DEVELOPING PARTIALLY DEHYDRATED PINEAPPLE PRODUCTS USING SOLAR DRIER

by

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THESIS
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DECLARATION

I hereby declare that this thesis entitled "Developing partially dehydrated pineapple products using solar drier" is a bonafide record of research work done by me during the course of research and that the thesis 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.

Vellayani
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CERTIFICATE

Certified that the thesis entitled "Developing partially dehydrated pineapple products using solar drier " is a record of research work done independently by Miss. ***Riji Hari*** *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

INTRODUCTION

India annually produces about fifty-four million tonnes of fruits and vegetables valued at about Rs. 10,000/- crores and is one of the largest producers of fruits and vegetables in the world (Food Industry, 1993). According to Sharma and Paul (1992) India's production of fruits alone is accounted to be 28 Million tonnes. Though our country is endowed with vast potential for development of its fruit processing industries, the growth has not been encouraging.

Kumbhar (1994) estimated that hardly 0.3 percent of our produce are utilised by the food processing industries. It compares dismally with developed countries where processing and preservation of fruits and vegetables is as high as 30 to 40 percent of their total production. Nearly 30 to 35 percent of the total production of fruits and vegetables worth Rs. 3,000/- crores are allowed to perish for want of post harvest facilities thus depriving the farmers the fruit of their labour (CFTRI, 1992). The reasons traced for the above situation are lack of right management techniques, technologies, market information, processing machinery, storage systems as well as poor quality seed strains. In this situation there is an urgent need to exploit our fruit wealth, to the maximum extent possible.

Among the various fruit crops cultivated in our country, pineapple has become one of the most important commercial fruit crop (Sen et al. 1980). The total production of pineapple in Kerala during 1991-92 has been estimated at 47241 tonnes with an area of 4870 hectares (Farm Guide, 1993). Poor marketing facilities, unsteady market price, high cost of production of pineapple products and non availability of latest technologies for processing are some of the problems faced by this fruit sector. Not only in the industrial sector but also from the nutritional point of view this fruit needs much attention. This fruit is good source of vitamin A and B and is rich in vitamin C ,Calcium. In addition it contains phosphorous, iron and an enzyme bromelin (Pawar et al., 1985).

One of the simplest and widely practiced technology for processing fruits and vegetables is drying. Sun drying is an age old method used for preserving food and is still in use in many parts of our country and in the world (Goyal and Mathew, 1990). The drying or dehydration is carried out mainly to ensure the quantitative loss due to bacterial and fungal attack; to prevent deterioration caused by its own enzymes and to stabilize nutrient contents as such in the processed foods (Maini et al., 1985). This method of preserving the food is also of strategic importance in meeting the defence needs over other methods due to its inherent logistic advantages and less energy and capital costs (Singh, 1985).

Solar drying, among various dehydration methods is rather a recent innovation for better quality and faster drying of foods. According to Kumar and Palaniappan (1994) drying can be done more efficiently with the proper utilization of solar energy. Solar drying ensures compact design, high quality, high thermal efficiency and low running and operation cost.

In this context, the present study is proposed to develop partially dehydrated pineapple products using solar drier and to draw a comparison with conventionally dried pineapple products with respect to nutritional, organoleptic and shelf life qualities.

Review of literature

REVIEW OF LITERATURE

The study entitled "Developing partially dehydrated pineapple products using solar dryer" was reviewed under the following subtitles:

2.1 Pineapple - its profile and scope.

2.2 Profile of the processed foods.

2.3 Drying as a method of food preservation.

2.4 Effect of pretreatments on dried products.

2.5 Organoleptic, shelflife and nutritional qualities of processed products

2.1 Pineapple - its profile and scope

Pineapple is one of the major fruit crops produced in kerala and has gained momentum as a commercial fruit (Krawger et al., 1992). Reports from Directorate of Agriculture , Thiruvananthapuram (1985) revealed that the major pineapple producing states are West Bengal, Assam, Megalaya, Manipur, Karnataka and kerala. However the productivity of pineapple in kerala is one of the lowest in the country (Processed Food Export Promotion Council, 1985). The total production of pineapple in kerala during 91-92 has been estimated to be 472441 tonnes with a highest production of 12613 tonnes in Eranakulam District followed by kannur (8546 tonnes) and Kottayam (6624 tonnes) (Farm Guide, 1994). Pineapple is cultivated in Kerala in a total area of 4870 hectares, the highest being in Ernakulam district (1443 hectares) followed by Kannur (879 hectares) and Kottayam (717 hectares).

Pineapple is a good source of vitamins and minerals. Norman (1986) reported that pineapple is a fair source of vitamin C which in turn is necessary for the normal formation of the protein collagen, and also favours the absorption of Iron. Bhalerao et al., (1989) revealed that bromelin is the enzyme present in pineapple which ensures good digestion of food in the alimentary canal. Fresh pineapple juice contains 11.2 to 16.2 g of total soluble solids per 100 ml; acidity, 0.46 to 1.21 g (as citric acid/100 ml); fructose, 1.72 to 4.75 g; glucose, 1.21 to 4.52g and sucrose, 2.47 to 9.73 g/100 ml (Krawger et al., 1992). Sahni et al., (1994) observed that fresh pineapple friut contains 9.0° Brix total soluble solids, 3.65 pH, 0.9 percent acidity (as citric acid), 18.72 mg of vitamin C /100g of pineapple fruit and 10.0° Brix/ Acid Ratio.

Kader *et al*., (1993) opined that the fruit and vegetable processing industries could play an important role in salvaging the wastage, utilizing 'cull' and subgrade fruits, stabilising prices during glut season, generating employment opportunities, meeting the requirements of defence forces in border areas and earning foreign exchange for the country by development of Exports. In a publication of Directorate of Extension of Kerala Agricultural University (1993) it has been reported that one hectare of pineapple could create employment potential of 1,200 man days and a value addition of 17,20,000/-, which in turn clearly illustrated the scope of post harvest technology in generating employment and income.

2.2 Profile of the processed foods

Fruits and vegetable processing can be defined as treatments between harvest to consumption which include handling, transportation, refrigeration, bleaching, freezing, canning, holding, washing, trimming, drying, irradiation, chemical preservation, packaging, storage and cooking. Mathur (1993) pointed out that during the last one decade there was a substantial progress in the quality and quantity of the products produced by Indian Food Industries and it was mainly due to many indegenous development in the feild of food technology. Herald (1992) reported that though processed convenient foods has been found attractive, consumers were choosy about health, taste and price of the products. Das et al., (1989) were of the opinion that the processed foods relevant to Indian context should be marketed in a manner that would benefit the consumer, the farmer and the society.

Singh (1980) revealed that pineapple and peaches were the two fruits which were commercially more important as preserved fruits than in their fresh form. In a report of Directorate of Agriculture, Thiruvananthapuram (1985) indicated that kew was the most important variety of pineapple which can be utilized for processing purposes. Department of statistics and Economics, Thiruvananthapuram (1985) reported that Annual world consumption of canned pineapple is 7,50,000 to 8,20,000 tonnes.

Processed Foods Export Promotion Council (1985) pointed out an annual production of 6000 tonnes of pineapple products mainly the slices/ titbits, in India and the USSR has been the major market for those products from India. Mahadeviah (1988) found out that organic acid, gum, sucrose and molasses could be formed from the processing waste of pineapple. Ananthakrishnan et al., (1989) observed that vinegar, sugar syrups and alcohol could be prepared from processing waste of pineapple. In India, the processed food exports have gone up hundred percent to reach 3,457 crores in 1992-93 and the export oriented units were expected to take the figure upto Rs. 7,000 crores per annum by the end of eighth Five Year Plan (Data Bank of Indian Food Industry, 1993). Indian Food technology is built up around the four major requirements of which the first one is to ensure availability of perishable products for a longer period and the second to make food available during the period of scarcity , thirdly to preserve fruits and vegetables in sugar syrups and lastly to make a large variety of unfermented and fermented beverages (Shaw, 1993).

Bhatnagar and Srivastava (1961) found that the reasons for the high cost of production of pineapple products were unsuitable methods of cultivation resulting in low yeild, short season, varying size and shape of the fruit resulting in high cannery waste. According to Action plan for promoting Exports from Kerala (1984), the introduction of latest technology in canning and marketing had given up a boost to the pineapple canning industries in Kerala. They also had stressed the need for setting up of a FPO office, introduction to better varieties of pineapple and to strengthen the existing pineapple processing units in the state.

2.3 Drying as a method of food preservation

2.3.a Open sun drying

Drying is an age old method for preserving and processing of foods (Maeda and Salunkhe,1973). They further pointed out that drying played a vital role in processing mango, sapota, pineapple, papaya, banana, ber, pear, cardomom, chilly and pepper. The main purpose of drying is to reduce the moisture content of the foods, moisture being the main cause for the spoilage of different types of foods (Mathur,1982). Maini et al., (1982) reported that more fruits were preserved by drying than by any other methods as they had major advantages like greater concentration in dried form, cheaper to produce with minimal labour, processing equipment, storage and distribution cost. Malathi et al., (1986) observed that conventional drying consumed a lot of time besides being unhygienic. Bhatnagar (1989) pointed out that traditionally food products were dried under sun by spreading directly on Kacha floor or cement floor.

Mathew (1989) had the opinion that there was a significant destruction of ascorbic acid and total carotene in leafy vegetables dried in open sun and improvement in their retention when dried in shade. Open sun drying and shade drying are the most common and time consuming drying methods (Goyal and Mathew, 1990). Jayaraman et al., (1991) revealed that prolonged drying of fruits prevent all the undesirable microbial spoilage. They further pointed out that sundrying was mainly confined to fruits, due to their high acidity and sugar content than vegetables. According to Torregian (1993) the osmotic dehydration of fruits and vegetables would improve the nutritional, sensorial and functional properties of the products than any other method of dehydration. Singaravelu and Arumugam (1993) showed that several kind of food materials could be dried under the sun for the purpose of preserving and processing.

2.3.b Solar drying

Berry _et al_., (1981) and Gupta and Nath (1984) reported that the solar drying of different vegetables required lesser time as compared to open sun drying. Singh and Kaur (1981) found that the dehydrated cauliflower products retained colour and flavour as fresh. Singh and Alum (1981) indicated that solar cabinet dryer is a low cost device in which chillie can be dried rapidly than in the open-sun. They further pointed out that subsequent loss of quality and total spoilage were also found to be reduced in the solar cabinet drier. Orejana and Embuseado (1984) revealed that drying rate,microbial safety and sensory qualities were in favour of solar dried fish and shellfish products. Malathi _et al_., (1986) opined that since solar drier consumed only less time besides being hygienic, it could be advocated for drying purposes. They further reported that the weight reduction of papaya sheet dried in solar dried was at the rate of 25.32 g per hour. Pawar _et al_., (1988) found that though the drying rate of onion flakes was fastest in the mechanical cabinet drier than in the solar driers, the complete prevention of pink discolouration was achieved only in solar drier and the sensory evaluation for colour, texture and overall acceptability received maximum score for the samples dried in solar drier.

Singh *et al.*, (1989) pointed out that the simple and less expensive solar drying systems could be used for perishables in different parts of the country. Dayal (1989) indicated that use of solar energy for drying offer advantages like better quality of the products, less pollution and freedom from unreliable supply of oil, electricity and coal. Solar driers had reduced the drying time considerably besides making significant improvement in the quality of dried product (Mathur *et al.*, 1989). Bhatnagar (1989) reported that several solar drying techniques and equipment had been developed for drying various food products and the quality of dried products depend upon the materials and conditions used for drying. Satbeer (1989) indicated that there was 50-75 percent reduction in the drying time of leafy vegetables in the solar drier as compared to open sun. The total loss of moisture was also found to be more rapid in solar drier. Retention of ascorbic acid was more and the solar dried vegetables scored better in organoleptic qualities than that of sun dried vegetables. He was of the opinion that the solar drier is an efficient and effective equipment for obtaining better quality dried products. Mathew et al., (1989) revealed that in a solar drier the product could be dried under better hygienic condition and it also guaranteed rapid drying with accountable retention of nutrients in food products.

