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RESEARCH PAPER OPEN ACCESS

FREEZE DRYING- A NOVEL PROCESSING FOR FRUIT POWDERS

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ABSTRACT

The invention of thermal processing by Nicholas Appert, a French confectioner brought a new era of research in food processing. Different procedures can be employed for thermal processing. It is still necessary to design a process that deliver the required minimum heat treatment. Today consumer demands much more than just safe and shelf stable food, including primarily higher quality food with greater convenience. Food processors look for more energy-efficient, cost-effective and high-speed processing technologies. Thermal processing can be achieved by a variety of techniques. Freeze drying is a special case of vacuum drying. Removal of moisture is a result of sublimation of water, without a phase change from solid to liquid. The restricted movement of liquid water preserves the original structure of the food material. In the present research the quality of jack fruit powder developed by applying dehydration or drying and freeze drying techniques was studied and compared. The nutrient quality and reonstitutional properties were studied by analysis. Vitamin A and C (AOAC Procedure) and acceptability were studied using five point hedonic scales. The Vitamin 'A' and 'C' content in dried powder (DP) was 150.45 IU AND 2.15 mg per/100g and in freeze dried powder (FP) was 250.68 IU and 5.92mg/100g of Jack fruit powders respectively. Juice was prepared using the powders and compared with fresh juice (Control). The Sensory scores for color, taste, flavor of freeze dried Jack fruit powder was equal to the fresh juice. Freeze drying is an appropriate technology for fruits and vegetables than conventional dehydration techniques.

KEY WORDS:
Jack Fruit, Dehydration, Freeze drying, Dried Powder.

INTRODUCTION

The Jackfruit (Artocarpus Heterophyllus) is a species of tree of the mulberry family (Moracea) and its fruit, native to South Western India, Bangladesh and Srilanks, and possibly also east to the Malay Peninsula. It is an evergreen tree growing

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to 10-15m tall. The leaves are alternately arranged, elliptical, 5-25 cm long and 3-12 cm broad, often lobed on young trees but entire on mature trees. Jackfruit is widely grown in south and Southeast Asia. It is also grown in parts of central and eastern Africa, Brazil, and in islands of West Indies such as Jamaica. It is the national fruit of Bangladesh and Indonesia. The tree is well adopted to humid tropical to tropical to tropical climates. A tree may yield as many as 150 large fruits annually attached to the trunk and its lateral branches. While some exotic varieties bear 250 to 500 fruits per year. The fruiting capacity of a tree depends upon the input supply, weather conditions, and protection from the insect pests and diseases. Jackfruit (Artocarpus heterophyllus L) is a good source of vitamins (especially vitamin A from β-carotene) fibre and minerals. It can be incorporated into a product to increase the nutritional content. It possesses wide varity of nutritional element such as carotene, Vitamin-B1, Vitamin-B2 and potassium. Fructose, Glucose and sucrose found to be the major sugars : carpic, myristic, lauric, palmitic, oleic, stearic, linoleic and arachidic acid found as major fatty acids with varying proportions in different part of jackfruit. Jackfruit crop matures in March to June, being highly perishable, Jackfruit bulbs has a limited shelf-life. Consequently, there is a need to utilize this crop for production of shelf stable products. The marginal growers cannot invest on big processing plants, thus the need arises to develop a suitable low-cost technology for dehydration of jackfruit so that a large number of Small growers could be benefited another method also used to prepared that is freeze drying method. It is a high-cost technology process. The preservation of foods as powder concentrate has received increased attention in recent years. A number of investigators have devoted their attention towards preparing powders. The aim of this research was to investigate the effect of dehydrating processing techniques hot air oven and freeze drying on the jack fruit powder..

MATERIAL AND METHODS

Tropical fruit powders have a large export potential because of their inherent advantages of weight reduction and product stability. The unripe starchy fruits are cut into slices, dried in a hot air oven dryer, powdered and packed. Freeze drying is a relatively innovative method of preparing dehydrated food powders. Fruit powders are often used in making juices. The jackfruit required for the preparation of powder was purchased from the local fruit market. (Figure No.1).

