_3	16 65
4	C T_2 P	14 75	16	C_2 T_2 P	15 85	28	C_3 T_2 P	16 75
5	C T_2 P_2	14 85	17	C_2 T_2 P_2	15 65	29	C_3 T_2 P_2	16 45
6	C T_2 P_3	14 95	18	C_2 T_2 P_3	15 55	30	C_3 T_2 P_3	16 35
7	C T_3 P	15 15	19	C_2 T_3 P	15 75	31	C_3 T_3 P	16 40
8	C T_3 P_2	14 95	20	C_2 T_3 P_2	15 75	32	C_3 T_3 P_2	16 80
9	C T_3 P_3	14 85	21	C_2 T_3 P_3	15 95	33	C_3 T_3 P_3	16 80
10	C T_4 P	14 95	22	C_2 T_4 P	15 95	34	C_3 T_4 P	16 35
11	C T_4 P_2	15 20	23	C_2 T_4 P_2	15 85	35	C_3 T_4 P_2	17 00
12	C T_4 P_3	15 05	24	C_2 T_4 P_3	16 05	36	C_3 T_4 P_3	17 15

Control Sample 14 15

level of the first month but this increase in value was very negligible

Treatment $C_3T_4P_2$ (70° Brix 60 degree centigrade and an immersion time of 45 minutes) with 16 85 $C_3T_3P_2$ (70° Brix 50 degree centigrade and an immersion time of 45 minutes) with 16 65 were the other treatments that stood very close to the treatment $C_3T_4P_3$

The lowest level of reducing sugar among the treated samples was obtained for treatment C T P_2 (60° Brix without heat ng the sugar solution and with an immersion time of 45 minutes) with a value of 14 1

For the other samples reducing sugar values ranged between 14 1 and 16 9 There was not much difference between samples But the samples treated with the highest sugar concentration had a greater amount of reducing sugar

The control sample had a very low value of reducing sugar 13 9 The value had immersed slightly from that of the first month but the level of reducing sugar still remained the lowest

Analysis of the dried banana products in the third month showed an overall increase in the reducing sugar level Thus there being a gradual increase in the reducing sugar content

The treatment $C_3T_4P_3$ with a value of 17 15 still had the max mum level of reduc ng sugar and all the treatments ranged between 14 25 and 17 15

Reducing sugar in treatment C T P was the lowest (14 25) among all the treatments In this case also all the treatments treated with higher sugar concentrations had a greater value of reducing sugar and those treated with lower concentrations of sugar had a lower level of reducing sugar Table 9

The control sample had a value of 14 15 which was lesser than any of the treated samples But the reducing sugar level had increased from previous months

Analysis of the banana products for reducing sugars in the fourth month gave a range between 17 25 and 14 35

Treatment $C_3T_4P_3$ (70^0 Brix 60 degree centigrade and 60 minutes immersion time) had the value 17 25 the other treatments also had a very closer level of reducing sugar like 17 15 for C_3T_4P 17 05 for $C_3T_4P_2$ 17 0 for $C_3T_3P_2$ Treatment $C_1T P_1$ had still got the lowest level of reducing sugar (Table 10)

Comparing the values of reducing sugar month wise there was no noticable change between the values obtained for two consecu ive months But on having an overall assessment it can be noted that there was a great difference in the values obtained for reducing sugar in the first and fourth months of analysis

The control sample st ll had a lower level of reducing sugar among the lot (14 3) But on comparing its value with the initial month of storage there has been a notable difference in the level

Table - 10

Effect of treatment on the reducing sugar of dried banana products - Fourth Month of Storage