Goyal and Mathew (1989) found that solar drier was the best for faster removal of moisture and greater retention of nutrients in peas. Ramana et al., (1991) indicated that the mustard leaves and the fenugreek leaves dried in solar drier showed lesser changes in the chlorophyll content and scored better for colour attributes as compared to open-sun dried. Mahajan et al., (1993) investigated that the drying ratio in both solar drier and in open sun was same, but the quality of the dried product was observed to be the best with the solar drier followed by open sun and it was quite inferior in the conventional hot air drier. Efficiency of any drying method can be evaluated on the basis of retention of ascorbic acid, loss of moisture and time taken for drying (Mathur, 1989). According to Mathew and Satbeer (1989) Since our country is fortunate enough to have solar energy in abundance during greater part of the year, wide popularity for such devices should be given in the rural and tribal areas where there is non-availability of electrical and other forms of additional energy. Mahapatra (1990) reported that natural drying process had been made efficient by the introduction of solar technology. Goyal and Mathew (1990) showed that solar drying is a recent innovation for better quality and faster drying of food.

2.4. Effect of pretreatments on the dried products

2.4.a. Blanching

In order to improve the shelf life quality of processed products with respect to colour, taste, flavour and appearance it is essential to apply different pretreatments like blanching, sucrose dipping, sulphuring and acid dip prior to dehydration (Seow et al., 1991). Blanching is a partial pre-cooking treatment in which vegetables or fruits are usually heated in water or on live steam before processing and is often called as scalding (Anonymous 1993).

Hendel (1971) indicated that nearly half of the original amount of vitamin C present in raw material was lost during blanching of fruits and subsequent processing. Labuza (1973) reported that 10 to 50 percent loss of ascorbic acid was found in unblanched vegetables due to heat, light and oxidation. He further revealed that maximum retention of ascorbic acid was in the blanched samples. Bradley et al., (1975) reported that leaching of nutrients and loss of texture were the most common textural changes occurred in vegetables during conventional blanching prior to dehydration. Sistrunk (1975) investigated that steam blanching retains higher vitamin contents. Pawar et al., (1985) pointed out that blanching was an important pretreatment for drying and dehydration of fruits. He also has the opinion that blanching not only helped in accelerating drying process but also helped in maintaining the quality of the product during processing and storage. He further reported that blanched samples of pumpkin were found organoleptically more acceptable than unblanched. Blanching of vegetables reduces the development of flavour (Anonymous 1986). Kalara et al., (1987) found that blanching of carrots prior to dehydration not only imparted an attractive colour but also improved its organoleptic and keeping quality. Ramesh and Nath reported that blanching of cow pea in water prior to processing resulted in the production of good quality product. Khvedelidze et al., (1990) observed that steam blanching of the material increased both the nutritional value as well as storage life. Nath (1990) revealed that the colour and flavour of the processed product was adversely affected by steam blanching. Sivakumar et al., (1991) concluded that blanching of bitter gourd rings of one cm thickness in boiling water for two minutes inactivated all the enzymes present in the rings.

Babenya et al., (1991) reported that blanching of vegetables prior to the preparation of the products ensured total inactivation of the enzyme. He also pointed out that blanching improved the consistency of the reconstituted product. Azizi et al., (1992) indicated that over blanched food products were likely to have poor flavour. Ranganna (1992) observed that canned acid foods which had undergone blanching prior to canning kept better than the unblanched. Blanching of fruits and vegetables practised prior to freezing and drying process inactivated all the enzymes present in it (Rahman, 1992). Loss of ascorbic acid was maximum in unblanched dehydrated vegetables (anonymous, 1992). Sharma et al., (1993) reported that steam blanched apricot fruits dried faster than the sulfur fumigated or chemical dipped fruits. They also reported that the blanched samples of dried figs showed rapid drying rate. Azizi and Ranganna (1990) finalised that although blanching resulted in loss of water soluble vitamins, it aided in the retention of ascorbic acid during dehydration. Feher (1993) observed that blanching decreased the peroxidase activity in peas.

2.4.b Sucrose immersion

Mathew et al., (1961) indicated that the pineapple cubes and rings dipped in sugar syrup along with addition of vitamin C kept the product fresh for twelve months at zero degree Farehnheat. Srivastava et al., (1961) showed that it was good to thaw, the pineapple slices freezed in polyethylene bags, in sugar syrup, before use. Amin and Bhatia (1962) reported that there was an increase in the sugars during sun drying of banana due to activity of amylase or invertase found in banana. Thirumaran al., (1985) reported that papaya treated with 70 to 75° Brix gave an improvement in the colour, appearance and texture to the papaya candy. Kalara (1987) found that dehydrated carrots in five percent sugar solution have the minimum drying period. Kolekar et al., (1988) found that green bananas dipped in sucrose ester emulsion ripened slowly than the untreated bananas.

Thonta et al., (1988) reported that maximum total soluble solids was noticed in fig fruits treated with sugar than in sugar solution. But the organoleptic evaluation indicated that fruits dipped in sugar solution was better in quality than with dry sugar. Bhagirathi et al., (1992) observed that the long soaking of blanched beans and cauliflower in sugar solution was the main cause of high levels of survivors in dried foods. Jayaraman (1993) found that dipping of fruits and vegetables in 20 percent sucrose for one hour minimised shrinkage and protected the tissue from damage due to cell rupture and in dried cauliflower it reduced cooking time to five minutes compared to fourteen minutes for untreated material. He further observed that sucrose immersion also improved shelf stability from three to twelve months under ambient conditions.

2.4.c Sulfuring

Labuza (1973) opined that there was 10 to 50 percent loss of ascorbic acid in sulphited vegetables and after storage of three months, loss of ascorbic acid was maximum in control samples than in sulphited samples. Salunkhe et al., (1973) reported that sulphitation of vegetable prevent losses of carotenoids during storage. Singh (1981) showed that sulphited product of cauliflower was found to retain colour and flavour. Pawar et al., (1985) pointed out that sulphiting was an important pretreatment for drying and dehydration of fruits. They were also of the opinion that sulphitation helps in maintaining the quality of the product during processing and storage. They further indicated that sulphitation retards browning and retains colour and was more acceptable organoleptically than unsulphited. Kalara et al., (1985) finalised that dipping of water blanched potato cubes in one percent KMS before drying improved the colour of the product. Pawar (1988) observed that the time required for drying of sulphited samples was less than control. Sulphitation decreased browning during storage but a decline was more in vitamin C content. He also found that in sensory evaluation sulphited samples received the maximum score for the colour, texture and overall acceptability. Sethi (1991) opined that addition of sulphur dioxide in mango pulp helped in retention of carotenoid and flavour.

Pawar et al., (1992) revealed that the total and reducing sugars were higher in sulphited poona figs. Arthur et al., (1992) stated that addition of sulphiting agents were most widespread methodology used in the food and beverage industries for control by browning in shrimps potatoes, mushrooms, apples and other fruits and vegetables and as well as to stabilize the flavour and colour of wines. He further reported that sulphiting agents were also antimicrobial when used in sufficient concentrations. Benkhemmar et al., (1993) found out that addition of KMS while processing the grapes improved vitamin C, tartaric acid, flavour and sugar content of the processed grape products and also improved the shelf-life. Sharma et al., (1993) reported that sulphur fumigations during drying of apricots prevent discolouration. There was only a minimum browning in sulphur fumigated samples than sulphite-treated samples. Arumugam (1993) revealed that dipping of sapota fruit flesh in 600 ppm of potassium metabisulphate for a minute before drying improved the shelflife to 120 days from 30 to 40 days.

2.5 Organoleptic, shelflife and nutritional qualities of processed products

Shukla et al., (1992) pointed out that browning reaction was a major reason for colour change in fruits and possible impairment of flavour and nutritive value in dried products. Seow and Kahtani (1990) reported that partially dehydrated pomegranate fruits had higher pH, acidity and total soluble solids content and remained acceptable with regard to taste, texture, appearance and flavour at 20 ± 2°C upto three months and after the three months of storage fungal decay was found. Seow et al., (1991) found that properly processed fruit products kept well and remained acceptable for more than one year and organoleptically relished by judges. Singaravelu and Arumugam (1993) pointed out that dehydrated sapota fruit flakes attained better scores with respect to its taste, flavour, colour and appearance and fungal decay was noticed after fourty days of storage.

Akamine and Goo (1971) revealed that controlled atmospheric storage had no effect on the weight loss or on the decay of the pineapple fruits. They further indicated that oxygen levels below two percent is effective in extending the storage life of fresh pineapple fruits. Thirumaran and Seralathan (1990) reported that in packaged tomato concentrate during storage showed decrease in total soluble solids, pH and vitamin C while acidity showed increase. The decrease in pH was 4.9 percent, total soluble solids - 3.6 percent and vitamin C - 28.7 percent and the increase in acidity was 4.46 percent. Seow and Shanmugam (1991) investigated that processed jack fruit juice kept well for more than seventeen days at storage temperature of 30^{o} C. Rangarao (1994) showed that the shelf-life of processed products can be extended upto two years at a temperature of less than 30^{o} C.

Labuza (1973) found that there was a minimum loss of ascorbic acid in sun dried control samples of vegetables after the storage of three months. Salunkhe et al., (1973) reported that during the storage periods there was a lesser loss of carotenoids from the dehydrated vegetables. Jellinek (1985) observed that there was loss of ascorbic acid in the processed food products under the influence of atmospheric oxygen.

Pawar et al., (1988) showed that the dehydrated onion flakes exhibited a progressive decrease in ascorbic acid and increase in total reducing sugars during storage periods. Pruthi (1988) studied the role of vitamin C in the discolouration of processed products and has reported that there was ten to fifteen percent loss of ascorbic acid during the storage periods.

As per the above studies, it can be concluded that processing of fruits and vegetables is gaining much importance today. The studies also reveals that for the purpose of processing, utilization of non-conventional energy should be popularised as the cost of conventional energy is increasing enormously day-by-day.

Materials and Methods

MATERIALS AND METHODS

The study on "Developing partially dehydrated pineapple products using solar drier" was carried out for the purpose of analysing the following factors:

1. To analyse the partially dehydrated pineapple products under two methods of drying for its chemical, organoleptic and shelflife qualities.
2. To analyse the products stored in polypropylene covers for its microbial content and for the organoleptic changes.

3.1 Selection of Fruits:

Among various fruits cultivated in Kerala, pineapple was selected for this study inorder to overcome the following bottle necks.

1. Limitation for its utilization for processing due to:
    a. Short storage life.
    b. Inadequate transport facilities.
    c. Inconvenient size and shape of the fruit.
2. The edible portion of the fruit constitutes only 40 to 45 percent and therefore utilization of cannery waste is indicated to reduce the cost of

production.

3. The low production of pineapple products especially the processed pineapple slices. Reports from Directorate of Agriculture indicated that only 3295 M/Tonnes of pineapple slices were exported from India in 1984-85 with the value of Rs. 242/- lakhs (Processed Food Export Council,1987).

The required quantity of fruits were collected in bulk from the farm, college of Agriculture, Vellayani and from the local markets. The fruits were cut manually using knives and the cut pieces were subjected to six different treatments prior to dehydration. The pretreatments undertaken were water blanching, steam blanching, sulphuring and sucrose immersion in concentrations of 50^0 Brix and 70^0 Brix.

Table (1):- Pretreatments undertaken prior to drying.

SL: No:	Pretreatments	Solar drier	Open Sun
1	Water blanching	S_1T_1	S_2T_1
2	Steam blanching	S_1T_2	S_2T_2
3	Sulphuring	S_1T_3	S_2T_3
4	Sucrose immersion in 50^o Brix	S_1T_4	S_2T_4
5	Sucrose immersion in 70^o Brix	S_1T_5	S_2T_5
6	Without any pretreatments	S_1T_6	S_2T_6

SPREADED PINEAPPLE SLICES IN THE SOLAR DRIER.

PACKING OFF THE SOLAR DRIED PINEAPPLE SLICES.

3.2 Method of Drying.

As per the study, drying was carried out both in solar drier and in open sun in order to prove the efficiency and benefits of solar drier as reported by many food technicians and scientists [Singaravelu and Arumugam (1993); Pawar and Patil (1992); Singh and Alam (1981)].