STANDARD PROCEDURE FOR JACKFRUIT POWDER:

The fresh and matured fruits were selected. The fruit maturity was indicates by hollow sound when tapped, spines and skins become flattened and wider; and developed a strong aroma. Cut fruit in half lengthwise. Carve out the sticky central core. Scoop out the individual fruitlets (bulbs). Sort bulbs according to size maturity and colour. Cut the end of the bulbs to remove the seeds. (Figure No. 2).

PREPARATION OF SAMPLE FOR

HOT AIR OVEN DRYING:

The fresh good fruit bulbs were collected and seeds were separated. The bulbs were cut into small pieces and are kept in aluminium trays. The quantity of the fruit taken was 1 kg. The aluminium trays were kept in hot air oven and the temperature was maintained at 600C. The total time taken for drying was 30 hrs. Drying was not done continuously; at a gap of 24 hrs the samples were dried. The samples were powdered in a mixer and sieved final quantity of powder was 178g. Powder was collected in polythene bags and stored in cool and dry place. (Figure No.3 and Photo No.1).

PREPARATION OF SAMPLE FOR FREEZE DRYING:

The fresh good fruit bulbs were collected and seeds were separated. The pulp is extracted from the bulbs. The collected pulp, was measured and powederd freeze drying flasks and kept for freeze drying. The flasks are set to the freeze dryer. The temperature is maintained at -400C and the vaccum is maintained at 86 m and dried for 40hours. Drying was not done continuously, at a gap of 24 hrs the sample were dried. The obtained powder was 160gm the powder was collected in polythene bags and is stored in cool and dry place. (Figure No.4 and Photo No.2).

PHYSICO CHEMICAL ANALYSIS

Moisture Estimation

About 3 g of the material is weighed into a weighed moisture box and dried in an oven at 100 to 1050C and cooled in a desiccator. The process of heating and cooling is repeated till a constant weight is achieved.

$$\text{Moisture \%} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Weight of the Sample}} \times 100$$

NUTRIENT ANALYSIS

Vitamin-A Estimation

Dissolve 2.5 gms weighted with an accuracy of 0.1 percent, in 5 ml of pentane R and dilute with 2-propanol R1 to a presumed concentration of 10 IU/ml to 15 IU/ml. Measure the absorbance (2.2.25) at the absorption maximum at 326 nm. Calculate the activity of Vitamin-A in international units per gram from the expression.

$$\text{Vitamin} - A = \frac{A_{326}\ V\ 1900}{100 \times m}$$

Note:

A_{326} = Absorbance at 326 nm

m = Mass of the substance to be examined in grams.

v = total volume to which the substance to be examined is diluted to give 10 1u/ml – 15 IU/ml.

1900= Factor to convert the specific absorbance of esters of rational into international units per gram.

Vitamin-C Estimation

Weight A quality equal to 100 mg of Vitamin C or pippet out A volume equal to that of 100 mg of Vitamin C in a Conical flask + 15 ml of Dil.H2SO4. warm the solution. Cool and adol 5 ml of starch solution and titrate with N/10 Iodine, to blue colour. Each ml of 0.1 M iodine = 8.806 mg.

Yield of jackfruit powder

The jackfruit bulbs yield can be calculated by weighting before and after drying. The

final yield of jackfruit bulbs powder can be calculated by weighting.

$$\text{Powder yield \%} = \frac{\text{Initial Weight – Final Weight}}{\text{Weight of the Sampl}} \times 100$$

Shelf life studies

Shelf-life studies was conducted to know the keeping quality of the jack fruit bulbs powder developed by different methods drying at the laboratory. The powder were evaluated at an interval of 0-7 days. The powders were also stored in two different temperatures that is one room temperature and the another samples in refrigerator at 4-60.