C			C_1			C_2		
S No	Treatments	Mean Values	S No	Treatments	Mean Values	S No	Treatments	Mean Values
1	C T P	14 45	13	C_2 T P	15 55	25	C_3 T P	15 05
2	C T P_2	14 35	14	C_2 T P_2	15 75	26	C_3 T P_2	16 65
3	C T P_3	14 70	15	C_2 T P_3	15 85	27	C_3 T P_3	16 85
4	C T_2 P	14 75	16	C_2 T_2 P	16	28	C_3 T_2 P	16 95
5	C T_2 P_2	15 05	17	C_2 T_2 P_2	15 85	29	C_3 T_2 P_2	17 05
6	C T_2 P_3	15 15	18	C_2 T_2 P_3	15 75	30	C_3 T_2 P_3	16 85
7	C T_3 P	15 35	19	C_2 T_3 P	15 75	31	C_3 T_3 P	16 85
8	C T_3 P_2	15 20	20	C_2 T_3 P_2	15 95	32	C_3 T_3 P_2	17 00
9	C T_3 P_3	15 05	21	C_2 T_3 P_3	16 05	33	C_3 T_3 P	17 03
10	C T_4 P	15 20	22	C_2 T_4 P	16 25	34	C_3 T_4 P	17 15
11	C T_4 P_2	15 30	23	C_2 T_4 P_2	16 15	35	C_3 T_4 P_2	17 05
12	C T_4 P_3	15 35	24	C_2 T_4 P_3	16 15	36	C_3 T_4 P_3	17 25

Control Sample 14 3

This analysis has been supported by the work done by Mir and Nirankarnath (1993) stating that storage increases the reducing sugar significantly though the overall acceptability is reduced

4 3 Influence of treatments on organoleptic qualities and changes during storage

Quality is a degree of excellence and a composite characteristic determining acceptability (Neelofur 1992)

The organoleptic qualities can be assessed by sensory evaluation Sensory evaluation of food is assumed to be of increasing significance as this provides information which may be utilized for development of a product and its improvement

According to Kramer and Twigg (1970) food quality detectable by our senses can be broken down into the main categories viz Appearance texture and flavor According to Kramer (1970) among the various quality attributes taste is the primary and most important one And hence due importance to every sensory characters has to be given in assessing the organoleptic qualities

The score obtained for the overall acceptability of the dried banana products for various months are given in tables 11 14

The overall acceptability of the dried banana products were tested with due importance to the different treatments to assess the effect of the same on the organoleptic quality of the products

Table 11

The effect of treatments on the overall acceptability of the dried banana products - First month of storage

C_1			C_2			C_3		
S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values
1	C T P	3 05	13	C_2 T P	3 05	25	C_3 T P	2 90
2	C T P_2	3 45	14	C_2 T P_2	2 55	26	C_3 T P_2	3 55
3	C T P_3	3 05	15	C_2 T P_3	2 55	27	C_3 T P_3	3 30
4	C T_2 P	3 15	16	C_2 T_2 P	3 05	28	C_3 T_2 P	3 55
5	C T_2 P_2	2 90	17	C_2 T_2 P_2	3 10	29	C_3 T_2 P_2	4 05
6	C T_2 P_3	2 70	18	C_2 T_2 P_3	3 05	30	C_3 T_2 P_3	3 90
7	C T_3 P	2 70	19	C_2 T_3 P	3 65	31	C_3 T_3 P	3 70
8	C T_3 P_2	3 40	20	C_2 T_3 P_2	3 70	32	C_3 T_3 P_2	3 55
9	C T_3 P_3	3 40	21	C_2 T_3 P_3	3 05	33	C_3 T_3 P_3	3 75
10	C T_4 P	3 05	22	C_2 T_4 P	3 75	34	C_3 T_4 P	4 35
11	C T_4 P_2	2 95	23	C_2 T_4 P_2	3 55	35	C_3 T_4 P_2	4 30
12	C T_4 P_3	3 05	24	C_2 T_4 P_3	3 55	36	C_3 T_4 P_3	4 70

Control Sample 3 45

The overall acceptab lity score obtained ranged between 2 50 to 3 40 Among the thirty six treatments that were evaluated the product with 70 percent sugar solution heated to 60 degree centigrade and immersed in the osmotic solution for 60 minutes ($C_3T_4P_3$) was adjudged to be the best product with the maximum score of 4 70 (Table 11)

This product had the highest sugar concentration used in the experimental study The fact that heating of the osmotic solution increases the very process of osmos s and thus the sweetness may justify the high acceptability of the product In this connection Berlstein *et al* (1990) reported that the sugar content of the pineapple rings increased by 10 percent at 50° Brix by 16 percent at 60° Brix and by 25 percent at 70° Brix

The products obtained were highly acceptable with a firm ring structure and an yellow brown color And with regard to the taste a little deviation from the original taste of the fruit did not affect the acceptability of the fruit Lerici *et al* (1984) pointed out that osmotically treated fruits were better in flavor texture and color than untreated fruits