For solar drying, a convection type solar drier was used for the study (Description of the solar drier and its figure is given in the appendix I).

The samples dried in solar drier required no attention and the samples were simply spread on all the three trays of the solar drier for dehydration. Mahapatra (1990) reported that natural drying process has been made efficient by the introduction of solar technology.

For the open sun drying, the samples were spread on an aluminium tray covered with a nylon net. Care and attention was required for open sun drying, inorder to prevent insect attack and to avoid flies. According to Goyal and Mathew (1990) open sun drying is one of the most common and time consuming drying method.

3.3 Pretreatments.

3.3.1 Water blanching:

Two kilogram of roundly cut pineapple slices of 2 cm width were taken and was put in the hot water at 97°C for two minutes. One kilogram of each of the treated pieces were dried both in solar drier and in open sun. Siva kumar et al., (1991) opined that blanching in boiling water for two minutes inactivated all the enzymes present in the food.

3.3.2 Steam blanching:

Two kilogram of fruit pieces was exposed to steam for two minutes and one Kilogram each was dried under two methods. Khvedelidze et al., (1990) had the opinion that steam blanching of the material increases both the nutritional value as well as the storage life.

3.3.3 Sulphuring:

Two kilogram of fruit pieces were exposed to sulphur fumes for thirty minutes. One kilogram each of the pieces were dried under two different methods. A total of sixty grams of sulphur was burned as a pretreatment for two kilogram of fruit pieces as recommended by Kalara (1985). Sharma (1993) reported that sulphur fumigated fruits had higher retention of sulphur dioxide , prevent the loss of ascorbic acid and inhibit browning during drying and subsequent storage than the sulphite-treated samples.

3.3.4 Immersion in 50 ^{0} Brix sucrose solution at 40 degree centigrade for thirty minutes:

Two kilogram of fruit pieces were immersed in sucrose solution of 50^{0} Brix at a temperature of 40^{0}C for thirty minutes. One kilogram each of fruit was dried both in solar drier and in open sun. Thirumaran et al., (1985) opined that papaya treated with 70 to 75^{0} Brix gave an improvement in the colour, appearance and texture to the papaya candy.

3.3.5. Immersion in 70 ^{0}Brix sucrose solution at 40 degree centrigrade for thirty minutes:

Two kilogram of fruit pieces were immeresed in 70^{0} Brix at a temperature of 40^{0}c for thirty minutes, and then dried under two different methods.

3.4. Without any pretreatments:

One kilogram each of the fruit pieces were subjected to two different methods of drying without undergoing any pretreatments and were used as the control sample for the comparison.

3.5 The main items of observations done on the dried pineapple products were:-

1. Time taken for drying.
2. Weight loss of the product.
3. Chemical and nutritional composition
4. Organoleptic qualities
5. Microbial contamination
6. Changes in the chemical and organoleptic qualities during storage
7. Cost benefit analysis

Comparative analysis was carried out with respect to the methods of drying and with respect to different treatments till an optimum moisture level is obtained.

Samples were drawn every month in duplicate for the analysis for various parameters:

3.5.1 Time taken for drying in solar drier and in open sun:

The time taken was recorded on the basis of the temperature, in terms of both degree centigrade and also the atmospheric relative humidity, and hours taken for drying.

3.5.2 Weight loss of the product:

Weight loss was determined by analysing the fresh weight before the dehydration and also after it had been dehydrated to the desired moisture level.

3.5.3 Chemical and nutritional qualities

Various chemical parameters and nutrients analysed are listed below:

3.5.3.a Acidity:

Acidity of each sample under different pretreatments was estimated by the procedure suggested by Ranganna (1986)

3.5.3.b Reducing sugar:

Reducing sugar was analysed in the products subjected to different treatments by the method suggested by Krishnaveni and Sadasivam (1984).

3.5.3.c Vitamin C:

Vitamin C content was determined in the various dehydrated samples by using the method suggested by Sadasivam et al., (1984)

3.5.4 Organoleptic qualities:

Each and every samples were assessed for organoleptic qualities inorder to find out the best product. Ten judges were selected as panel members. These judges were selected through the triangle test as suggested by Mahony (1985). The samples were tested for its overall acceptability by the sensory evaluation with the due emphasis on the attributes such as taste, flavour, appearance, texture and colour (score card is shown in appendix II). The scores assigned for each attribute ranged from 1 to 5 viz very good, good, fair, poor, and very poor. Scores for overall acceptability was obtained by determining the average mean score for each character.

3.5.5 Microbial contamination:

The products prepared were assessed for microbial contamination viz bacteria, fungus and yeast. For the detection, nutrient agar, potato dextrose agar and maltose extract were used respectively.

3.5.6 Changes in the chemical and organoleptic qualities during storage:

Changes in the chemical and organoleptic qualities were analysed at the end of each month.

3.5.7 Cost benefit analysis:

Cost benefit analysis was carried out based on the prices of different items needed for the preparation of the dehydrated products.

3.6 Statistical analysis of the data

All the above said observations were statistically analysed and two replications for each analysis were made. The CRD was used as the programme for the statistical analysis.

Result and Discussions

RESULTS AND DISCUSSIONS.

Results obtained for the study entitled "Developing partially dehydrated pineapple products using solar drier" were discussed under the following lines:

4.1. Assessment of chemical and nutritional qualities of the partially dehydrated pineapple products.

4.2. Assessment of organoleptic qualities of the products.

4.3. Assessment of the changes in the chemical, organoleptic and microbial contamination of the products during the storage periods.

4.4 Cost benefit analysis

4.1. Assessment of chemical and nutritional qualities of the partially dehydrated pineapple products.

Chemical and nutritional qualities of the partially dehydrated pineapple products were assessed with regard to its moisture content, weight loss, PH, acidity, reducing sugar and vitamin C.

4.1.a. Moisture and weight loss:

The total time taken for drying depend upon the temperature and the relative humidity. Relative humidity of air may be defined as its percentage of saturation with moisture vapour. Since air is the drying medium, the drier the air, the more rapid is the rate of drying. Dehydrated foods are hygroscopic and hence there is a tendency to absorb moisture from air, unless it is stored in air tight containers.

As per the table(2) when the temperature was 33.4^{0}C and the relative humidity 73 percent, the time taken to obtain desirable moisture level was thirty hours and when the temperature was 33.6^{0}c and the relative humidity is 79 percent, the time taken was twenty-eight hours. The temperature variation was only 0.2^{0}C whereas the relative humidity variation was more ie, six percent more at 33.6^{0}c (79 percent) than at 33.4^{0}C (73 percent). Hence the variation in drying period can be assessed to be due to the increase in relative humidity. Kordylas(1990) found out that the rate of drying depends on the relative humidity and size or thickness of the fruit or vegetable pieces.

Table(2). Effect of temperature, relative humidity and time taken on the moisture content and weight loss of the dehydrated products.

Treat-ments	Average Temper-ture(°C)	Relative humidity (%)	Time taken (hrs)	Moisture(%)		Initial wt(Kg)	Final wt(gm)	Wt loss (gm/kg)
				Fresh	Dried			
S_1T_1	33.4	73	30	85	9.05	1.0	200	800
S_1T_2	33.6	79	28	85	9.08	1.0	200	800
S_1T_3	33.4	73	30	85	8.95	1.0	199	801
S_1T_4	33.6	79	28	85	9.10	1.0	215	785
S_1T_5	33.6	79	28	85	9.10	1.0	215	785
S_1T_6	33.4	73	30	85	9.15	1.0	215	785
S_2T_1	33.4	73	30	85	9.04	1.0	200	800
S_2T_2	33.6	79	28	85	9.06	1.0	200	800
S_2T_3	33.4	73	30	85	8.92	1.0	198	802
S_2T_4	33.6	79	28	85	9.06	1.0	200	800
S_2T_5	33.6	79	28	85	9.06	1.0	200	800
S_2T_6	33.4	73	30	85	9.12	1.0	215	785

Key:

S_1 Solar Drying

S_2 Open Sun Drying

T_1 Water blanched

T_2 Steam blanched

T_3 Sulphuring

T_4 50° Brix sucrose immersed

T_5 70° Brix sucrose immersed

T_6 Control samples

From the table(2) it is clear that the variation in atmospheric temperature and relative humidity does not bring much difference in the moisture content and weight loss of the dehydrated products, but it influences the time taken for drying. Mudambi (1991) was of the opinion that temperature and relative humidity has less or negligible control on sun drying.

Garg and Ashok (1989) pointed out that the most important factor which determines the extent of deterioration in dried products during storage is the moisture content of the final product. According to Ali (1989) the moisture to be removed from a particular product is determined by initial moisture content of the product. Orejana et al., (1984) stressed the need for keeping the moisture level of the dried products below ten percent to ensure prolonged shelflife. Dayal (1989) found that the moisture content of dried fruits containing 60 to 90 percent initial weight reduced to 10 to 12 percent after dehydration. In the present study, moisture and weight loss of the prepared pineapple products was determined and is presented in Table (2).

The above table clearly depicts that drying methods did not bring significant changes in the moisture content and weight loss of the pineapple products. The moisture content of the dried samples under different treatments ranged between 8.92 and 9.15 with an average of 9.06. The water blanched sample after solar drying had the moisture content of 9.05 and the weight loss was 800 g/Kg whereas the water blanched sun dried sample were found to have a moisture content of 9.04 with a negligible difference of 0.01 percent and the weight loss was almost same.

The steam blanched solar dried product had a moisture content of 9.08 as against 9.06 for sun dried sample. Weight loss was found to be the same for the products dried under the two methods.

The sulphured solar dried samples were found to have 8.95 percent of moisture while products after sun drying possessed 8.92 percent moisture and the difference was only 0.3 percent. The weight loss was found to be slightly higher in sun drying (802 g) than in solar drying(801 g).

The 50^0Brix sucrose immersed solar dried samples had the moisture content of 9.1 which was more than 0.04 percent than that of sun dried samples (9.06) of the same treatment. Weight loss was also higher in sundried samples than that of solar dried samples with a weight loss of 785 g/Kg and the difference being 5g/Kg.

Similar trend was observed in moisture content when they were immersed in 70^0 Brix sucrose solution before drying. However a slight difference in the moisture level was observed with respect to drying method, the difference being 0.4 percent.

The average moisture content of solar dried and sun dried products was found to be 9.15 percent and 9.12 percent respectively with a difference of 0.3 percent. But the weight loss was found to be the same for both the samples dried under different methods.

From the table it is clear that open sun dried pineapple samples had comparitively less moisture than that of solar dried samples. The difference in the weight loss of the products dried under two methods was found to be negligible. Drying ratio was not found to differ in solar drying and in open sun drying (Mahajan et al., 1993). Singaravelu and Arumugam (1993) had also supported the above finding. From the above findings it can be concluded that moisture content as well as the weight loss of pineapple products dried under different methods was negligible.

4.1.b. Assessment of pH, acidity, reducing sugar and vitamin C content in fresh and partially dehydrated pineapple products:

Sen et al., (1980) reported that fresh pineapple fruit contains moisture 8.5 percent ; sugar 13 percent; protein 0.6 percent; mineral matter 0.05 percent; phosphorous 0.01 percent; calcium 0.02 percent., fiber 0.3 percent., iron 0.9 percent., acids 0.6 percent., vitamin A (carotene per 100g) 60 IU; riboflavin (per 100g) 120 mg and vitamin C (per 100g) 63 mg.

PH, acidity, reducing sugar and vitamin C content in fresh and partially dehydrated pineapple products were determined and the results are presented in Table(3).

According to Krawger et al., (1992) chemical constituents present in fresh pineapple juice include total soluble solids 11.2 to 16.2 g/ 100 ml; acidity 0.46 to 1.21 g/ 100 ml citric acid; fructose 1.72 to 4.75 g/ 100 ml; glucose 1.21 to 4.52 g/ 100 ml and sucrose 2.47 to 9.73 g/ 100 ml.

Table 3. Chemical parameters and vitamin C content of solar dried and sun dried products in comparison with fresh pineapple.