Organoleptic Evaluation

Sensory evaluation was conducted for jackfruit bulbs powder by preparing juice with the developed powder. Evaluation was an important part of the process for developing new food products. The trails carried out at the laboratory were evaluated through sensory evaluation to test the acceptability and in turn to standardize the product. The procedure followed for sensory evaluation was given below.

RESULTS AND DISCUSSIONS

The preservation industry at present is able to utilize less percent of the total production for conversion into products like canned fruit juices and their beverages, pulps, powders, squashes, jams and jellies. The quality of the processed products can also be improved by up grading some of the preservation practices. Preservation of foods as powders concentrate has received increased attention in recent years.

JACK FRUIT POWDER YIELD:

The yield of jack fruit powder was presented in table no;1 the jack fruit powder yield by hot air oven was 1000g and after drying the yield was 178g. Initial weight of raw material and final yield of freeze drying sample was 1000g and 160g respectively. There is no significant difference in the yield of the powder between the hot air oven and freeze drying methods. (Table No.1)

EFFECT OF DRYING ON THE QUALITY OF DEHYDRATED POWDER:

The powder developed as such was subjected to sensory evaluation. The fresh powders were given to panel members to evaluate in all the sensory attributes. The mean scores of sensory evaluation was presented in Table No.7. The mean sensory scores for colour, taste, flavour of the hot air oven dried sample was 4.1, 4.1 and 4.0 and in the freeze dried sample was 4.3, 4.4 and 4.1 respectively, comparatively the freeze dried sample has retained a good colour than hot air oven dried sample. (Table No.2, Figure No. 5 and Photo No. 3)

PHYSICO CHEMICAL ANALYSIS:

Moisture Estimation

The moisture content was estimated in the samples before and after storage of 7 days was presented in Table No.8. The initial and final moisture content of the samples dried in hot air oven and stored at room temperature and refrigerated temperature was 5.9 and 6.0 and 6.2 percent respectively. The initial and final moisture content in freeze dried samples was 5.4 and 5.5 percent

at room temperature and refrigerated sample was 5.7 percent respectively. There was a significant difference in the moisture content of the samples dried in hot air oven and freeze drier after seven days.

Subramanian et al (1976) notice that freeze dried fruit juice powder when packed in cans or pouches and flushed with nitrogen, the moisture content was less than one percent had a storage life of one year. (Table No.3 and Figure No.6)

Estimation of Vitamin- A

The vitamin-A content of the samples before and after storage was presented in Table No.9 the vitamin-A content of the sample dried in hot air oven and stored in room temperature and refrigerator sample was 150.45 IU. The vitamin-A content in freeze dried sample were 250.68 IU in room temperature and refrigerated sample. There was no significant different in the vitamin-a content of the sample dried in hot air oven and freeze drier.(Table No.4 and Figure No.7)

Estimation of Vitamin-C

The vitamin-C content was estimated in the samples before and after storage of 7 days was presented in Table No.10. The vitamin-C contents of the samples dried in hot air oven and stored in room temperature and refrigerated samples was 2.15 mg. The vitamin-C content in freeze dried samples was 5.92 mg in room temperature and refrigerated temperature. There was a significant difference in the vitamin-C content of the sample dried in hot air oven and freeze drier. The samples of freeze drying was 5.92 mg. which was double the fold more than hot air oven. Because in freeze drying the samples were not exposed to high temperature.(Table No.5 and Figure No.8)

RECONSTITUTIONAL PROPERTIES OF JACK FRUIT POWDER

Jack fruit is a seasonal fruit the main objective of the study was to develop powders. So that they can be used in unseason. Juice was prepared to sensory evaluation. The amount of powder to be added to prepare 100ml of juice was standardized by organoleptic evaluation. The standardization amount of powder to be used was presented in the (Table No.6)

The mean sensory score of the samples represents that of all the samples in all the sensory attributes, 'T3' sample in which 7.5 g at jack fruit hot air oven dried sample scored high in all the sensory attributes. So the sample T3 was kept for shelf life and studied for reconstitution properties before and after storage.