The texture was also found to be acceptable It did not possess a very soft texture nor was it very hard Totally considering all the attributes for evaluation it was unbiasely proved that the samples with a sugar concentration of 70 percent and an

osmotic temperature of 60 degree centigrade gave the best values organoleptically

The scores obta ned by the other samples ranged between 2 55 and 4 70 indicating that all the samples were acceptable by having obtained values above the mid value of 2 50 It also needs to be noted that the scored third and fourth ranks were second by treatments $C_3T_2P_2$ 4 05 $C_3T_4P_2$ 4 30 and C_3T_4P 4 35 respectively with a seventy percent sugar solution

Similarly on assessment the least score was obtained by two samples viz $C_2T_1P_2$ and $C_2T P_3$ with a sugar concentrat on of 65 percent

The low sugar concentration leading to a comparatively reduced sweetness in the processed product may be one of the prime cause or factor for the low scores obtained since taste was the major attribute which with a lesser score caused a wide range of difference between the max mum and minimum scores Though all the scores ranged between 2 55 and 4 70 it was found that the product was cent percent acceptable

Corresponding to the thirty six treatments that were carried out the control sample scored 3 45 The score of the control sample went well above that of the mid value of but the treated samples had a better score count with a better ranking than that of the control sample There was a significant difference between the control sample and the maximum scored sample

Table 12

The effect of treatments on the overall acceptability of the dried banana products Second month of storage

C			C_1			C_2		
S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values
1	C T P_1	2 85	13	C_2 T P	3 05	25	C_3 T P	3 05
2	C T P_2	3 05	14	C_2 T P_2	2 55	26	C_3 T P_2	2 75
3	C T P_3	3 05	15	C_2 T P_3	3 40	27	C_3 T P_3	3 05
4	C_1 T_2 P	3 40	16	C_2 T_2 P	3 05	28	C_3 T_2 P	4 05
5	C T_2 P_2	3 45	17	C_2 T_2 P_2	2 95	29	C_3 T_2 P_2	4 05
6	C T_2 P_3	2 85	18	C_2 T_2 P_3	3 05	30	C_3 T_2 P_3	4 05
7	C T_3 P	2 75	19	C_2 T_3 P	3 60	31	C_3 T_3 P	3 50
8	C T_3 P_2	3 05	20	C_2 T_3 P_2	3 65	32	C_3 T_3 P_2	3 55
9	C T_3 P_3	3 35	21	C_2 T_3 P_3	3 05	33	C_3 T_3 P_3	3 70
10	C T_4 P	2 95	22	C_2 T_4 P	3 50	34	C_3 T_4 P	4 05
11	C T_4 P_2	2 95	23	C_2 T_4 P_2	3 45	35	C_3 T_4 P_2	4 25
12	C T_4 P_3	3 05	24	C_2 T_4 P_3	3 40	36	C_3 T_4 P_3	4 5

Control Sample 3 7

Inspite of a thorough and clear investigation in the organoleptic studies incidences of chance variations and estraneous factors cannot completely be ruled out but variations if any shall necessarily be negligible

After a months storage the organoleptic qualities of the thirty six samples of dried banana fruit was assessed to study the variation if any in the overall acceptability of the products (Table 12)

As per the results obtained from the judges after sensory evaluation treatment C_3 T_4 P_3 (70° Brix 60° centigrade and 60 minutes immersion time) still ranked first among all the samples

It needs to be stated in this context that the highest scored sample was also the top scorer for the second month of analysis but the score count had decreased during the second month It was only 4 50 corresponding to 4 70 obtained in the first month

Comparing the difference between the two values it has been found that there is no marked difference between the two scores obtained by the same sample for two consecutive months The second months score thus claiming an equal acceptability

The scores ranged from 2 55 to 4 50 and all the scores were found to be above the mid value level proving the acceptability of the products for the second month evaluation also

From the monthly analysis it was found that a total of six samples viz C_3 T_4 P_3 (4 5) C_3 T_4 P_2 (4 25) C_3 T_2 P (4 05) C_3 T_2 P_2 (4 50) C_3 T_2 P_3 (4 05) and C_3 T_4 P (4 05) had a score above 4 showing that the acceptability of about 17 percent of the total samples were good 22 2 percent of the samples ranged between 2 50 and 3 00 And 61 1 percent of samples scored between 3 00 and 4 00 out of a maximum score of 5 00