Nutrient Contents	Fresh pineapple	Dried pineapple	
		Solar dried	Sun dried
pH	3.6	3.78	3.78
Acidity (gm per 100gm)	1.18	*1.16	*1.14
Reducing sugar (gm per 100 gm)	1.80	*1.59	*1.48
Vitamin C (mg /100 g)	32.0	0.4	0.4

* Mean value of all treatments.

As per the table(3) it was found that in fresh pineapple the vitamin C was 32 g/ 100 g of pineapple. Whereas in dried product, the vitamin C was reduced to 0.4 g/ 100g. Mathew (1989) pointed out that there was a significant destruction of ascorbic acid in the sun dried vegetable products than in the products dried in the shade. In the present study the pineapple fruit was found to have 1.8 g of reducing sugar, 1.18 percent of acidity with a pH of 3.6 while 100 g of dried pineapple product had 1.48 to 1.59 g reducing sugar, 1.14 percent to 1.16 percent acidity with a pH of 3.78. Increase in pH in the dried products was reported by Torregian (1993), Bawa et al., (1987) and Paul (1986).

4.2. Assessment of the organoleptic Qualities of the product:

Assessment of the organoleptic qualities was done mainly to draw conclusions about a particular food from a large population through the selection of a limited number of panel members. Organoleptic assessment of the dehydrated products is of much importance since they constitute a major group of our export potential. According to Mahony(1985) the organoleptically assessed samples formed a true representative of the products developed and organoleptic assessment stands essential for the further development of the products. Through sensory evaluation tests, the judges can investigate changes in acid content or even sugar content in food products and the changes in sensory characteristics of food in turn will provide clues about physical characteristics also.

Table (4) depicts the mean score obtained for different quality attributes and for the overall acceptability of the products prepared under different drying methods.

According to Rolls et al; (1981) in the various quality attribute tests, the first preference goes to the taste followed by flavour, appearance, texture and colour. Among the different samples prepared under two drying methods, the sulphured and 50^0 Brix sucrose immersed solar dried samples had got the highest meanscores of 4.9 each for taste as against 4.05 and 3.6 respectively for sun dried samples. Next to sulphured sample, the 70^0 Brix sucrose immersed sample and the control sample from solar drying scored 4.8 for taste. In the case of sucrose immersed samples, the 50^0 Brix sucrose immersed solar dried sample attained better score (4.9) than that from sun dried 50^0 Brix (3.6) and sun dried 70^0 Brix sucrose immersed pineapple products (4.7).

The water blanched samples prepared under solar drying and sun drying obtained scores of 4.7 and 4.1

respectively. Least scores were obtained by the steam blanched (3.7) and 50^0 Brix sucrose immersed (3.6) sun dried samples. Same treatments from solar drying showed better scores as 4.3 and 4.9 respectively.

Table (4). Quality attribute scores obtained by the pineapple products dried under two methods

SL: No:	Treat-ments	Quality Attributes					Over all accepta-bility
		Taste	Flavour	Appearance	Texture	Colour	
1	S_1T_1	4.7	5.0	4.5	4.8	4.9	4.81
2	S_1T_2	4.3	3.9	3.9	4.3	4.03	4.01
3	S_1T_3	4.9	5.0	5.01	4.9	5.0	5.01
4	S_1T_4	4.9	4.05	4.3	4.8	4.4	4.5
5	S_1T_5	4.8	4.92	5.01	4.8	5.0	4.91
6	S_1T_6	4.8	4.1	4.13	4.5	4.23	4.30
7	S_2T_1	4.1	4.6	4.3	4.8	4.5	4.51
8	S_2T_2	3.7	3.9	4.02	4.8	3.5	4.0
9	S_2T_3	4.05	4.6	4.4	4.7	4.7	4.51
10	S_2T_4	3.6	3.9	3.73	4.23	3.6	3.8
11	S_2T_5	4.7	5.0	4.32	4.98	4.73	4.71
12	S_2T_6	4.5	4.0	4.12	4.83	4.9	4.3

Flavour is the unique character of odour and taste. According to Rolls et al., (1981) flavour is the quality attribute which stands next to taste. Ranganna (1986) stated that flavour is an important factor which enriches the consumer's preference to a particular product. Flavour can also be produced artificially with the help of some synthetic materials. As per the table(4), the scores obtained for flavour for all the pretreated samples under solar drying, except the 70^0 Brix sucrose immersed sample (4.92), were found to be better than that of the open-sun dried samples. The 70^0 Brix sucrose immersed sun dried sample had a score of 5.0. The solar dried water blanched sample (5.0); solar dried steam blanched sample (4.6); the sulphured sample (5.0); 50^0 Brix sucrose immersed sample (4.05) and the solar dried control sample (4.1) scored better than that of sun dried water blanched sample (4.6); sun dried steam blanched (3.9); sun dried sulphur sample (4.6); 50^{0}Brix sucrose immersed sample (3.9) and the sun dried control sample with the score of 4.0.

Next to the flavour comes the appearance of the processed product. As the consumers preference to appearance is one of the major factor leading to the increasing demand of the product, it is very essential to keep the appearance of the product quite attractive (Christensen, 1985). Shrivelling and colour change are the two main factors usually occurs in the processed products which affects the appearance of the product (CFTRI Reports, 1991). Table (4) elucidates that the sulphured solar dried (5.0) and 70^0 Brix sucrose immersed solar dried samples (5.0) had attained the highest score as against 4.4 and 4.32 in sun dried pineapple samples. Only the steam blanched sample from sun drying showed better score (4.02) than that of solar dried (3.9) samples. In general, all other solar dried samples scored better ranks with a score of 4.5, 4.3 and 4.13 respectively for water blanched, 50^0 Brix sucrose immersed and control samples.

According to Ranganna (1991) texture is the property of food which is associated with the sense of feel or touch experienced by the fingers or the mouth. The texture of the processed products depends upon the nature of the fruits used and also on the different types of pretreatments applied (Maga and Schutz, 1973). However the texture of the product may not be noticed unless the container had been unsealed and this in turn may be the reason that it had been placed only after taste, flavour and appearance. In texture, the solar dried steam blanched (4.3) and solar dried 70^{0} Brix sucrose immersed samples (4.8) were found to have a comparatively lesser score than that of sun dried steam blanched (4.8) and sun dried 70^{0} Brix sucrose immersed samples (4.9). All the other solar dried pineapple samples -water blanched(4.8), sulphured (4.9), 50^{0} Brix sucrose immersed (4.8) and control samples (4.5) were found to have better scores than sun dried water blanched (4.8), sulphured (4.7), 50^{0} Brix sucrose immersed (4.23) and control samples (4.83).

Colour is associated with every aspect of our lives and influences many of our day-to-day decisions, involving food. According to the reports from CFTRI (1990), the aesthetics, safety, sensory characteristics and acceptability of food are all affected by colour. The joint FAO/WHO Expert committee on food additives recognised that colour has an effect on food choices (Anonymous, 1991). Clydesdale (1984) found that colour affect the preparation of the sensory characteristics such as sweetness, salt and flavour. However the magnitude of its role will depend on its total contribution to food quality. According to table (4), in the colour attribute tests, all the solar dried samples given the treatments viz water blanching (4.9), steam blanching (4.03), sulphuration (5.0), 50 ^{0} Brix sucrose immersion (4.4) and 70^0 Brix sucrose immersion (5.0) scored better.

According to Kordylas (1990) the overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of a food and its palatability or sensory quality. The absence of nutritional qualities and the presence of harmful or toxic ingredients are parameters which are of vital interest to the consumer. After analysing each quality attributes, the scores of overall acceptability was determined for each of the treated samples.

As per table (4), the overall acceptability scores of the dehydrated products ranged between 3.8 to 5.0. The highest score was attained by the solar dried sulphured sample and solar dried 70^0 Brix sucrose immersed sample as 5.0 and 4.9 respectively. Samples applied the same treatment from sun drying had a score of 4.5 and 4.7 which were lesser than the scores of solar dried samples. The water blanched solar dried sample had a score of 4.8

and was higher than the water blanched sun dried samples (4.5). Next to this stands solar dried 50^0 Brix sucrose immersed with a score of 4.5 as against 3.8 for the sun dried samples. The control sample from both drying methods had an equal score of 4.3. The steam blanched sample in the solar drying had a score of 4.1 as against 4.0 in open sun drying.

In general, all the solar dried samples obtained better scores than that of sun dried samples and the least score of 3.8 was obtained by the sun dried 50^0 Brix sucrose immersed sample than that of sun dried water blanched (4.5), steam blanched (3.5), sulphured (4.7), 50^0 Brix sucrose immersed (3.6) and 70^0 Brix sucrose immersed (4.73) dried pineapple samples. The exception is for the control sample in which the sun dried sample appeared to be better (4.73) than that of solar dried control sample (4.23). From the above, it is clear that in most of the quality attribute tests, the solar dried samples showed better scores than the sun dried samples. Similar results were obtained by Rai (1990), Goyal and Mathew (1990) and Maharajan et al., (1993).

Among the various pretreatments applied it is necessary to find out which one of the pretreatments is best to apply prior to dehydration. For this, the comparison of CD values to the mean scores obtained for four months of storage periods with regard to the various pretreatments and quality attributes was done and the results are presented in the table(5).

As indicated in table(5) there was a significant difference in taste between the differently treated dried pineapple products. Comparison with CD values showed that only the sulphured and control samples did not differ significantly. All the other samples - water blanched, steam blanched and 50^{0} Brix sucrose immersed samples showed a significant difference between each other. In the case of sucrose immersed samples, both the 50^{0} Brix and 70^{0} Brix sucrose immersed samples attained an equal score of 4.5.

In flavour, sucrose immersed samples under different drying methods obtained an equal score (4.4). The steam blanched and control samples had also shared the same score (4.5). The highest score was obtained for the sulphured samples whereas the least score was obtained by the water blanched samples.

Table (5). Effect of pretreatments on quality attributes of the pineapple products

SL: No:	Treatments	Taste	Flavour	Appearance	Texture	Colour
1	Water-blanching	3.3	4.1	4.6	4.7	4.1
2	Steam-blanching	4.6	4.5	4.8	4.8	4.8
3	Sulphuring	4.9	4.6	5.0	4.8	5.0
4	50^{o} Brix Sucrose immersed	4.5	4.4	3.7	4.6	4.1
5	70^{o} Brix Sucrose immersed	4.5	4.4	3.6	4.6	4.1
6	Control	4.8	4.5	4.2	4.7	4.3
	CD values	0.28	0.23	0.22	0.27	0.25

In appearance, almost all dried pineapple products showed a significant difference. Here also sulphured samples showed the highest score (5.0) and least score was attained by the 70^{O} Brix sucrose immersed samples. All the samples except the sucrose immersed samples had significant difference in their scores when compared to the CD values. Eventhough the sucrose immersed samples did not differ significantly, in appearance, no two treatments share an equal score.

In texture, every two differently treated dried pineapple samples attained equal score. The water blanched and control samples; steam blanched and sulphured samples which had the highest value of 4.8; and the 50^{0} Brix and 70^{0} Brix sucrose immersed samples shared equal scores. There is no significant difference between the samples because the difference between the treatments did not exceed the CD value.

In colour, three samples- water blanched, 50^{0} Brix and 70^{0}Brix sucrose immersed samples obtained the score of 4.1 which in turn proved that there is no significant difference between these samples in colour attribute. The sulphured samples scored 5.0 and was the highest. Next to sulphured samples, stood the steam blanched samples and the difference between them was negligible. But these samples differ significantly from all the other samples.

From the above findings it is clear that the sulphur fumigated samples scored highest with regard to different quality attribute tests. Several scientists Pawar et al., (1992); Benkhemmar et al.,(1993) and Arthur et al.,(1992) had supported this. Sharma et al., (1993) reported that sulphur fumigated dried products scored higher in their organoleptic qualities.

4.3 Assessment of the changes in the Chemical, oraganoleptic and shelflife qualities of the partially dehydrated pineapple products (ANOVA table for various parameters are given in appendix IV).

