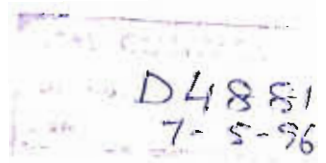


DEVELOPMENT OF PRESERVATION TECHNIQUES FOR
PALMYRAH FRUIT SECTIONS (RAW FRUITS)

BY

K. RADHIKA RANI
B.Sc. (H.Sc)



THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE
IN THE FACULTY OF HOME SCIENCE

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NOVEMBER, 1995

CERTIFICATE

Mrs.K. RADHIKA RANI, has satisfactorily prosecuted the course of research and that the thesis entitled DEVELOPMENT OF PRESERVATION TECHNIQUES FOR PALMYRAH FRUIT SECTIONS (RAW FRUITS) submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 6. November, 1995.

Place: Hyderabad.



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CERTIFICATE


This is to certify that the thesis entitled DEVELOPMENT OF PRESERVATION TECHNIQUES FOR PALMYRAH FRUIT SECTIONS (RAW FRUITS) submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN HOME SCIENCE of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Mrs.K.RADHIKA RANI under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

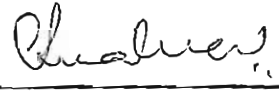
No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

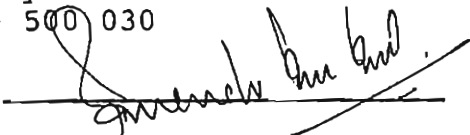

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(K. RADHIKA RANI)

DECLARATION

I, Mrs.K. RADHIKA RANI, hereby declare that the thesis entitled DEVELOPMENT OF PRESERVATION TECHNIQUES FOR PALMYRAH FRUIT SECTIONS (RAW FRUITS) submitted to the A.P. Agricultural University for the degree of Master of Science in Home Science is a result of the original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

Date: November, 1995

(Mrs.K. RADHIKA RANI)

Place: Hyderabad.

LIST OF SYMBOLS AND ABBREVIATIONS

APAU	:	Andhra Pradesh Agricultural University
Ca	:	Calcium
cm	:	centi meter
CO ₂	:	Carbondioxide
Cu	:	Copper
Fe	:	Iron
FPO	:	Fruit products order
g	:	gram
HClO ₄	:	Perchloric acid
HCl	:	Hydrochloric acid
H ₂ SO ₄	:	Sulphuric acid
HNO ₃	:	Nitric acid
Kcal	:	kilo calorie
kg	:	kilo gram
KMS	:	Potassium meta bisulfite
ml	:	milli litre
mg	:	milli gram
Mg	:	Magnesium
min	:	minutes
Mn	:	Manganese
N	:	Normality
NaOH	:	Sodium hydroxide
nm	:	nanometer
No.	:	Number
ppm	:	parts per million

Rs. : Rupees
SO₂ : Sulphurdioxide
Zn : Zinc
< : Less than
> : greater than
°C : degree temperature

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ABSTRACT

The present study was conducted to develop preservation techniques for tender palmyrah palm (*Borassus flabellifer* Linn.) fruit as its shelf life is very limited and because of wide acceptability during summer, attempt was made to preserve the palmyrah fruits by developing suitable preservation methods.

Fresh palmyrah fruits were obtained from nearby village. Initially proximate composition of the fruits was estimated by using standard procedures. Different preservation methods were developed and they are (a) use of different temperatures i.e., ambient temperature (37-40°C), refrigeration temperature (4-6°C) and dehydration temperature (50-70°C), (b) use of different concentrations of sugar syrup i.e., 50°Brix sugar syrup and 70°Brix sugar syrup, (c) use of honey i.e., 40°Brix and 80°Brix, (d) use of 50°Brix sugar syrup with chemical preservatives (Potassium metabisulfite and sodium benzoate). The processed fruits were stored in food grade polyethylene containers of half litre capacity. Storage study was for a period of ten days and organoleptic evaluation was done by a trained panel of 6 members (from Post-Graduate and Research Centre, Rajendranagar, Hyderabad) at 2 days interval using score card. The preserved products were analysed for total and reducing sugars and minerals such as calcium, magnesium, zinc, iron, copper and manganese by using standard procedures. Standard plate count was done to know the bacterial load, at the end of the storage period.