The lowest score was obtained for the treatment C_2T P_2 (65^0 Brix without heating and an immersion time of 45 minutes)

Corresponding to this the lowest scorer for the first month also was the above started treatment Negligible / no difference was noted between the scores obtained during the two consecutive months for this product

In the second month evaluation of the sensory characters it was found that the control sample had a better score of 3 70 corresponding to its score obtained in the first The decreased acidity level may be a contributing factor for this change is acceptability score

Score of the control sample was lesser than that of the treated samples The treated samples obtained a better score than the control

Taking into account the product as a whole there was no much variation for the score between the two months but totally there was a little decline in the acceptability of the products

Table 13

The effect of various treatments on the overall acceptability of dried banana products - Third Month of storage

C			C_2			C_3		
S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values
1	C T P	2 70	13	C_2 T P	2 95	25	C_3 T P	2 95
2	C T P	3 00	14	C_2 T P_2	2 45	26	C_3 T P_2	2 45
3	C T P_3	2 95	15	C_2 T P_3	3 15	27	C_3 T P_3	2 75
4	C T P	3 05	16	C_2 T_2 P	3 05	28	C_3 T_2 P	3 70
5	C T_2 P_2	3 10	17	C_2 T_2 P_3	2 75	29	C_3 T_2 P_2	3 65
6	C T_2 P_3	2 50	18	C_2 T_2 P_3	2 85	30	C_3 T_2 P_3	3 90
7	C T_3 P	2 55	19	C_2 T_3 P	3 20	31	C_3 T_3 P	3 65
8	C T_3 P_2	2 95	20	C_2 T_3 P_2	3 55	32	C_3 T_3 P_2	3 65
9	C T_3 P_3	3 10	21	C_2 T_3 P_3	2 95	33	C_3 T_3 P_3	3 65
10	C T_4 P	2 95	22	C_2 T_4 P	3 35	34	C_3 T_4 P	3 95
11	C T_4 P_2	2 80	23	C_2 T_4 P_2	3 10	35	C_3 T_4 P_2	4 15
12	C T_4 P_3	3 05	24	C_2 T_4 P_3	3 10	36	C_3 T_4 P_3	4 30

Control Sample 3 2

The products had still maintained the fru t shape and firmness the flavor and texture Though the products remained acceptable the appearance was slightly affected with the fading of the bright yellow brown color to a slightly faded color

There was no evidence of microbial attack and hence did not pave way for toxic contamination

As the dehydrated fruit products were acceptable during the second month also they were further subjected to the organolept c evaluation during the third month

The organoleptic quality assessment carried out for the third consecutive month indicated that treatment $C_3T_4P_3$ (70° Brix 60° centigrade and 60 minutes immersion time) still ranked highest with a score of 4 35 Table 13

Comparing the scores obtained for the product with that of the previous months no notable difference was found with the score of the second month but on comparison of the difference between the scores of the first and third month a clear d fference is noted between the scores of the products showing a significant change in the acceptability of the product

The score count showed that the acceptabil ty of the same product though ranked f rst had reduced comparatively This can be said so based on the score comparison

Among the thirty six samples there were just two samples that fell below the mid score level of 2 50 showing that all

the other products were still acceptable The number of treatment scores ranging between 2 50 and 3 00 increased to 41 6 percent corresponding to 22 2 percent of the second month there were only 2 treatments with score above 4 00 and they were $C_3T_4P_2$ with score of 4 15 and $C_3T_4P_3$ with a score of 4 30

The lowest score in this regard was obtained by two samples viz $C_2T\ P_2$ (65° Brix without heating and an immersion time of 45 minutes) and $C_3T\ P_2$ (70° Brix without heating the sugar solut on and an immersion time of 45 minutes) It is noted that both the low ranked samples had an unheated osmotic solution thereby reducing the absorption of sugar by the fru t rings during osmotic dehydration Thus higher temperature increased the rate at which sugar was transported into the fruit ring as reported by Beristein *et al* (1990)

As in the case of treated samples control samples also showed a decrease n the overall acceptability as seen from the decrease in the score The treated samples scored more than the control samples to a considerable extent which indicate that treatments appl ed may have an influence for improving their acceptability