The sensory evaluation results were presented in (Table No.7.a., 7.b. Figure No.9.a., 9.b. and Photo No. 4) The mean sensory score of the samples represents that of all the samples in all the sensory attributes, 'T3' sample in which 7.5 g at jack fruit hot air oven dried sample scored high in all the sensory attributes. So the sample T3 was kept for shelf life and studied for reconstitution properties before and after storage.

RECONSTITUTIONAL PROPERTIES OF POWDERS

Organoleptic evaluation is the important

essential requirement to decide the acceptability of the product which will decide the shelf life of any product as it is , subjective sensory evaluation mainly depending upon on the human liking the acceptability toward the various sensory attributes. (Table No.8)

The reconstitution properties of the developed powders was studied by preparing juices with the powders, and subjected to set of panel members. The sensory evaluation results revealed that the sensory scores for the colour of hot air oven dried sample kept at room temperature and refrigerator and freeze dried (Room temperature and refrigerator) was 4.1, and 4.2 respectively. The colour of the control was 4.1 (Fresh jack fruit juice) which is nearer to the freeze dried sample. After the storage the sensory evaluation results revealed that the sensory scores of the colour of hot air oven dried sample kept at room temperature and refrigerator and freeze dried (Room temperature and Refrigerator) was 3.9, 3.8 and 3.8, 4.0 respectively. The sensory scores of the taste of hot air oven dried sample kept at room temperature and refrigerator and freeze dried (Room temperature and refrigerator temperature) was 4.1, and 4.3 respectively. The taste of the control was 4.2 which is nearer to the freeze dried sample. After the storage the sensory evaluation results revealed that the sensory scores of the taste of hot air oven dried sample kept at room temperature and refrigerator and freeze dried (Room temperature and Refrigerator) was 3.5, 3.6 and 3.7,3.8 respectively. The taste of the control was 4.2 which is higher than hot air oven and freeze dried samples. Among the samples near to control the freeze drying sample. The sensory scores of the flavours of hot air oven dried sample kept at room temperature and refrigerator temperature and freeze dried (room temperature and refrigerator temperature) was 4.0 and 4.2 respectively. The flavour of the control was 4.2 which is nearer to the freeze dried sample. After the storage the sensory evaluation results revealed that the sensory scores of the flavour of hot air oven dried sample kept at room temperature and refrigerator temperature and freeze dried (room temperature and refrigerator temperature) was 3.5, 3.5 and 3.8, 3.9 respectively.

The sensory scores of the texture of hot air oven dried sample kept at room temperature and refrigerator temperature and freeze dried (room temperature and refrigerator temperature) was 4.5 and 4.5 respectively. The flavour of the control was 4.2 which is nearer to the freeze dried sample. After the storage the sensory evaluation results revealed that the sensory scores of the texture of hot air oven dried and freeze dried was (room temperature and refrigerator temperature) was 3.8, 3.9 and 3.9, 4.0 respectively. The sensory scores of the overall acceptability of hot air oven dried sample kept at room temperature and refrigerator temperature and freeze dried (Room temperature and refrigerator temperature) was 4.4 and 4.6 respectively. The flavour of the control was 4.2 which is nearer to the freeze dried sample. After the storage the sensory evaluation results revealed that the sensory scores of the overall acceptability of hot air oven dried and freeze dried was (Room temperature and refrigerator temperature) was 3.6, 3.7 and 3.8, 3.8 respectively. The results

revealed that the hot air oven and freeze dried samples of jack fruit powders were acceptable and reconstitution properties of the powders were acceptability. Among the two techniques the freeze dried powders were good in all sensory attributes and also retention of nutrients.