The palmyrah fruits were found to be low in protein and fat but high in moisture content. Fruit was found to be rich in minerals i.e., calcium, magnesium, iron, zinc, copper and manganese.

The organoleptic evaluation results show that the fruits at ambient temperature (37-40°C) stored for only 12 hours. The fruits stored at refrigeration temperature (4-6°C) kept well for 8 days. The products stored by dehydration process were found to be better in acceptability and storage compared to the fruits stored at ambient (37-40°C) and refrigeration (4-6°C) temperatures. The fruits preserved by using different concentrations of sugar syrup show, that the fruits preserved by candy preparation were well accepted, compared to the fruits preserved in 70°Brix sugar syrup - open kettle one period process and open kettle slow process; and also fruits in 50°Brix sugar syrup, for a storage period of 10 days. Fruits preserved in 80°Brix honey were acceptable for 6 days only, due to insufficient syrup strength to preserve the fruit. The fruits preserved in 50°Brix sugar syrup with chemical preservatives stored well for 10 days. The use of combination of preservatives (potassium metabisulfite and sodium benzoate) in sugar syrup was found better compared to the use of preservatives individually in the preservation of fruits. Use of preservatives have not only increased the shelf life but also prevented the spoilage of the fruit. It can be observed that the use of high temperatures, use of higher concentrations of sugar syrup and honey, use of chemical preservatives was found to be better in increasing the shelf life of the preserved product.

The total sugars and reducing sugars in the preserved products were found to be high in those using sugar syrup as a media for preserving the fruits. The lower contents of total and reducing sugars in the fruits preserved at ambient temperature (37-40°C) and refrigeration (4-6°C) temperatures may be attributed to the oxidation of sugars in the fruits. The estimated mineral contents in the preserved products were in lower concentrations which may be due to the leaching of minerals into the processed water by ex-osmosis.

Microbiological evaluation of the preserved products show that use of higher temperatures and use of higher concentrations of sugar syrup showed low bacterial counts compared to those stored at ambient (37-40°C) and refrigeration temperatures (4-6°C) which may be due to low moisture availability. The use of chemical preservatives have also showed low bacterial count compared to those stored at ambient (37-40°C) and refrigeration temperatures. So the use of high concentration of sugar syrup, high temperatures and use of chemical preservatives have reduced the bacterial load.

CHAPTER I

INTRODUCTION

Palm trees are nature's gift which has tremendous potentiality for full exploitation. Palm belt in the world roughly extends from 44° south latitude to 45° north latitude and widely encompasses the tropical countries like Congo, Indo-China, Srilanka, India, Bangladesh, Indonesia and Malaysia (Hanumaiah and Kamble, 1989).

"*Borassus*" is a genus of four species of tall dioecious palms, distributed in the tropics of the old world. Genus "*Borassus*" is from greek, name applied to covering of fruit, where as species "*flabellifer*" from latin, meaning fan bearer. *Borassus flabellifer* is the only species found in India. *Borassus flabellifer*, is a native of tropical Africa and is found in many of the comparatively dry parts of India, Burma, Ceylon and is common along the coastal areas of the peninsula, Bihar, West Bengal and northern part of the Ceylon. It is widely distributed in Malaya. *Borassus flabellifer* is known by various names in different languages and it is known as 'Tar' in Hindi and 'Tadichettu' in Telugu.