The total appearance of the products was not very acceptable since the color had faded still further giv ng a dull and unappetizing look The flavor was not altered completely though there was a little deviation from the original flavor One main cause for this may be that the products had been stored for three months

Table-14

The effect of treatments on the overall acceptability of dried banana products - Fourth month of storage

C_1			C_2			C_3		
S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values	S No	Treatments	Mean Score Values
1	C_1 T_1 P_1	2 60	13	C_2 T_1 P_1	2 80	25	C_3 T_1 P_1	2 65
2	C_1 T_1 P_2	3 05	14	C_2 T P_2	2 40	26	C_3 T_1 P_2	2 45
3	C_1 T_1 P_3	2 95	15	C_2 T_1 P_3	2 75	27	C_3 T P_3	3 15
4	C_1 T_2 P_4	2 80	16	C_2 T_2 P	2 95	28	C_3 T_2 P_1	3 50
5	C_1 T_2 P_2	3 05	17	C_2 T_2 P_2	2 55	29	C_3 T_2 P_2	3 60
6	C_1 T_2 P_3	2 25	18	C_2 T_2 P_3	2 85	30	C_3 T_2 P_3	3 80
7	C_1 T_3 P_1	2 35	19	C_2 T_3 P_1	2 95	31	C_3 T_1 P_1	3 50
8	C_1 T_3 P_2	2 85	20	C_2 T_3 P_2	3 15	32	C_3 T_3 P_2	3 15
9	C_1 T_3 P_3	3 25	21	C_2 T_3 P_3	2 80	33	C_3 T_3 P_3	3 45
10	C_1 T_4 P_1	2 95	22	C_2 T_4 P	2 60	34	C_3 T_4 P_1	4 10
11	C_1 T_4 P_2	2 85	23	C_2 T_4 P_2	3 10	35	C_3 T_4 P_2	4 40
12	C_1 T_4 P_3	2 85	24	C_2 T_4 P_3	3 00	36	C_3 T_4 P_3	3 80

Control Sample 1 60

It was noted by Mir and Nirankarnath (1993) that flavor changes may be attributed to the alteration in the chemical composition

The products were assessed for microbial contamination and it was found that there was no attack of any micro organism in the products

The organoleptic qualities were assessed for the fourth month Since there was no microbial deterioration the evaluation was carried out by the same panel of judges who had assessed the sensory characters for the first three months

The scores obtained for the products during the fourth month as shown n table 6 revealed that the score for overall acceptability declined About 55 5 percent of the products scored between 2 0 to 3 0 indicating that they scored values were around the mid value of 2 5 Only two treatments $C_3T_4P_1$ and $C_3T_4P_2$ scored above 4 00 38 8 percent of the samples of the products scored between 3 00 and 4 00

The highest score (4 4) however was scored by treatment $C_3T_4P_2$ (70° Brix 60° centigrade with an immersion time of 45 minutes) Though the particular treatment was not ranked first in all the previous cases it stood very close to the h ghest scores always with scores 4 30 4 25 and 4 15 respectively for the three months

The treatment C_3T_4P stood second with an overall acceptability score of 4 10

The lowest score secured was for the treatment C T_2 P_3 (60° Brix and heating temperature of 40 degree centigrade with an immersion time of 60 minutes) with a score of 2 25

There was a notable difference between the mean scores obtained in the initial stages and the fourth month of evaluation and hence it can be stated that there was a linear and steady decrease in the overall acceptability of the dried products

Correspondingly the control group was found to have a very poor score for the fourth month The score count had fallen down tremendously from 3 2 to 1 6 This was the lowest score obtained amongst all the samples and all the treated samples scored above the control sample

The control sample had a very poor appearance The offlavor produced was very discouraging and the particular sample was proved a total failure by the end of the fourth month of storage proving that treated products had a better taste flavor texture and appearance than sundried ones Lerici *et al* (1985) had supported the above finding

The treated products towards the end of the fourth month had a very cloggy appearance It had become soggy in texture The products had started to develop an offlavor which may be due to actions of organic compounds which had been present in the food stuffs or by action of molds insects or other pests as suggested by Louis & Robert (1973)

Taking due concern on the overall acceptability of the dried products for the four months of storage in general it was found that 26 39 percent of the products had an acceptability percentage between 100 76 during the first month of storage All the other products were in the score range of 75 51 with a percent count of 73 61