CONCLUSION

The main objective of the study was to study the effect dehydrating processing techniques hot air oven and freeze drying on the jack fruit powder. The loss of moisture, yield of the product, nutrient content of vitamin-A and vitamin-C and acceptability was studied. The study also envisage to use the developed dried jack fruit powders in the preparations of the juice and the acceptability of these powders were also studied by sensory evaluation and keeping quality. Jack fruit was selected and two different driers using hot air oven drier and freeze drier was studied the effect of these two drying methods on the moisture content was hot air oven dried powder 5.9% and freeze dried powder 5.4%: vitamin-A content of the hot air oven dried powder was 150.45 IU and freeze dried powder was 250.68 IU, and vitamin-A-C content of the hot air oven dried powder was 2.15 mg and freeze dried powder was 5.92 mg. The freeze dried powders contain higher nutrient retention than hot air oven dried powder. Because in freeze drying samples were not exposed to high temperature.The dried powders were subjected to sensory evaluation in the form of juice. To prepare juice amount of powder was standardized. To 100ml of juice preparation 7.5g of powder was acceptable in all the sensory attributes.The powders were kept for storage for a period of seven days. Powders were subjected to sensory evaluation in the form of juice before and after storage. The samples were also stored in two different temperatures that is room temperature and refrigeration at 4-60C. The sensory evaluation attributes revealed that the freeze dried sample stored at refrigerator scored equal to fresh juice in all the attributes. The sensory scores at the control (fresh fruit juice) and freeze dried (refrigerator sample) after storage for colour was 4.1, 4.00 taste was 4.2, 3.8 flavour was 4.2, 3.9 texture 4.2, 4.0 and overall acceptability was 4.2, 3.8 respectively. Freeze drying comparatively found to be better drying method then the hot air oven drying method, because of the better rehydration, better colour, flavour, taste, texture and overall acceptability better nutrient content of vitamin-A and vitamin-C.

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Figure 1: Research of Jack Fruit Powder