4.3.1 Changes in the acidic content of dried pineapple products during storage.

The acidic content of the dried pineapple products was measured with regard to the total content of citric acid in the product as suggested by Ranganna (1991). He opined that the Brix- acid ratio is one of the principal indices of quality of processed pineapple products and the juice having an acidity exceeding 1.0 percent is considered tart to taste. According to Mahony (1986) change in the acidic content produces sourness in the stored product. The growth of micro organisms is also affected by acidity. The high acid foods like fruits are therefore naturally resistant to micro organisms (Kordylas, 1990).

The details presented in the Table (6) showed that the acidic content of the pineapple products undergone different pretreatments, ranged between 0.85 and 1.16.

The water blanched samples from open sun drying showed an acidic content of 0.88 g/ 100ml of pineapple during the first month whereas the samples from solar drying showed an acidic content of 0.9. But during the second month, the samples from both the drying method showed a slight decrease of 0.1 gm in acidity and the samples from the open sun drying retained the acidic content as same for the rest two months. But the solar dried samples showed a gradual and uniform degradation in acidity of 0.1 every month.

The steam-blanched samples from sun drying had an acidic content of 0.96 in the first month of storage while those from solar drying had an acidic content of 0.97. The open sun dried and solar dried samples showed a decrease in acidity of 0.1 during the second month of which the sun dried samples reduced to 0.93 during the third and fourth month. The solar dried steam blanched samples retained the same value in the third month and showed a reduction of 0.1 in the fourth and last month of storage.

The samples from both open sun drying and solar drying which had undergone sulphuring as pretreatment showed a decrease in the acidic content.

The sun dried samples had an acidic content of 1.13 which was decreased to 1.12 during the second,third and fourth month while the solar dried samples showed a greater acidic value of 1.15 during the first month which reduced uniformly in the second and third month with a reduction of 0.1 each and retained the same value in the fourth month.

The sucrose immersed samples (50^{0} Brix) from open sun drying and solar drying showed an acidic content of 1.0 and 1.03 respectively of which the sun dried retained the same value as 0.99 in the second, third and fourth month while solar dried sample showed a decrease of 0.1 during second month and retained it in the third month. During the fourth month, acidity reduced to 1.01.

Table (6): Acidity of dehydrated Pineapple products at various storage periods.

SL: No:	Treatments	Storage periods			
		1st month	2nd month	3rd month	4th month
1	S_1T_1	0.9	0.88	0.87	0.86
2	S_1T_2	0.97	0.96	0.96	0.95
3	S_1T_3	1.15	1.13	1.12	1.12
4	S_1T_4	1.03	1.02	1.02	1.01
5	S_1T_5	1.01	0.99	0.99	0.99
6	S_1T_6	1.16	1.15	1.14	1.14
7	S_2T_1	0.88	0.87	0.87	0.87
8	S_2T_2	0.96	0.95	0.93	0.93
9	S_2T_3	1.13	1.12	1.12	1.12
10	S_2T_4	1.0	0.99	0.99	0.99
11	S_2T_5	1.0	0.99	0.99	0.99
12	S_2T_6	1.14	1.14	1.13	1.13

The 70^0 Brix sucrose immersed sun dried sample had the same acidic content as that of 50^0 Brix sample as 1.0, 0.99, 0.99, 0.99 during the first, second, third and fourth month respectively. The solar dried sample of

70^{0}Brix sucrose immersed also had the same value as that of the open sun drying for all the three months of storage except in the first month which showed an increase of 0.01 per 100 ml.

The acidic content of sun dried control sample was 1.14 while those of solar dried was 1.16. Samples from both drying methods showed a decrease of 0.1 in the second and third month after which the samples retained the acidity during fourth month.

Among the different pretreated samples sulphured samples from solar drying were found to have the highest acidic content and it was also found that none of the samples showed a marked degradation in the acidic content during the various storage periods. Thirumaran and Seralathan (1990) reported that there was 4.46 percent increase in acidity in packaged tomato concentrate during storage. Singh et al., (1983) showed that there was a decrease in acidity during the storage periods of Guava cheese at room temperature.

As per the Table(7) which depicts comparison between the various pretreatments with regard to its acidic content. As seen from the table, it is observed that there was significant difference between the treatments.

Table (7). Effect of pretreatments on the acidic content of dehydrated pineapple products

SL: No:	Treatments	Acidity (mean value)
1.	Water blanched	0.88
2.	Steam blanched	0.95
3.	Sulphured	1.13
4.	50^{o} Brix (Sucrose) immersed	1.0
5.	70^{o} Brix (Sucrose) immersed	0.99
6.	Control samples	1.14
	CD values	0.0556

When the mean acidic value was compared with the CD value it was found that there was significant difference between the sulphured samples and the sample immersed in 50^{0} Brix, 70^{0} Brix and control samples. Similarly there was significant difference in the acidic content in water blanched samples (0.88) when compared with that of steam blanched (0.95), sulphured(1.13), 50^0 Brix sucrose immersed (1.0), 70^0 Brix sucrose immersed (0.99) and also with that of control samples (1.14). The control samples also had significant differences, with respect to the acidic content, when compared with those of water blanched, steam blanched, 50^0 Brix immersed, and 70^0Brix immersed samples. The sulphured samples and the control samples were not significantly different. Similarly there was no significant difference among 50^0 Brix and 70^0 Brix immersed samples and steam blanched samples with regard to its acidic value.

Table(8): Effect of storage periods on the acidic content of partially dehydrated pineapple products

Storage period	Acidity (mean value)
1^{st} month	1.03
2^{nd} month	1.02
3^{rd} month	1.013
4^{th} month	1.010
CD values	0.0040

Effect of different storage periods on the acidic content indicated that (Table 8) there was significant difference in the acidic content of treated samples at various storage periods. ie, the storage period had an influence on the acidity of the stored products.

When compared with CD value, acidic content of products during second month was significantly different from each other and also differs between the second and third month. However no significant difference was observed between third and fourth months.

Table (9): Effect of drying methods on the acidity of pineapple products.

Drying Methods	Acidity (mean value)
Solar drying	1.024
Sun drying	1.011
CD values	0.03

Table (9) depicted that since the mean acidic value of the products under different method of drying did not exceed the CD value, there is no significant difference between the two drying methods with regard to the acidic content. So it can be concluded that method of drying doesn't influence the acidity of dried products.

4.3.2. Changes in the pH content of dried pineapple products during storage.

pH content did not show any significant difference upto three months and after which it showed a variation of 0.05. After drying there was an increase of pH from 3.6 in fresh to 3.78 in the dried ones. During storage of first three months, the pH remained the same and in the fourth month, a slight increase of 0.02 was noticed. Thus in the final month all the dried products showed a pH of 3.80. Torregian (1993) reported an increase in pH in the processed food during the storage period. Similar results were also reported by Ranganna (1987), Giridar Lal et al (1986), Siddappa et al., (1989) and Paul (1986). In contrast, Bawa et al., (1987) indicated that there was no significant difference in the pH of the processed products during the storage.

4.3.3 Assessment of the changes in the reducing sugar content of the processed products during storage periods.

Reducing sugar is abundant in fruits. Usually fructose and glucose are the two main reducing sugars found in fruits (siddappa,1987). During drying the amount of reducing sugars increases and therefore the quantity of reducing sugar is more in dehydrated foods (Das, 1986).

Table (10) Reducing sugar content of the dehydrated pineapple products at various storage periods.

SL: No:	Treatments	Reducing sugar content at various months			
		1st month	2nd month	3rd month	4th month
1	S_1T_1	1.36	1.36	1.38	1.39
2	S_1T_2	1.68	1.68	1.68	1.69
3	S_1T_3	1.58	1.58	1.59	1.59
4	S_1T_4	1.39	1.39	1.39	1.39
5	S_1T_5	1.68	1.68	1.69	1.69
6	S_1T_6	1.59	1.59	1.59	1.59
7	S_2T_1	1.46	1.46	1.46	1.48
8	S_2T_2	1.52	1.53	1.54	1.55
9	S_2T_3	1.47	1.47	1.47	1.48
10	S_2T_4	1.47	1.47	1.48	1.49
11	S_2T_5	1.54	1.55	1.55	1.56
12	S_2T_6	1.48	1.48	1.48	1.49

The reducing sugar content of the products prepared under different methods were determined and the results are presented in Table (10).

As indicated in table(10), the reducing sugar content of samples ranged between 1.36 to 1.69. The highest value of 1.69 was scored by the 70^{o} Brix sucrose immersed solar dried and the steam blanched solar dried samples. The samples subjected to the same treatment dried under sun had a value of 1.54 and 1.52 respectively. Next to it was the control and sulphured solar dried samples with a value of 1.59 and 1.58 whereas the samples dried under sun was found to have reducing sugar of 1.48 and 1.47 respectively. But in the case of 50^{0} Brix sucrose immersed samples, the open sun dried ones had reducing sugar content of 1.47 which was higher than the solar dried samples (1.39). The water blanched solar dried samples had the least reducing sugar content (1.36). The open sun dried samples were found to attain higher value (1.46) than the solar dried over with respect to reducing sugar content.

With regard to the reducing sugar content during storage it was found that, in general, all the samples from both solar drying and sun drying showed a slight increase. Most of the samples did not show any difference in the reducing sugar content upto three months. Increase in reducing sugar during storage was reported by many food technicians and scientists - Pawar et al., (1988)., Thirumaran et al., (1986) and Sethi (1985).

In the first month, the solar dried water blanched sample had a lesser score (1.36) when compared with sun dried sample which remained the same for the second month also. During third and fourth month, a slight increase of 0.02 and 0.03 was noticed and the values were 1.38 and 1.39 respectively. In the case of sun dried water blanched sample the values remained as 1.46 for three months and in the fourth month it was found to be 1.48. The solar dried steam blanched sample showed no difference with regard to its reducing sugar content(1.68) for first three months and an increase of 0.01 (1.69) in the fourth month, whereas the sun dried steam blanched sample showed a gradual increase throughout the storage periods as 1.52, 1.53, 1.54 and 1.55 for first, second, third and fourth months respectively.

In the case of solar dried sulphured sample, during first and second month, the value remained as 1.58 and in the third and fourth month, it was 1.59 with an increase of 0.01. The sun dried sulphured sample showed an increase of 0.01 only in the fourth month. The solar dried samples attained higher value than that of sun dried samples.

The solar dried 50^{0} Brix sucrose immersed sample showed no change in reducing sugar content (1.39) throughout the storage periods, whereas the sun dried sample showed an increase of 0.01 each during the third month (1.48) and fourth month (1.49). The sun dried samples had a higher score than the solar dried.

The solar dried 70^{0} Brix sucrose immersed sample showed a value of 1.68 in first and second month and 1.69 in third and fourth month for reducing sugar. The sun dried samples had a lesser value (1.54) and it kept on increasing as 1.55, 1.55 and 1.56 in the second, third and fourth month of storage periods respectively.

The control solar dried samples had a higher value (1.59) than that of sun dried samples and it remained as same throughout the storage periods of four months. The sun dried samples had a value of 1.48 during first, second and third months and an increase of 0.01 was found during the fourth month (1.49).

Table (11): Effect of pretreatments on the reducing sugar content of dehydrated pineapple products.

Treatments	Reducing sugar content (gm/100 ml)(mean value)
Water blanching	1.38
Steam blanching	1.47
Sulphuring	1.68
50^{o} Brix	1.54
70^{o} Brix	1.59
Control	1.47
CD value	0.022

The effect of pretreatments, drying methods and storage periods on the reducing sugar content of the prepared products were statistically analysed. As per the table (11), significant difference was noticed in reducing sugar content of samples with respect to different treatments applied. The mean values of six treatments when compared with the CD values and it was found that among various pretreatments applied, the sulphured samples showed the highest value (1.68) with respect to reducing sugar content than those of sucrose immersed samples. Next to it comes the samples undergone 70^0 Brix immersion (1.59) and the lowest value was observed in water blanched samples (1.38).

Table (12): Effect of storage periods on the reducing sugar content of pineapple products.