During the second month 23 12 percent samples secured an overall acceptability score between 100 76 while 73 61 percent samples were in the range of 75 51 None of the samples secured a score below 50 percent

In the score range of 100 76 the fruit acceptance fluctuated from 19 44 in the third month to 9 76 in the fourth month 72 23 percent and 79 13 percent of the fruit samples occupied the range between 75 51 for the third and fourth months of storage respectively The score range below 50 was secured by 8 33 percent samples during the third month and 11 10 percent samples during the fourth month

On the whole it can be stated that there was a decrease with storage time on the acceptability of the products Majority of the dried products secured a range between 76 51 by the end of the 4 months The products fell below the score range of 50 percent only with an increase in the storage time

Table 15

Percentage distribution of mean score values for the overall acceptability of dried banana products during storage

	Percentage Range	Percentage Distribution for values of overall Acceptability during storage			
		1st Month of storage	2nd Month of storage	3rd Month of storage	4th Month of storage
1	100 76	26 39	23 12	19 44	9 76
2	75 51	73 61	76 88	72 23	79 13
3	50 and below			8 33	11 11

4 4 Assessment of Microbial contamination of dried banana products

The presence of the flavor and a loss of appetizing appearance indicated the microbial decay formed in the food by the action of the microorganisms

On viewing under the microscope the products showed colonies of Aspergillus and Penicillium which confirmed the presence of microbial decay The products when assessed for microbial contamination during the early months of storage were found to be free from contamination The presence of these micro organisms may be the cause for the deterioration of the dried products

Since the product failed to maintain attributes like color appearance texture flavor and taste the storage study was discontinued

4 5 Cost benefit analysis of the dried banana products

Cost benefit analysis was carried out to assess the extent of expense arised to obtain dehydrated products subjected to different treatments The major food materials which contributed to the cost of the products include banana and sugar

The overhead charges for the products subjected to different treatments was computed The cost of the products are presented in Table 16 From the above table it can be found that cost of the products with different treatments ranged from Rs 15 50 per 1/4kg to 17 50 per 1/4 kg

Table - 16

Cost Benefit Analysis

C_1			C_2			C_3		
S No	Treatments	Cost	S No	Treatments	Cost	S No	Treatments	Cost
1	$C\ T\ P$	15 50	13	$C_2\ T\ P$	16 10	25	$C_3\ T\ P$	16 70
2	$C\ T\ P_2$	15 50	14	$C_2\ T\ P_2$	16 10	26	$C_3\ T\ P_2$	16 70
3	$C\ T\ P_3$	15 50	15	$C_2\ T_1\ P_3$	16 10	27	$C_3\ T\ P_3$	16 70
4	$C\ T_2\ P_1$	16 30	16	$C_2\ T_2\ P$	16 90	28	$C_3\ T_2\ P$	17 50
5	$C\ T_2\ P_2$	16 30	17	$C_2\ T_2\ P_2$	16 90	29	$C_3\ T_2\ P_2$	17 50
6	$C\ T_2\ P_3$	16 30	18	$C_2\ T_2\ P_3$	16 90	30	$C_3\ T_2\ P_3$	17 50
7	$C\ T_3\ P_1$	16 30	19	$C_2\ T_3\ P$	16 90	31	$C_3\ T_3\ P$	17 50
8	$C\ T_3\ P_2$	16 30	20	$C_2\ T_3\ P_2$	16 90	32	$C_3\ T_3\ P_2$	17 50
9	$C\ T_3\ P_3$	16 30	21	$C_2\ T_3\ P_3$	16 90	33	$C_3\ T_3\ P_3$	17 50
10	$C\ T_4\ P$	16 30	22	$C_2\ T_4\ P$	16 90	34	$C_3\ T_4\ P$	17 50
11	$C\ T_4\ P_2$	16 30	23	$C_2\ T_4\ P_2$	16 90	35	$C_3\ T_4\ P_2$	17 50
12	$C\ T_4\ P_3$	16 30	24	$C_2\ T_4\ P_3$	16 90	36	$C_3\ T_4\ P_3$	17 50

Considering all the factors like nutritional chemical composition and the organoleptic qualities the treatment with 70 percent sugar concentration was found to be the best and hence though there is a difference of Rs 1 20 per 1/4 kg dried fruit and 0 60 per 1/4 kg dried fruit when compared to the treatments with 60° Brix and 65° Brix respectively the difference is not very significant or marked