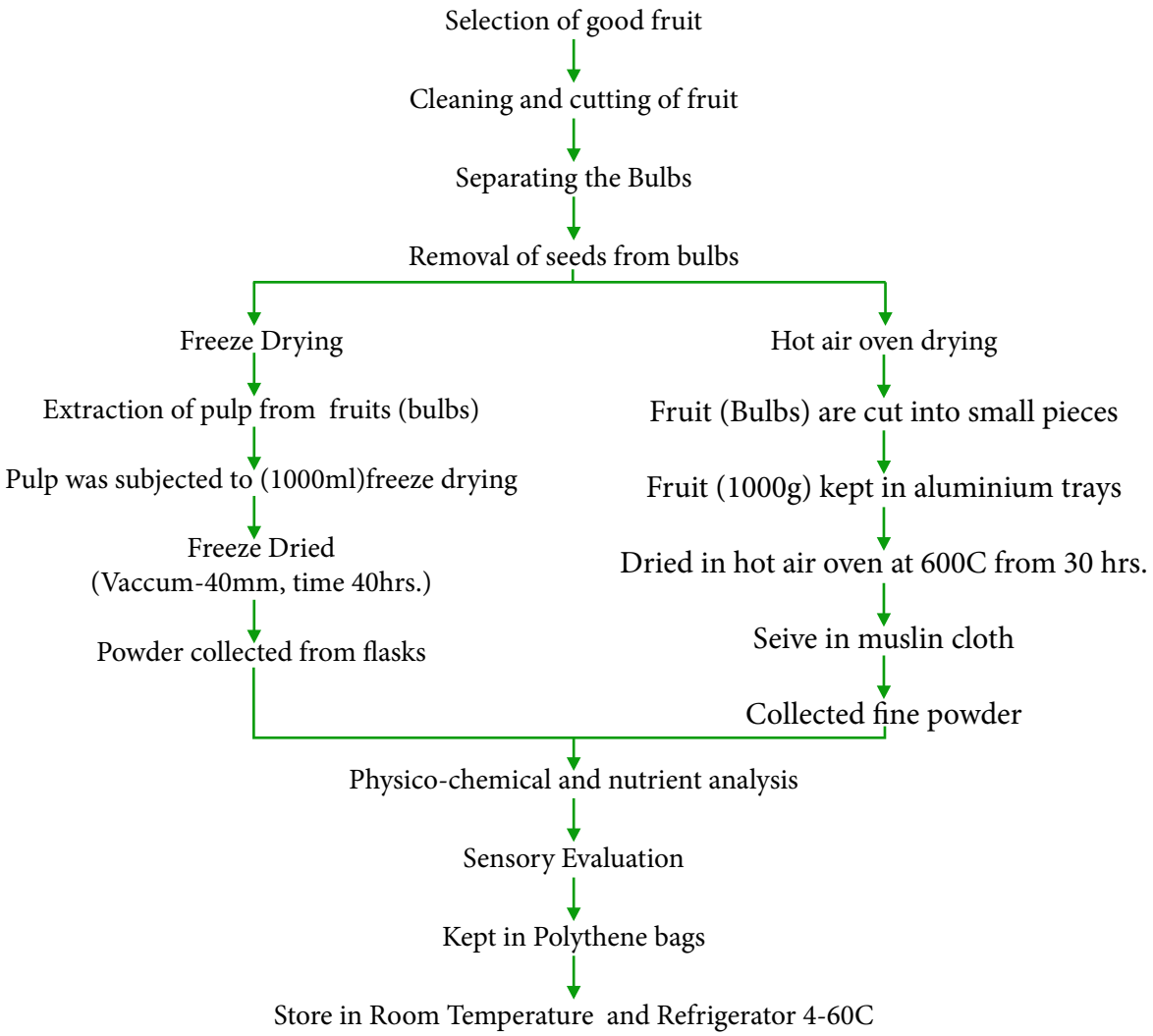

Figure 2: Flow chart for preparation of sample

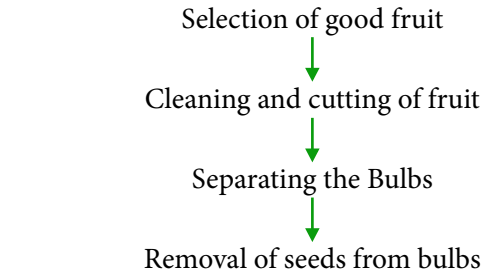

Figure 3: Flow chart jackfruit powder dried in hot air oven.

Selection of the Fruit
↓
Bulbs were separated
↓
Removal of seeds
↓
Bulbs were cut into small pieces
↓
Put in Aluminium trays
↓
Kept in hot air oven (600C; 30 hrs)
↓
Dry the pieces and make into fine powder
↓
Seive in muslin cloth
↓
Preserved in polythene bags
↓
Store in cool and dry place

Figure 4: Flow chart jackfruit powder dried in freeze dryer

Selection of the fruit
↓
Bulbs are separated
↓
Removal of the Seed
↓
Extraction of pulp from bulbs
↓
1000 ml pulp kept for freeze drying
↓
Vaccum pump on -400C
↓
Vaccum pump maintain 76 m
↓
Dried for 3 weeks
↓
Powder collected from Flasks
↓
Preserved in polythene bags
↓
Stored in cool and dry place

Photo 1: Preparation of Jack Fruit Sample in Hot Air Oven Drier

Photo 2: Preparation of Jack Fruit Powder in Freeze Drier

Table 1: Jack fruit powder yield from hot air oven and freeze drying method.