Storage periods	Average Reducing Sugar content
1st month	1.51
2nd month	1.51
3rd month	1.52
4th month	1.53
CD value	0.657

The table (12) revealed that there was a significant difference in the reducing sugar content with different storage periods. The samples were found to have higher reducing sugar content at the fourth month of storage (1.53) and the lowest in the first month (1.51). The table also revealed that there is a gradual increase in the reducing sugar content throughout the storage periods with 1.51 in the first and second month, 1.52 in the third month and 1.53 in the fourth month of storage. Pawar et al.., (1988) showed that the dehydrated onion flakes exhibited a progressive increase in total reducing sugar content during the storage periods. Singh and Mathur (1953), Thirumaran et al.., (1986) and Sethi (1985) had also noticed an increase in reducing sugar of the processed fruit products during the storage periods. Bawa et al.., (1987) indicated an increase in reducing sugar content in carrot juice during the storage periods at room temperature.

Table (13): Effect of drying method on the reducing sugar content of dehydrated pineapple products.

Drying methods	Average Reducing sugar content
Solar drying	1.51
Sun drying	1.52
CD value	0.012

The table (13) explains the effect of drying methods on the reducing sugar content. There is no significant difference in the reducing sugar with respect to the methods of drying. Samples from solar drying showed a mean value of 1.51 for reducing sugar as against 1.52 in sun drying. The difference in reducing sugar content did not exceed the CD value 0.012 indicating that the drying methods had no effect on the reducing sugar content. Amin and Bhatia (1962) reported that there was an increase in sugar during sun drying of banana due to activity of the enzyme amylase or invertase.

4.3.4 Assessment of the changes in the vitamin C content of the processed products during storage periods.

Vitamin C or ascorbic acid is essential for the normal functioning of our body. Cort et al.., (1975) reported that vitamin C protect essential fatty acids, essential amino acids, vitamin A, vitamin E, thiamine and folic acid. It also makes iron more available. Pineapple contains 30 to 65 mg of vitamin C per 100 gm of the fruit.

After drying under solar drier and open sun, there was a deep distruction of vitamin C from 32 mg/100g in fresh pineapple to 0.4 mg per 100g in dehydrated pineapple. Vitamin C had remained as 0.4 mg throughout the storage period. Destruction of vitamin C during processing was reported by several scientists like Mathew(1989), Robert and Endel (1977) and Das and Jain(1986). However Benkhemmar et al., (1993) found that properly processed grapes had retained vitamin C content during the storage period upto 3 to 4 months.

4.3.5 Assessment of the changes in the organoleptic qualities of the products during the storage periods.

According to Ranganna (1991) no process can turn out identical unit-to-unit, hour-to-hour or day-to-day and the variations observed in the product reflect the variability of the raw materials, processing techniques, operators, panel members and the other causes. Seow et al., (1991) opined that there will be individual difference in scores among products for a similar pretreatment.

As per (table 14), in the first month, for taste the scores ranged between 3.1 to 5.0 in which the highest score was obtained by the 50^{o} Brix sucrose immersed sun dried sample which has got the least score. In the case of flavour, the highest score was shared by the solar dried water blanched, solar dried sulphured and the solar dried as well as the sun dried 70^{o} Brix sucrose immersed samples (5.0). The steam blanched and 50^{o} Brix sucrose immersed samples, both being the sun dried samples, scored the least (4.1).

Table(14): Meanscores of the dried pineapple products for quality attribute test during the first month.

Treat-ments	Taste	Flavour	Appearance	Texture	Colour	Overall acceptability
S_1T_1	4.6	5.0	5.0	4.8	5.0	4.9
S_1T_2	4.6	4.2	4.4	4.8	4.7	4.54
S_1T_3	4.9	5.0	5.0	5.0	5.0	5.0
S_1T_4	5.0	4.3	5.0	4.9	5.0	4.84
S_1T_5	4.9	5.0	5.0	4.9	5.0	4.96
S_1T_6	5.0	4.6	5.0	4.8	5.0	4.88
S_2T_1	3.6	4.4	4.9	4.9	4.8	4.52
S_2T_2	3.3	4.1	4.8	4.9	3.4	4.1
S_2T_3	3.4	4.6	5.0	4.7	4.8	4.5
S_2T_4	3.1	4.1	4.4	4.7	3.9	4.04
S_2T_5	4.7	5.0	5.0	5.0	5.0	4.94
S_2T_6	4.8	4.3	4.8	4.9	4.6	4.7

In appearance almost all the solar dried samples except the steam blanched ones and the control sample scored the highest with the least score of 4.4 for the 50°Brix sucrose immersed sun dried sample and the solar dried sample. The sulphured and the 70° Brix sucrose immersed samples had also scored the highest. In texture, the solar dried sulphured sample and the 70° Brix sucrose immersed sun dried sample scored the highest with the least score of 4.7 for the sun dried sulphured and 50° Brix sucrose immersed samples. In colour all the sun dried samples except steam blanched sample and the sun dried 70° Brix sucrose immersed sample scored the highest and the lowest of 3.4 for the sun dried steam blanched samples. In overall acceptability, the highest score of 5.0 was scored by only one sample and is the solar dried sulphured sample. Next to it was the solar dried 70° Brix sucrose immersed sample (4.96) with the least score being 4.1 for the sun dried steam blanched sample.

In the second month, (table 15), in taste, none of the samples scored the highest of 5.0 and the range was from 4.5 to 4.9. The highest score of 4.9 was attained by the solar dried 70° Brix sucrose immersed sample. In flavour, the score ranged between 4.1 and 5.0. The highest score was attained by the two solar dried samples of water blanched and sulphured and a sun dried sample of 70^{o}Brix sucrose immersed sample. In appearance, the range was between 3.3 and 5.0 in which the solar dried sulphured and 70^{o} Brix sucrose immersed samples scored the highest and the least score of 3.3 for the sun dried 50^{o} Brix sucrose immersed samples. In texture the highest score of 4.9 was attained by solar dried 50^{o} Brix sucrose immersed sample and the least of 4.4 was for the solar dried control sample and the sun dried 50^{o} Brix sucrose immersed sample. In colour, the scores ranged between 3.4 to 5.0 in which the least score obtained by sun dried 50^{o} Brix sucrose immersed sample and the highest was shared by the solar dried sulphured and 70^{o} Brix sucrose immersed samples. Scores obtained for Overall acceptability ranged between 3.96 to 4.92. The solar dried sulphured sample scored the highest and the least score was for sun dried 50^{o} Brix sucrose immersed samples.

Table(15): Meanscores of the dried pineapple products for quality attribute test during second month

Treat-ments	Taste	Flavour	Appearance	Texture	Colour	Overall acceptability
S_1T_1	4.5	5.0	4.0	4.7	4.9	4.62
S_1T_2	4.6	4.2	3.4	4.5	3.5	4.04
S_1T_3	4.8	5.0	5.0	4.8	5.0	4.92
S_1T_4	4.9	4.1	4.0	4.9	4.0	4.38
S_1T_5	4.7	4.9	5.0	4.7	5.0	4.86
S_1T_6	4.8	4.2	3.4	4.4	3.6	4.08
S_2T_1	4.6	4.8	3.8	4.7	4.6	4.5
S_2T_2	4.6	4.3	3.6	4.7	3.7	4.20
S_2T_3	4.6	4.6	3.9	4.6	4.9	4.52
S_2T_4	4.5	4.2	3.3	4.4	3.4	3.96
S_2T_5	4.6	5.0	3.7	4.8	4.6	4.54
S_2T_6	4.7	4.1	3.6	4.8	3.5	4.14

In the third month of storage (table 16), in taste, the scores ranged between 2.7 and 4.9 in which the score of 4.9 was obtained for the solar dried sulphured, 50^{o} Brix and 70^{o} Brix sucrose immersed samples. In flavour the least score of 3.4 was obtained by the sun dried steam blanched sample and the highest of 5.0 to the sun dried 70^{o} Brix sucrose immersed and the solar dried sulphured and 70^{o} Brix sucrose immersed sample. In appearance the least score of 4.0 was attained by the sun dried 70^{o} Brix sucrose immersed samples and all other samples except the water blanched and steam blanched samples from solar drying scored the highest of 5.0. In texture the range was between 3.8 to 5.0 in which the solar dried sulphured and sun dried 70^{o} Brix sucrose immersed samples scored the highest. The sun dried 50^{o} Brix sucrose immersed sample scored the least (3.8). In colour, 3.2 was the least score which was secured by sun dried steam blanched sample and the highest score of 5.0 to the sun dried 70^{o} Brix sucrose immersed sample and all other solar dried samples except the steam blanched samples. In Overall acceptability 3.52 was the lowest score and was attained by the sun dried 50^{o} Brix sucrose immersed sample. The highest score (4.94) was attained by the solar dried 70^{o} Brix sucrose immersed samples.

Table(16): Meanscores of the dried pineapple products for quality attribute test during third month.

Treat-ments	Taste	Flavour	Appearance	Texture	Colour	Overall acceptability
S_1T_1	4.8	4.9	4.9	4.8	5.0	4.9
S_1T_2	4.0	3.5	4.4	4.0	4.7	4.12
S_1T_3	4.9	5.0	5.0	5.0	5.0	5.0
S_1T_4	4.9	4.0	5.0	4.7	5.0	4.72
S_1T_5	4.9	5.0	5.0	4.8	5.0	4.94
S_1T_6	4.8	3.7	5.0	4.1	5.0	4.52
S_2T_1	3.6	4.3	4.8	4.9	4.3	4.4
S_2T_2	2.7	3.4	4.2	4.8	3.2	3.7
S_2T_3	3.5	4.3	4.8	4.7	4.3	4.32
S_2T_4	2.7	3.5	4.0	3.8	3.6	3.52
S_2T_5	4.7	5.0	4.9	5.0	5.0	4.92
S_2T_6	4.3	3.8	4.8	4.8	4.3	4.4
CD value	0.205	0.182	0.188	0.201	0.172	

As per (table 17), in the fourth and final month of storage period, in taste, the scores ranged between 4.1 to 4.8 in which only the solar dried sulphured and 50^{o} Brix sucrose immersed samples scored the highest (4.8) and the lowest score was obtained for the sun dried 50^{o} Brix sucrose immersed and the solar dried steam blanched samples (4.0).

In flavour, the least score (3.6) was obtained by the sun dried 50^{o} Brix sucrose immersed and the solar dried steam blanched sample (4.0) and the highest score of 5.0 by solar dried sulphured samples. In appearance, the range was between 3.1 and 4.9. The solar dried sulphured and 70^{o} Brix sucrose immersed samples scored the highest and the solar dried control sample scored the least (3.1). In texture, the highest score of 4.9 was attained by the solar dried sulphured sample and the least score of 3.9 by the solar dried steam blanched sample.

In colour, the solar dried steam blanched sample (3.2) has the least score and the solar dried sulphured and 70^{o} Brix sucrose immersed samples scored the highest (4.9). In Overall acceptability score, the range was from 3.58 to 4.9.

Table(17): Meanscores of the dried pineapple products for quality attribute test during fourth month.

Treat-ments	Taste	Flavour	Appearance	Texture	Colour	Overall acceptability
S_1T_1	4.7	4.9	4.0	4.7	4.6	4.58
S_1T_2	4.0	3.6	3.2	3.9	3.2	3.58
S_1T_3	4.8	5.0	4.9	4.9	4.9	4.9
S_1T_4	4.8	3.8	3.2	4.6	3.6	4.0
S_1T_5	4.7	4.8	4.9	4.6	4.9	4.8
S_1T_6	4.6	3.8	3.1	4.0	3.3	3.8
S_2T_1	4.6	4.9	3.7	4.7	4.3	4.44
S_2T_2	4.2	3.7	3.5	4.7	3.5	3.92
S_2T_3	4.7	4.7	3.9	4.6	4.7	4.52
S_2T_4	4.0	3.6	3.2	4.0	3.3	3.62
S_2T_5	4.6	5.0	3.7	4.8	4.3	4.48
S_2T_6	4.2	3.7	3.3	4.8	3.4	3.88
CD value	0.205	0.182	0.188	0.201	0.172	

From the above findings, it can be concluded that during the storage period, the solar dried samples scored the highest in overall acceptability tests. Pawar et al., (1988) pointed out that sensory evaluation with respect to colour, texture and Overall acceptability, solar dried samples supercede the sun dried samples. Mathur et al., (1989) pointed out that solar dried samples had an improved quality with regard to its quality attributes. Maharajan et al., (1993) stated that the quality of the solar dried product was observed to be the best when compared to the open sun drying.