Hence it can be stated that at a cost of Rs 17 50 per kg 250 gms of dried banana products which are highly acceptable and Nutritious can be recommended for consumption Thus proving that osmotically dehydrated fruits retain a large percentage of the fresh fruit flavor and are suitable for producing fruits with a lesser processing time as also found by Angla *et al* (1991)

SUMMARY

A study entitled Application of osmotic dehydration technique for the product development in banana (Musa (AAB group) Palayamkodan) was undertaken to develop shelf stable dehydrated banana products using osmotic dehydration

Thirty six different treatments were applied to obtain good quality products Different treatments include sugar concentrations of 60° Brix 65° Brix and 70° Brix at there different temperatures 40°C 50°C 60°C and one without heating with an immersion time of 30 minutes 45 minutes and 60 minutes

Acceptable and shelf stable products were obtained and the products prepared were analysed for the weight loss moisture loss and drying time nutritional and chemical changes organoleptic qualities and changes during storage assessment of microbial contamination of the products and cost benefit analysis

The weight loss of the fruits after the initial dewatering was assessed and it was found that the amount of weight lost from the fruits increased with the increase in sugar concentration temperature and immersion time

The effect of the various treatments on the weight loss of the products indicated that weight loss of the dried banana products prepared accounted to be 75 percent of the original weight

The moisture level of the fresh fruit was found to be 70 percent The moisture content of the different treated products ranged between 8 5 to 9 4 percent

On analysis of the drying time of the various treatments the samples treated with 70° Brix the highest of the sugar concentrations applied was found to require the least time for drying

On assessing the nutritional and chemical changes the dried banana fruits showed only trace amount of Vitamin C The pH of the banana fruit was found to be 5

The acidity of the dried products ranged from 59 45 Treatment $C T_3P_3$ (59) had the highest acidity the treatments with higher sugar concentrations had a lower acidity The lowest value for acidity was found in treatment $C_3T_4P_3$

During storage acidity value of the dried products were found to decline

Analysis of reducing sugar content of the dried banana products indicated that the highest value (16 8) for reducing sugar was obtained by treatment $C_3T_4P_3$ This may be due to the higher concentration of sugar temperature and immersion time Other treatments with higher levels of reducing sugar were $C_3T_4P_2$ (16 65) C_3T_4P $C_3T_3P_3$ and $C_3T_3P_2$ all with a reducing sugar level of 16 55 percent

Treatment C T P had the lowest level of reducing sugar (14 05) The same level was noted in $C_1T P_2$ For the first month the control sample had a low level of reducing sugar (13 85)

Reducing sugar content of the dried banana products was found to be increased for certain treatments during storage Treatments $C_3T_4P_3$ had the maximum level of reducing sugar (16 9) Treatment $C_3T_4P_2$ (16 85) and $C_3T_3P_2$ (16 65) stood very close to $C_3T_4P_3$ The lowest level was however seen in treatment $C_1T\ P_2$ with a value of 14 1 For all the other samples values ranged between 14 1 and 16 9 The control sample had a low value of 13 9

Analysis of the dried banana products in the third month showed an overall increase in the reducing sugar level Values of all the samples ranged between 14 25 17 50

The control sample had a value of 14 15 which was lesser than any of the treated samples It had increased from that of the previous months

Analysis of the reducing sugar content for the products of the fourth month showed a range of 14 25 17 25 The reducing sugar content of the control sample was 14 3 which was lower than any of the treated samples

From the above findings it can be seen that there was a gradual increase in the levels of reducing sugar in the dried banana products

The organoleptic qualities of the dehydrated banana products were assessed by sensory evaluation The analysis of the overall acceptability for the initial month showed that among the thirty

six treatments the product with 70 percent sugar solution heated to 60°C and immersed in the osmotic solution for 60 minutes was adjudged to be the best product with the maximum score of 4 70

The products were highly acceptable with regard to organoleptic qualities for the initial period They had a firm ring structure and an yellow brown color The texture was also good The scores obtained for the overall acceptability ranged between 2 50 4 70 The lowest score was obtained by two samples with 65 percent sugar concentration The control sample had a score of 3 45 The treated samples had a better score count and a better ranking