S. No	Powder yield	*Hot Air Oven Drying*	Freeze drying
1.	Initial weight of the raw material (g)	1000	1000
2.	Final weight of the material (g)	178	160
3.	Power yield (%)	17.8	16.0

Table 2: Mean sensory scores of developed jack fruit powder by different methods of drying

S. No	Sensory Attributes	*Hot Air Oven Drying*	Freeze drying
1.	Colour	4.1	4.3
2.	Taste	4.1	4.4
3.	Flavour	4.0	4.1
4.	Texture	4.5	4.5
5.	Overall acceptability	4.5	4.6

Figure 5: Mean Sensory Scores of developed Jack Fruit Powder by different Methods of Drying

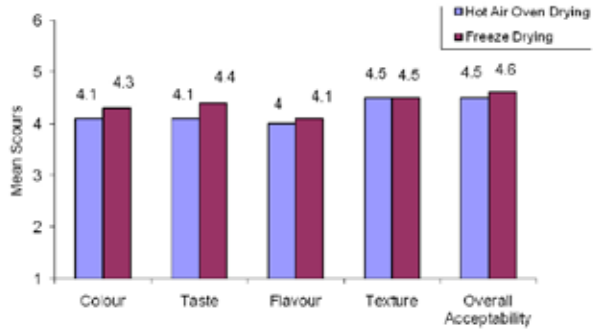

Photo.3: Hot Air Oven and Freeze Drier Jack Fruit Powders

Figure 6: The percent Moisture Content of Sample Before and After Storage

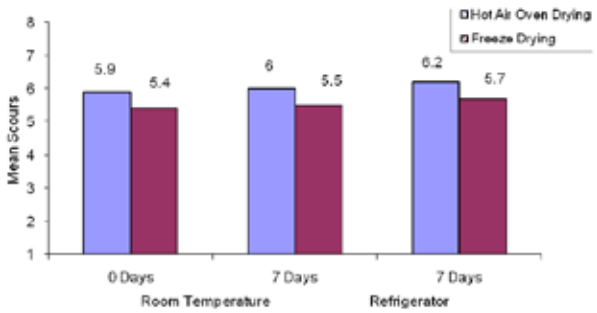

Table 3: The percent moisture content of sample before and after storage

S. No	Samples	*Moisture (%)*	
		0 day	7days
1.	**Hot air oven dried powder**		
	Room temperature	5.9	6.0
	Refrigerator Temperature	----	6.2
2.	**Freeze dried powder**		
	Room temperature	5.4	5.5
	Refrigerator Temperature	----	5.7

Figure 7: The Vitamin – A Content of Samples Before and After Storage

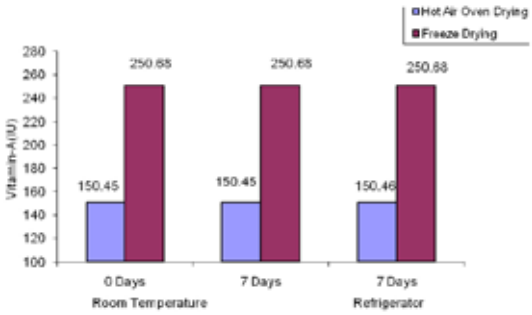

Figure 8: The Vitamin – C Content of Samples Before and After Storage

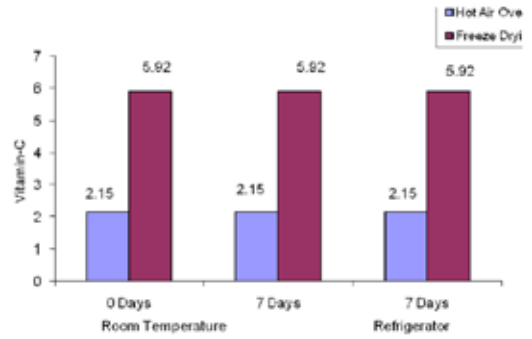

Table 4: The vitamin-A content of the samples before and after storage

S. No	Samples	*Vitamin-A (IU)*	
		0 day	7days
1.	**Hot air oven dried powder**		
	Room temperature	150.45	150.45 01
	Refrigerator Temperature	----	150.46
2.	**Freeze dried powder**		
	Room temperature	250.68	250.68 01
	Refrigerator Temperature	----	250.68