The palmyrah palm tree provides various edibles and non-edible products which contributes to economy of the state. Palmyrah palm tree bears the fruits which are large and fibrous, containing usually 3-nut like portions,

each of which encloses a seed. When the fruits are tender the seeds consist of a soft, sweet, gelatinous pulp with a little fluid in them. During hot months the soft gelatinous kernel (before hardening sets in) is exceedingly refreshing item of food. The pulp gradually hardens into a bony kernel and develops a fibrous coat. The cotyledon in germinating seeds, a cream coloured substance of cheesy consistency which is sweet and pleasant, delicious to taste and is liked by one and all. When the seedlings are 2-3 months old, the tender shoots which are starchy are edible, and sometimes flour is made from dried tender seedlings. The other edible is the ripened palmyrah fruit which is the mesocarp and is golden coloured, luscious, sweetish and pasty in texture. The juice is squeezed out and dried in thick layers into an edible preparation called 'punatoo' in Ceylon and 'palm jelly' (Tati thandra) in India. This juice is consumed as such or made into sweet products in Bengal.

Palm juice is an important product obtained from the inflorescence of both male and female trees and is known as "neera" which is a refreshing drink with pleasant sweet taste and cools the body system. Palm gur, palm sugar and palm candy are the direct products obtained from the processing of palm juice. Palm gur (palm jaggery) is obtained by evaporation of neera to a semi-solid consistency. It is sweet whole sugar mass containing all the

vital constituents of neera. Palm sugar and candy are obtained in crystal form prepared out of palm syrup at the appropriate stage of concentration and adopting suitable crystallization techniques. Besides the sugars (sucrose) they are also rich in vital constituents of neera, retained in them. Palm gur, palm sugar and palm candy are the sweetening agents with valuable nutrients that contribute to nation's health. Sweets, aerated beverages like palm cola, palmata and fruit preserves like jams, jellies, canned fruits etc. are prepared with palm sugar (Hanumaiiah and Kamble, 1989). Sugar based candy, liquid glucose etc. is also made out of it.

Other than the edibles, non-edible products and other minor products like, brooms, brushes, timber etc. can also be obtained from palm trees. Fibre obtained from leaf stalks is of good quality and has been commonly used for the preparation of ropes, brushes and brooms in villages. Palm leaves were used especially for writing epics in the olden days. At present, palm leaves were used extensively for making fans, umbrellas, baskets, mats etc. and also a common roofing material for the houses. The stem of the palm tree is cheap and excellent timber material which is very widely used in different forms of constructions such as rafters, pillars, posts, crude bridges. It is also used as watering channels, after removing inner pulp in longitudinally cut halves. Poor

quality timber, leaf stalks, fruit stalks, unutilized fruit material are excellent fire wood and are cheap. The products prepared from naar and fibre are having good export potential (Ramakrishna Rao, 1994).

Apart from all these, the edibles of palmyrah palm tree were found to have medicinal and nutritional importance also (Ramakrishna Rao, 1994). Since the utility of palm tree is multiparous it is popularly described as "Kalpavriksham" of earth.

According to Blatter (1926) who has made an extensive study on the subject of palms of British India and Ceylon exclaimed "Every part of the palmyrah palm is turned in account in some way or other". By far the most important aspect of this tree is a source of food. The source is the edibles of the palmyrah palm. The edibles of the palm are seasonal and their seasonal availability is as below (Ramakrishna Rao, 1994): Neera is obtained from month of January to June, Palmyrah fruit (tender) is obtained from June to August, Ripe palmyrah fruit is seen in months of August to October and in the remaining part of the year tender seedlings of germinating cotyledon are obtained. Palmyrah trees are well known for their 'neera' production and scientific research on utilization of neera as commercial product is in progress. Palmyrah trees are also well known for their tender fruits, which are



Plate 1: Palmyrah palm tree (Borassus flabellifer Linn.)