For the second month of evaluation also the highest score was obtained for the same treatment $C_3T_4P_3$ Since there was no significant difference between the scores obtained for the same treatment for the two months the treatment $C_3T_4P_3$ claimed equal acceptability for the second month The scores of the other treatments ranged from 2 55 to 4 50 The lowest score was obtained by treatment $C_2T_1P_2$

The control sample had a better score count for second month when compared to that of the first month The score of the control sample was found to be lesser than the treated samples

During the third month the treatment $C_3T_4P_3$ still ranked first the score count was found to decrease Treatment $C_2T P_2$ and $C_3T P_2$ scored the least for the third month with a score of 2 45 The treatment $C_1T_2P_3$ had the lowest score during fourth month of analysis

with a score of 2 25 The control sample had a very poor score compared to the treated sample with a score count of 3 20 in the third month and 1 60 in the fourth month

The was a gradual decline in the overall acceptability during storage and showed incidences of microbial attack

Cost benefit analysis was carried out to assess the extent of expense arised to obtain dried products using banana prepared giving different treatments

It was observed that 250 gms of the dried banana products can be prepared at a cost of 17 50 per 1/4 kg which is highly acceptable and can be recommended for consumption The expense of the products did not differ much with regard to different treatments

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*Originals not seen

APPENDICES

APPENDIX - 1

SPECIMEN EVALUATION CARD FOR TRIANGLE TEST

Name Date

Product Time

Two of the three samples are identical determine the odd sample

No	Code No of samples	Code No of odd sample
1		
2		
3		
4		

(S gnature)

APPENDIX 2

SPECIMEN EVALUATION CARD FOR COMPOSITE SCORING TEST

Name Date

Product Time

Assign scores for each sample for varous characteristics

Quality attributes	Maximum Score	Code No of Samples 1	2	3	4	5	6	7
Appearance	5							
Color	5							
Flavor	5							
Texture	5							
Taste	5							
Total Score	25							

Comments

(Signature)

ABSTRACT

Application of osmotic dehydration technique for the product development in banana (Musa (AAB group) Palayamkodan) was a study under taken to develop shelf stable dehydrated banana products using osmot c dehydration

Thirty six d fferent treatments viz sugar concentrations of 60° Brix 65° Brix and 70° Brix without heating and at there different temperatures 40° C 50° C and 60° C with an immersion time of 30 minutes 45 minutes and 60 minutes were applied

Weight loss moisture loss and drying time nutritional and chemical changes orgamoleptic qualities and changes during storage assessment of microbial contamination of the products and cost benefit of the prepared products were analysed

The weight loss of the fruits after initial dewatering showed that the amount of weight lost increased w th increase in sugar concentration temperature and immersion time the net weight loss of the dried banana products accounted to be 75 percent of the original weight Regarding the time taken for drying samples treated with 70° Brix required the least time for drying

Nutr tional and chemical analusis of the dried banana fruit showed only trace amount of Vitamin C

Acid ty level was h ghest in treatment $C T_3P_3$ The treatments with higher sugar concentrations had a lower level of acidity The lowest value for acidity was seen in treatment $C_3T_4P_3$ On storage the acidity of dried products were found to decline

Analysis of reducing sugar content of dried banana product showed the highest value for treatment $C_3T P_3$ and the lowest leve was seen n treatment C T P and C T P_2 The control sample had value lesser than any of the treated samples

The reducing sugar level of the dr ed banana products was found to increase w th storage The reduc ng sugar level of the control sample ncreased with storage but was always lesser than the values of the treated samples

The organoleptic qualities of the dehydrated banana products were assessed by sensory evaluat on the product w th 70° Br x 60° C and 60 m nutes immersion t me was found to be the best dur ng the n tial stages of storage The lowest score was obtained by two treatments w th 65 percent sugar concentration

The same treatment was found to rank f rst for all the four months of storage but there was a decrease n the value obtained The least value for the fourth month of analysis was scored by treatment C T_2P_3

The control sample had a very poor score compared to the treated samples

There was a gradual decl ne in the overall acceptabil ty during storage and showed incidences of m crobial attack

Cost benef t analys s showed that 250 gms of dried banana products can be prepared at cost of 17 50/ 1/4 kg wh ch s h ghly acceptable and can be recommeded for consumpt on