Table(18): Effect of pretreatments and storage periods on the taste attribute.

Treatments	1st month	2nd month	3rd month	4th month
Water-blanching	3.6	3.0	3.15	2.9
Steam-blanching	4.7	4.6	4.7	4.3
Sulphuring	4.9	5.0	4.9	4.9
50°Brix	4.6	4.4	4.7	4.3
70°Brix	4.6	4.5	4.6	4.3
Control	4.8	4.9	4.7	4.7

CD value 0.28

Effect of storage periods on treatments with respect to taste attribute, (table(18)), depicted that in first month there was no significant difference between the samples other than the water blanched one. In second month, comparison with CD value showed that there was significant difference in all the samples except the control samples when compared to the sulphured samples. In third month, there was significant difference among the water blanched, sulphured and 70^{o} Brix sucrose immersed samples. In the fourth month, the comparison showed that there was no significant difference among the steam blanched, 50^{o} Brix and 70^{o} Brix sucrose immersed samples. The water blanched and the sulphured sample differed significantly with each other.

In flavour, (table 19), the comparison with the CD value showed that in the first month only the water blanched samples showed a significant difference. In the second month, the water blanched and 70^{o} Brix sucrose immersed samples showed a significant difference. In the third month, the 50^{o} Brix sucrose immersed, 70^{o} Brix sucrose immersed and the control samples did not differ significantly and the water blanched, steam blanched and sulphured samples differed significantly with each other. In the fourth month, the sulphured and the control samples showed a significant difference with other samples when compared to the CD values.

Table(19): Effect of pretreatments and storage periods on the flavour attribute.

Treatments	1st month	2nd month	3rd month	4th month
Water-blanching	4.35	3.75	4.45	3.8
Steam-blanching	5.0	4.05	4.95	3.85
Sulphuring	5.0	4.15	5.0	4.15
50°Brix	4.9	4.0	4.7	3.9
70°Brix	5.0	3.9	4.9	3.9
Control	5.0	4.0	4.85	4.0

CD value 0.23

In the case of appearance, though the 50° Brix and 70° Brix sucrose immersed samples did not differ each other, they showed a significant difference when compared to other treatments. As per table(20) in the second month, the water blanched and steam blanched samples showed a significant difference. The sulphured samples differed significantly with all other samples except steam blanched samples. In third month, the sulphured, 50^{o} Brix and 70^{o} Brix sucrose immersed samples showed a significant difference. In the fourth month, the sulphured sample showed a significant difference with all the other samples. Similarly the steam blanched samples also showed a significant difference with the other samples except with the water blanched samples.

Table(20): Effect of pretreatments and storage periods on the appearance attribute.

Treatments	1st month	2nd month	3rd month	4th month
Water-blanching	4.9	4.5	4.9	4.2
Steam-blanching	4.95	4.8	4.95	4.4
Sulphuring	5.0	5.0	5.0	5.0
50^{o}Brix	3.8	3.6	3.9	3.3
70^{o}Brix	3.7	3.5	4.0	3.3
Control	4.95	3.6	4.95	3.3

CD value 0.22

The (table 21) depicts that in texture, in the first, second, third and fourth month of storage no significant differences were observed.

Table(21): Effect of pretreatments and storage periods on the texture attribute.

Treatments	1st month	2nd month	3rd month	4th month
Water-blanching	4.9	4.9	4.7	4.3
Steam-blanching	5.0	4.9	4.8	4.4
Sulphuring	5.0	4.8	4.9	4.5
50°Brix	4.7	4.7	4.6	4.2
70°Brix	4.8	4.8	4.7	4.2
Control	4.9	4.8	4.7	4.2

CD value 0.271

In colour attribute evaluation tests, the (table 22) indicated that in first month, the steam blanched, sulphured and the control samples showed a significant difference with all other samples. In the second month, all the samples except water blanched, 50° Brix and 70° Brix sucrose immersed samples and the control samples showed a significant difference. In the third month, only the water blanched samples showed a significant difference. In the fourth month, the water blanched, steam blanched and the sulphured samples showed a significant difference with all the other samples and also with each other.

Table(22): Effect of pretreatments and storage periods on the colour attribute.

Treatments	1st month	2nd month	3rd month	4th month
Water-blanching	4.6	3.3	4.6	3.8
Steam-blanching	5.0	4.5	5.0	4.7
Sulphuring	5.0	5.0	5.0	5.0
50°Brix	4.45	3.6	4.8	3.4
70°Brix	4.5	3.5	4.8	3.4
Control	4.95	3.8	4.95	3.5

CD value 0.251

So the water blanched samples scored the least with respect to every quality attributes as against the sulphured samples which scored highest in all the quality attribute tests. The lowest scores for the water blanched samples may be attributed to the loss of water soluble vitamins from the pineapple slices. And as the water was drained off completely before drying there is a chance for the decrease in taste of the products.

4.3.6 Assessment of the microbial contamination in the stored pineapple products.

The shelflife quality of the processed product is one of much importance because the need for improving different processing technique is infuenced by the shelf life quality. (Tandon, 1987). Monthly analysis of the processed product is necessary in order to find out whether the product has any qualitative deterioration.

The dried pineapple products prepared in this study was analysed for the microbial infestation such as yeast, fungus and bacteria. Direct plate method and serial dilution were useful to detect the presence of any microbes. No microbial infestation was detected upto four months. For the identification of micro organisms, maltose extract, potato dextrose agar and nutrient agar were used respectively. Bacillus species was detected as the bacteria; Aspergillus species as fungi and yeast were detected from all the stored dehydrated pineapple products after the fourth month of storage period. It was also noted that initiation and severity of microbial infestation was more in the sun dried samples.

Moisture content of the processed pineapple products was kept approximately ten percent and this low moisture content may be the reason for the safe storage of the products upto four months. Siddappa (1987) stressed the need for bringing the moisture level of fruits and vegetables below 15 percent for the safe storage in partially dried products. Singaravelu and Arumugam (1993) showed that the processed sapota fruit flakes with a moisture content of eleven percent had the shelflife of only 120 days.

4.4 Cost Benefit Analysis:

According to Singh (1985) dehydration has usually been more costly than sun drying, but the superior cooking quality of the dehydrated products will cause them to command a sufficiently higher price which will counter balance the slightly greater cost of production. Maini (1982) has the opinion that drying is the most efficient method of preservation in which the advantages like greater concentration in dry form and are cheaper to produce with minimal labour, processing equipment, storage and distribution cost.

The cost benefit analysis was carried out based on the cost of various factors needed for the preparation of differently pretreated and dehydrated pineapple products such as cost of fresh pineapple fruit, sugar, polypropylene covers and the overhead charges including labour cost and fuel. Since the cost varies from product to product, it is necessary to find out the actual cost of the dehydrated products individually.

The below given (table 23) depicts the cost benefit analysis of the products developed. Sucrose immersed samples was found to have the highest cost of Rs. 15.75/- per quarter Kg. This increase in the price is due to the addition of sugar. The lowest cost of Rs. 13.85/- was for the plain dehydrated pineapple products. The water blanched and steam blanched samples shared an equal price of Rs. 14.00/- each.

Table (23): Cost analysis of differently treated dehydrated pineapple products of quarter kilogram.

SL: No:	Pineapple products	Cost Rs.	Cost Ps.	Cost/1/4 Kg
1	S_1T_1/S_2T_1	56	25	14.00
2	S_1T_2/S_2T_2	56	25	14.00
3	S_1T_3/S_2T_3	58	50	14.60
4	S_1T_4/S_2T_4	62	00	15.50
5	S_1T_5/S_2T_5	63	00	15/75
6	S_1T_6/S_2T_6	55	50	13/85

From the above, it can be inferred that different pretreatment or the drying methods does not have much influence on the cost of the dried products prepared.

Results of the study proved the efficacy of solar drier in processing of foods, especially for preparation of better quality dried pineapple products.

Summary

SUMMARY

The present study entitled "Developing partially dehydrated pineapple products using solar drier" was undertaken to assess the chemical, nutritional and organoleptic qualities of the partially dehydrated pineapple products, subjected to different treatments and drying methods. The study also assess the changes in their quality and acceptability of the products with storage.

Chemical and Nutritional Qualities of the partially dehydrated pineapple products were assessed with regard to its moisture content and weight loss, pH, acidity, reducing sugar and vitamin C.

In the case of moisture, though almost all the solar dried samples were found to have a lesser moisture content, the difference between the solar dried and sun dried samples was found to be negligible. The weight loss of the products after dehydration was almost same for both solar dried and open sun dried samples.

With regard to the chemical composition, the

pH of the fruits increased after dehydration. The pH of the processed pineapple products increased from 3.6 to 3.78. Acidity was found to decrease in the dried products. Decrease was found to be more in the open-sun dried samples. In the case of reducing sugar also the sun dried samples recorded lower values when compared to the solar dried samples. A deep destruction of vitamin C was noted in the processed pineapple products.

Assessment of the organoleptic qualities of the products revealed that in the case of taste, the sulphured and the 50^{0} Brix sucrose immersed solar dried samples proved to be the best. Out of the twelve treatments, all the solar dried samples except the 70^{0} Brix sucrose immersed sample were found to be better than that of the open-sun dried samples. The sulphured and 70^{0} Brix sucrose immersed solar dried samples attained the maximum score. Evaluation of texture attribute showed that only the water blanched, sulphured, 50^{0} Brix sucrose immersed and control solar dried samples were found to have a better score than that of the samples undergone same treatment but sun dried. The other samples - steam blanched and 70^{0} Brix sucrose immersed sun dried samples showed higher scores than that of the samples dried under solar drier. In colour, only the control sun dried sample scored better than that of solar dried samples. All other solar dried samples - water blanched, steam blanched, sulphured, 50^0 Brix sucrose immersed samples and 70^0 Brix sucrose immersed samples proved to be better than that of sun dried samples. In overall acceptablity all the solar dried samples obtained better scores than that of sun dried samples and the least score was obtained by the sun dried 50^0 Brix sucrose immersed samples. The highest score was obtained by the sulphured and 70^0 Brix sucrose immersed solar dried samples.

Effect of treatments and drying methods on the quality attributes indicated that there is significant difference between samples treated differently under different drying methods.

From the above observations, it can be concluded that in all the quality attribute tests, including overall acceptability, the sulphur fumigation was proved to be the best to apply as pretreatment, and solar drying as a drying method.

Periodical assessment of the changes in the acidic content of the dried products revealed that only the water blanched samples from both sun drying and solar drying showed a slight decrease in the acidic content throughout the storage periods. The 50^0 Brix and 70^0 Brix sucrose immersed sun dried and solar dried samples had the same value during the storage periods. In general among the different pretreated samples, the sample which had not undergone any pretreatments (control) was proved to possess a high acidic value followed by the sulphured samples.

Evaluation on the influence of storage periods showed that storage periods had an influence on the acidic content of the products. And in the case of drying methods there seemed no significant difference among the samples with regard to the acidic content.

Periodical evaluation on the changes in the pH content of the pineapple products was noticed only during the fourth month of the storage. However as the pH showed an increase in the fourth month, acidity was found to decrease.

Assessment on the effect of drying methods and pretreatments on the changes in reducing sugar during the storage periods showed that the highest value was attained by the 70^0 Brix sucrose immersed and steam blanched solar dried samples and the least value was scored by the water blanched solar dried sample. Changes in the reducing sugar content was noticed in almost all the samples. Only the control solar dried sample retained the same value throughout the storage periods. Most of the samples showed an increase in the reducing sugar content only after the second month of storage period. The sulphured sample had the highest value with the least value in water blanched sample.

Analysis of reducing sugar content with respect to its storage periods showed a gradual increase in the reducing sugar content throughout the storage periods and all the samples possessed a higher reducing sugar content in the fourth month of storage.

Effect of drying methods showed that the drying methods had not much influence on the reducing sugar content of the products dried under different methods.

Periodical assessment of the changes in the vitamin C content of the processed products during storage periods revealed that there was drastic destruction of vitamin C in the products. No further deterioration was noticed in vitamin C content with storage.