Plate 2: Bunch of palmyrah fruits (Borassus flabellifer Linn.)

available only in summer (June-August) and are relished very much. But the fruits are easily perishable and they cannot be stored for longer periods at room temperature. Shelf life is very short and the availability of the fruit is only for a particular season and is limited to certain areas only. No literature is available on preservation methods for palmyrah fruits. Hence, an attempt was made to find out satisfactory preservation methods to increase the shelflife of the palmyrah fruits. So, the present study was planned with the following objectives:

1. To see the keeping quality of palmyrah fruit in polyethylene (transparent) containers.
2. To see the keeping quality of the fruit at different temperatures (A) Room temperature (B) Refrigeration
3. Preserving the fruit in sugar syrup solution (50 per cent sugar syrup) with sodium metabisulfite (600 mg/kg)
4. Preserving the fruit in sugar syrup solution without metabisulfite
5. Preserving the fruit using honey as covering liquid
6. Organoleptic studies on preserved products done at different time intervals.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Palmyrah palm trees are the nature's gift to the man kind, because of its varied utility it is known as the 'kalpavriksha' of the earth. Palmyrah palm trees are well known for their tender palm fruit in summer which are relished as soothing and refreshing fruit. But the availability of the fruit is only in a particular (June-August) season. To increase the shelf life as it is highly perishable and also to make it available in other seasons of the year, various preservation techniques have been attempted. A variety of preservation methods are used depending on the type and nature of fruits and vegetables which are seasonal and are perishable in nature. The principles in general, followed in the preservation against the spoilage of fruits and vegetables are as follows (Srivastava and Sanjeev Kumar, 1994):

- I. Prevention or delay of microbial decomposition
 - a) by keeping out micro-organisms (asepsis)
 - b) by removal of micro-organisms Eg: by filtration
 - c) by hindering the growth and activity of micro-organisms: Eg. by low temperature, drying, anaerobic conditions, chemicals or antibiotics

d) by killing the micro-organisms Eg. by heat or radiation.

II. Prevention or delay of self-decomposition of the food.

a) by destruction or inactivation of enzymes Eg. by blanching

b) by prevention or delay of chemical reactions. Eg. prevention of oxidation by means of an antioxidant.

III. Prevention of damage by insects, Rodents, animals, mechanical causes etc.

Based on the above principles of preservation, various methods of preservation, are employed and the methods generally used are as follows (Srivastava and Sanjeev kumar, 1994).

1. Asepsis (Absence of infection)

Asepsis means preventing the entry of micro-organisms in the test sample. Maintaining of general cleanliness while picking, grading, packing and transporting of fruits and vegetables increases their keeping quality and products prepared will be of superior quality.

2. Preservation by high temperature

Application of heat leads to coagulation of proteins and inactivation of their metabolic enzymes leading to the destruction of micro-organisms present in foods. The specific heat treatment varies with the kind of organism and nature of food to be preserved and other means of preservation in addition to use of high temperature. High temperatures used for preservation are usually:

- (i) Pasteurization temperature (below 100°C)
- (ii) Sterilization temperature (100°C or above)
- (iii) UHT - Total sterilization

3. Preservation by low temperature

Microbial growth and enzymatic and other physiological reactions are retarded in fruits and vegetables stored at low temperatures. The lower the temperature, the greater the retardation. Low temperatures can be produced by:

- i) Cellar storage (about 15°C)
- ii) refrigeration or chilling (0 to 5°C) and
- iii) freezing (-18°C to -40°C)

4. Preservation by chemicals

Microbial spoilage of food products is also controlled by using chemical preservatives which do not

include salt, sugar, acetic acid, oils, alcohol etc. but only microbial antagonists. Inhibitory action is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes. Two important chemical preservatives permitted in many countries are:

- i) Sulphur dioxide (including sulphites) and
- ii) Benzoic acid (include benzoates). These two are also allowed in India according to fruit products order (FPO, 1955).

5. Preservation by drying

Micro-organisms need moisture to grow. So when the concentration of water in the food is brought down below a certain level, they are unable to grow. Moisture can be removed by the application of heat as in sun-drying or by mechanical drying (dehydration by cabinet drier, vaccum drier and freeze drier etc.).

6. Preservation by filtration

In this method of filtration, the juices are clarified by settling or by using ordinary filters and then passed through special filters which are capable of retaining yeasts and bacteria. Various types of germ-proof filters are used for this purpose.