Table 5: The vitamin-C content of the samples before and after storage

S. No	Samples	*Vitamin-C (mg)*	
		0 day	7days
1.	**Hot air oven dried powder**		
	Room temperature	2.15	2.15 01
	Refrigerator Temperature	----	2.15
2.	**Freeze dried powder**		
	Room temperature	5.92	5.92 01
	Refrigerator Temperature	----	5.92

Table 6: Standardization of Juice Using Jack Fruit Powder

S. No	Particulars	*Samples*			
		T1	T2	T3	T4
1	Jack Fruit Powder (g)	2.5	5.0	7.5	10.0
2	Sugar (gr)	10	10	10	10
3	Water (ml)	100	100	100	100

Table 7 (a): Mean sensory evaluation and overall scores for hot air oven dried powder juice samples.

S. No	Samples	*Flavour*	*Texture*	*Colour*	*Taste*	*Overall accept-ability*
1	T1	3.5	3.6	3.7	3.7	3.7
2	T2	3.9	3.9	4.0	4.0	3.9
3	T3	4.0	4.5	4.1	4.1	4.4
4	T4	3.7	3.5	3.5	3.6	3.6

Table 7(b): Mean sensory evaluation and overall scores for Freeze dried powder juice samples.

S. No	Samples	*Flavour*	*Texture*	*Colour*	*Taste*	*Overall accept-ability*
1.	T1	3.6	3.7	3.9	3.5	3.7
2.	T2	3.9	3.9	4.1	3.9	3.9
3.	T3	4.2	4.5	4.2	4.3	4.6
4.	T4	3.9	4.0	3.9	3.9	3.9

Figure 9a: Mean Sensory Evaluation and Overall Scores for Hot air oven Dried Powder Juice Samples

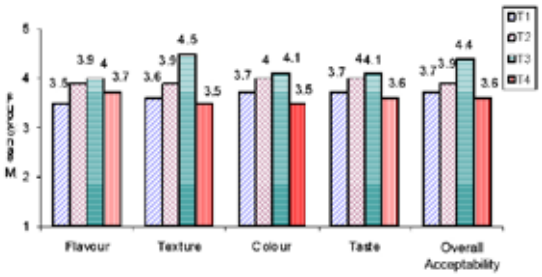

Photo 4: Preparation of Juice with Jack Fruit Powders
A: Freeze Dried Jack Fruit Powder Juice
B: Hot Air Oven Dried Jack Fruit Powder Juice

Figure 9b: Mean Sensory Evaluation and Overall Scores for Freezed Dried Powder Juice Samples

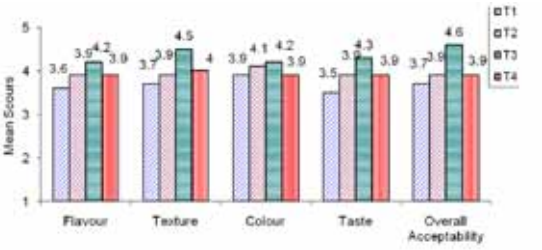

Table 8: Sensory evaluations of standardized jack fruit powder juice samples before and after storage.

S. No	Samples	*Colour*		*Taste*		*Flavour*		*Texture*		*Overall acceptability*	
		0day	*7day*	*0day*	*7day*	*0day*	*7day*	*0day*	*7day*	*0day*	*7day*
1.	Fresh juice (Control)	4.1	---	4.2	---	4.2	---	4.2	---	4.2	---
2.	Hot air oven dried powder										
a)	Room temperature	4.1	3.9	4.1	3.5	4.0	3.5	4.5	3.8	4.4	3.6
b)	Refrigerator temperature		3.8		3.6		3.5		3.9		3.7
3.	Freeze dried powder										
a)	Room temperature	4.2	3.9	4.3	3.7	4.2	3.8	4.5	3.9	4.6	3.8
b)	Refrigerator temperature		4.0		3.8		3.9		4.0		3.8