Monthly evaluation of the changes in the organoleptic qualities of the products during storage periods revealed that in taste attribute tests, in first month the 50^0 Brix sucrose immersed solar dried sample had got the highest score whereas during the second month the 70^0 Brix sucrose immersed solar dried sample scored higher. In the third month besides the 50^0 Brix and 70^0 Brix sucrose immersed samples, the sulphured solar dried allowed the highest score. And in the fourth and final month of storage period, only the sulphured and 50^0 Brix sucrose immersed solar dried samples scored the highest.

The water blanched, sulphured, steam blanched and control solar dried samples scored highest with respect to the flavour and appearance attribute tests in the first month whereas in texture and colour, most of the sun dried samples attained highest scores during the first month. Eventhough the sun dried samples scored best in the first month, the solar dried samples were found to be superior in the subsequent period of storage with respect to colour and texture. In flavour attribute, solar dried samples were found to be best throughout the storage period. With respect to appearance both solar dried and sun dried products shared an equal score during initial storage period. However when the storage time increased, only the solar dried samples were found to be acceptable. In texture, though both the solar dried as well as the sun dried samples scored highest in the second and third month, solar dried products were found to be better with advancing storage period.

In overall acceptability, the sulphured solar dried and 70^0 Brix sucrose immersed solar dried samples had scored the highest. Of these two samples, again the sulphured solar dried pineapple product proved to be best in the first, second and fourth month of storage period, with respect to the overall acceptability.

Assessment on the effect of storage periods on the organoleptic qualities of the dried products revealed that there exist a significant difference in the quality attributes in the pineapple products with respect to the different treatments.

Evaluation of the microbial contamination in the stored pineapple products revealed that the Bacillus species, Aspergillus species and yeast were detected as micro organisms from the dried products after the fourth month of storage.

The cost benefit analysis revealed that the sulphured samples had the highest price of Rs.15.75/- per quarter kg of the product. The lowest cost was for plain dehydrated (control) samples. In general there was not much difference in the cost of differently treated pineapple products and among the different drying methods.

To summarise, it can be concluded that the pineapple fruits can be processed successfully as slices in polypropylene covers with the help of both solar drier and in open sun. The study also revealed that better quality products can be efficiently prepared with the help of solar drier than in the open sun. Among the various pretreatments applied, sulphur fumigated samples proved to be the best.

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* Originals not seen

Appendix

APPENDIX I

DESCRIPTION OF THE SOLAR DRIER USED FOR THE STUDY.

The solar drier used for this study consists of the main body, foldable sides - both left hand and right hand, top inclined frame with polythelene sheets, Product loading tray - bottom, middle & top which are made up of Aluminium wire mesh which enables air circulation and fast drying of the products.

The main body of the solar drier is made up of Aluminium sheet. The outer part of the bottom of the main body is insulated with thermocole sheet, for minimising the heat loss. Rubber legs are also fixed with screw to the main body. To this main body aluminium plates are fixed with aluminium rivets for supporting the side covering. Collars are also provided on both the sides of the main body towards the inside to avoid air leakage. A Black Mat finish paint in two coats were applied all over the metal sides.

To operate the solar drier, first take out the folded solar drier unit and keep the folding side towards the sun, unfold it and lock it from both the sides. Load

A SOLAR DRIER.

the products in the clean trays. Place these trays on the support of the folding sides. Finally close the unit from both the sides with the polythene sheet frame. Lock the sides with the folding sides.

Load with fresh products, close and lock it. The system should not be disturbed while the drying is on. Visual observation can be made through the transparent polythene sheet.

Appendix II.

Sensory Evaluation of the Attributes

(Organoleptic Evaluation)

Evaluation card For Triangle Test.

In the triangle test three sets of sugar solution of different concentration were used of which two solutions were identical. The panel members were asked to identify the sugar solution of different concentration.

Name of the products - Sugar solution.

Note: Of the three samples given, identify the odd sample.

SL: No:	Code no: of samples	Code no: of the identical sample	Code No of the odd sample
1	XYZ		
2	ABC		

APPENDIX III

SCORE CARD

Criteria	A	B	C	D	E	F	G	H	I	J

1. Taste

    Excellent (5)
    Very Good (4)
    Good (3)
    Fair (2)
    Poor (1)

2. Flavour

    Very pleasant (5)
    Pleasant (4)
    Neither pleasant nor unpleasant (3)
    Unpleasant (2)
    Not at all pleasant (1)

3. Appearance

    Very Good (5)
    Good (4)
    Fair (3)
    Poor (2)
    Very poor (1)

4. Texture

    Soft (5)
    Neither hard nor soft (4)
    Hard (3)
    Very hard (2)
    Brittle (1)

5. Colour

    Very Good (5)
    Good (4)
    Fair (2)
    Poor (2)
    Very poor (1)

APPENDIX IV

ANOVA TABLE FOR ACIDITY, REDUCING SUGAR AND THE DIFFERENT QUALITY ATTRIBUTES.

ANOVA TABLE FOR ACIDITY

Source	df	ss	MSS	F
A	1	4.272461E-03	4.272461E-03	.8214155
B	5	.8424454	.1684891	32.3934**
AB	5	1.869202E-03	3.738403E-04	7.187385E-02
Error-1	12	6.241608E-02	5.20134E-03	
C	3	4.600525E-03	1.533508E-03	32.74208**
AC	3	2.136231E-04	7.120768E-05	1.520362
BC	15	9.231567E-04	6.154378E-05	1.314027
ABC	15	6.713867E-04	4.475912E-05	0.9556561
ERROR	36	1.686096E-03	4.683601E-05	

** Significant at 1 percent level.

ANOVA TABLE
(REDUCING SUGAR)

Source	df	ss	MSS	F
A	1	.1152344	.1152344	.50825
B	5	90.70508	18.14102	80.01321**
AB	5	3.320313E-02	6.640625E-03	0.0292893
Error-1	12	2.720703	.2267253	
C	3	0.1386719	4.622396E-02	3.872727*
AC	3	0.0234375	0.0078125	.6545455
BC	15	.1113281	7.421875E-03	.6218182
ABC	15	9.570312E-02	6.380209E-03	.5345455
ERROR	36	.4296875	1.193576E-02	

* Significant at 5 percent level.

** Significant at 1 percent level.

ANOVA TABLE FOR DIFFERENT QUALITY ATTRIBUTES

ANOVA TABLE FOR TASTE

Source	df	ss	MSS	F
A	1	3.501953	3.501953	16.31992**
B	5	142.794	28.55879	133.0906**
AB	5	0.5605469	.1121094	.5224559
Error-1	108	23.17481	.2145815	
C	3	7.123047	2.374349	11.42647**
AC	3	6.040039	2.013346	9.689154**
BC	15	5.614258	.3742839	1.801227*
ABC	15	1.647461	.1098307	.5285563
ERROR	324	67.3252	.2077938	

* Significant at 5 percent level.

** Significant at 1 percent level.

ANOVA TABLE FOR FLAVOUR

Source	df	ss	MSS	F
A	1	10.50195	10.50195	62.40567**
B	5	11.06836	2.213672	13.15429**
AB	5	.5859375	.1171875	.6963623
Error-1	108	18.17481	.1682852	
C	3	94.79004	31.59668	232.0074**
AC	3	8.272461	2.757487	20.24761**
BC	15	3.772461	.2514974	1.846689*
ABC	15	1.290039	8.600261E-02	.6314979
ERROR	324	44.125	.1361883	

* Significant at 5 percent level.

** Significant at 1 percent level.

ANOVA TABLE FOR APPEARANCE

Source	df	ss	MSS	F
A	1	2.700195	2.700195	15.03171**
B	5	141.7002	28.34004	157.7661**
AB	5	1.999024	.3998047	2.225672
Error-1	108	19.40039	.1796333	
C	3	40.46582	13.48861	110.3624**
AC	3	1.100586	.366862	3.001628*
BC	15	28.13379	1.875586	15.34586**
ABC	15	1.700195	.1133464	.9273884
ERROR	324	39.59961	.122221	

* Significant at 5 percent level.

** Significant at 1 percent level.

ANOVA TABLE FOR TEXTURE

Source	df	ss	MSS	F
A	1	4.407227	4.407227	21.39238**
B	5	3.140625	.628125	3.048877*
AB	5	.3681641	7.363281E-02	.3574087
Error-1	108	22.25	.2060185	
C	3	25.01563	8.338542	43.89434**
AC	3	8.076172	2.692057	14.17107**
BC	15	.709961	4.733073E-02	.2491504
ABC	15	1.148438	.0765625	.4030273
ERROR	324	61.54981	.1899685	

* Significant at 5 percent level.

** Significant at 1 percent level.

ANOVA TABLE FOR COLOUR

Source	df	ss	MSS	F
A	1	4.21875	4.21875	28.08234**
B	5	74.18457	14.83691	98.76273**
AB	5	1.769531	.3539063	2.355796*
Error-1	108	16.22461	.1502279	
C	3	88.25586	29.41862	178.9125**
AC	3	2.246094E-02	7.486979E-03	4.553287E-02
BC	15	33.45703	2.230469	13.56484**
ABC	15	1.239258	8.261719E-02	.5024453
ERROR	324	53.27539	.1644302	

* Significant at 5 percent level.

** Significant at 1 percent level.

Abstract

DEVELOPING PARTIALLY DEHYDRATED PINEAPPLE PRODUCTS USING SOLAR DRIER

by

Riji Hari

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement (for the degree)

MASTER OF SCIENCE IN HOME SCIENCE

(Food Science and Nutrition)

Faculty of Agriculture

Kerala Agriculture University

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Vellayani, Thiruvananthapuram

1995

ABSTRACT

The present investigation was undertaken to study the efficiency of solar drier as against open sun drying in the partial dehydration of the pineapple products.

Assessment on the moisture content and weight loss, pH, acidity, reducing sugar and vitamin C revealed that there was a negligible difference in the moisture content of the samples dried under two different methods. The weight loss of the product were also found to be almost same for both solar dried as well as the sun dried samples.

The pH of the dried pineapple products was found to be increased after the dehydration while the acidity was reduced. The reducing sugar content was also reduced in dried samples. But more reduction in acidity and reducing sugar was found in sun dried samples than in the solar dried samples. A drastic destruction of vitamin C content was noticed after the dehydration, in the dried products subjected to different storage conditions.

Assessment of the organoleptic qualities indicated that the solar dried samples were proved to be

best with respect to its various quality attribute tests. Only in appearance and colour attribute tests, the sun dried samples showed better scores than that of solar dried ones. Among the various pretreatments applied, the sulphur fumigated samples scored the highest in all the quality attribute tests.

Periodical evaluation of the changes in the acidic content showed that there was a slight decrease in the acidity throughout the storage periods in most of the samples, which in turn proved that the storage periods had an influence on the changes in acidic content of the products. Analysis of the changes in pH content indicated a slight increase during the storage.

Monthly analysis of the changes in the reducing sugar content revealed a gradual increase in all the samples from both solar drying and sun drying throughout the storage periods of four months. Among the different pretreatments, the sulphur fumigated samples was found to contain higher reducing sugar content. Not much difference was noticed in the reducing sugar content, with drying methods and storage periods.

Periodical assessment of the changes in the Organoleptic qualities during the storage periods of four months revealed that only the solar dried sulphur fumigated samples scored highest in all the months of storage with respect to different quality attributes. The organoleptic scores of quality attribute tests showed a decrease only during the fourth month of storage. The storage periods and drying methods also had an influence over the organoleptic qualities of the processed products.

Microbial assessment revealed that Bacillus species, Aspergillus species and yeast were identified as micro organisms in all the dried products after a period of four months.

The cost benefit analysis revealed that the price of different products ranged between Rs. 13.85/- and Rs. 15.75/- and there is not much difference in the cost of products undergone different pretreatments and drying methods.

The above findings clearly indicated that pineapple fruits can be processed efficiently using solar drier. This investigation also revealed that sulphur-fumigation was best to apply as pretreatment prior to dehydration. In general, the solar dried samples proved to be best both qualitatively and organoleptically.