7. Preservation by carbonation

Carbonation is a process of dissolving sufficient carbondioxide in water or soft drinks. So that the product when served gives off gas as fine bubbles and has characteristic taste. Moulds and yeasts require oxygen for their growth and they became inactive in presence of carbondioxide.

8. Preservation by sugar

Syrups containing 66 per cent or more of sugar do not ferment. Sugars absorbs most of the available water with the result that there is very little water for the growth of micro-organisms hence their multiplication is inhibited, and even those already present die out gradually. Dry sugar does not ferment. Thus sugar acts as a preservative by osmosis and not as true poison for micro-organisms. Fruit syrup, jam, jelly, marmalade, preserve, candy, crystallized fruit and glazed fruit are preserved by higher sugar content.

9. Preservation by fermentation

Decomposition of carbohydrates by micro-organisms or enzymes releasing alcohol and CO_2 is called fermentation. In commercially produced wines the production of 14 per cent of alcohol acts as a preservative against the growth of yeast and moulds.

10. Preservation by salt

Salt at the concentration of 15-25 per cent is sufficient to preserve most products. Salt inhibits enzymatic browning and discolouration and also acts as an antioxidant. Salt in the form of brine is used for canning and pickling of vegetables (Eg. Cucumber, onions).

11. Preservation by antibiotics

Certain metabolic products of micro-organisms have been found to have germicidal effect and are termed as Antibiotics. The most commonly used antibiotics to preserve fruits and vegetables and their products are Nisin (used in canning of mushrooms, tomatoes and milk products) and subtilin (used in preservation of asparagus and corn peas).

12. Preservation by irradiation

Sterilization of food by ionizing radiations is a recent venture of preservation which is gaining general acceptance and is being cleared by many countries of the world.

Little information available on statistics, potentiality, nutritive value and medicinal value of palmyrah palm fruit and also on edibles of palmyrah palm were presented below:

As there is no available literature on preservation of palmyrah fruit, preservation technologies generally used for fruits and vegetables (as the same principles are being followed in the present study) have been discussed under the following subheadings.

- 2.1 STATISTICS OF PALMYRAH PALM TREES
- 2.2 POTENTIALITY OF SINGLE PALMYRAH PALM
- 2.3 NUTRITIVE VALUE OF TENDER PALMYRAH PALM FRUIT AND EDIBLES OF PALMYRAH PALM
- 2.4 MEDICINAL VALUE OF PALMYRAH PALM FRUITS AND EDIBLES OF PALMYRAH PALM
- 2.5 PRESERVATION AT DIFFERENT TEMPERATURES
- 2.6 PRESERVATION BY USE OF CHEMICAL PRESERVATIVES
- 2.7 PRESERVATION BY CANDY PROCESSING
- 2.8 PRESERVATION BY DEHYDRATION
- 2.9 MICROBIOLOGICAL EVALUATION OF FRUITS AND THEIR PRODUCTS
- 2.1 STATISTICS OF PALMYRAH PALM TREES

The most commonly relished fruit in south India which is seen mainly in Tamil Nadu, Andhra Pradesh and Karnataka is the palmyrah tender fruit. It is also seen

along the coastal areas of Bihar and West Bengal in north India.

Statistical data of palmyrah palm trees as per the Agricultural Survey of India was not recorded (as it is not a agricultural food crop). Due to the lack of statistical data, certain references quoted by a few people have been given below:

Nair (1987) reported that the palmyrah palm trees in India numbered 7.76 crores in the year 1985-86 out of which only 5.44 crores are tappable but only 1.52 crores were tapped. Utilization of other products have not been recorded. According to Kamble (1987) the number of palmyrah trees were 10.89 crores in India but only 7.3 crores were tappable while actual palms tapped remained 1.3 crores only. Krishna Bharati (1987) had claimed that India possess more than 8 crores of palm trees out of which not even 3 crores were fully utilised. In the year 1994, Rama Krishna Rao in his review article on palm trees mentioned a very high number of trees i.e., 17 crores and out of which only 13 crores of trees were used for neera tapping. This shows that the recorded number of palmyrah palm trees have tremendously increased from 8 crores in 1987 to 17 crores in 1994 in India.

Studies relating to the statistics of other states in India were not available except in Tamil Nadu

and Andhra Pradesh. Nair (1987) reported that palmyrah palm trees numbered 5.01 crores in Tamil Nadu but only 3.39 crores were tapped. Ramakrishna Rao (1994) reported that in Andhra Pradesh palmyrah trees accounted for 7.51 crores out of which only 6.7 crores were tapped. Out of 17 crores of palm trees in India (Ramakrishna Rao, 1994), Andhra Pradesh accounted for 7 crores.

2.2 POTENTIALITY OF SINGLE PALMYRAH PALM

The palm tree is accounted with good amount of useful material for preparation of various products. The materials available from palm tree are neera, fibre, eark, leaf and naar. The finished products obtained from the above material are Gur, Brushes, Basket, Mats respectively. In addition baskets were also made from Naar.

The raw material available from single palmyrah palm and also the quantity of raw material needed for preparing the finished products are given in Table 1 along with the amount realisable from each product (Hanumaiah and Kamble, 1989).

Table 1. Potentiality of single palmyrah palm (per year)

Name of the material	Quantity available	Finished products	Value realisable (Rs.)
Neera*	150 litres	Gur 20 kg	200.00
Fibre	1 kg	Brush: 12 Nos	48.00
Eark	2.5 kg	Basket 4 Nos	50.00
Leaf	8 Nos	Mats 6 Nos	28.00
Naar	16 Nos	Basket 1 No.	10.00
		Total	342.00

* If sweet sap is catered as neera, the returns realisable would be much higher.

2.3 NUTRITIVE VALUE OF TENDER PALMYRAH PALM FRUIT AND EDIBLES OF PALMYRAH PALM

The available literature on proximate composition of palmyrah fruit as well as edibles have been given below. The reported literature on the proximate composition of the tender palmyrah palm fruit has been given by Mitra and Mittra in 1940. Almost similar results were obtained by Gopalan et al. (1994). The composition of the palmyrah fruit was given in Table 2.

Table 2. Proximate composition of tender palmyrah palm fruit (per 100 g)

Nutrient	Proximate composition of palmyrah palm fruit	
	Mitra and Mittra (1940)	Gopalan <u>et al.</u> (1994)
Moisture (g)	92.6	92.3
Protein (g)	0.6	0.6
Fat (g)	0.1	0.1
Mineral water (g)	0.2	0.2
Crude fibre (g)	0.1	0.3
Carbohydrate (g)	6.2	6.5
Calcium (mg)	5.0	10.0
Phosphorous (mg)	16.0	20.0
Iron (mg)	NR	0.5
Total calorie value (Kcal)	27.0	29.0

NR - Not recorded

It is seen from the above table that Gopalan et al. (1994) reported slightly higher values compared to the values given by Mitra and Mittra (1940).

Mitra and Mittra (1940) reported on the edibles of palmyrah palm other than the tender palm fruit. The edibles are Neera, Targur, Cotyledon, Pulp of ripe fruit and flour of tender seedlings.

Neera: Neera is the name given to sweet unfermented juice obtained from the inflorescence of both male and female

plants. It is observed that neera is being offered specially during festival occasions like "Gramadevata" poojas or Jataras in villages (information obtained from villagers through personal contact).

Targur: Targur is the name given to palm jaggery prepared by concentrating neera to a semisolid state and poured into required rectangular moulds based on market requirement. Palm gur is a dark solid with a characteristic flavour. Instead of sugar jaggery, palm jaggery can be used as sweetening agent with valuable nutrients.

Cotyledon: Cotyledon is a cream coloured substance of cheese like consistency which develops inside the kernel of ripe fruit as soon as small roots are seen springing out from fibrous surface of seeds. It has sweet, pleasant taste.

Ripe fruit: The pulp of the mesocarp of the ripe fruit is golden yellow coloured, luscious, sweetish and pasty in texture. This ripe fruit is used in making of "thati thandra" and also in preparation of sweet snacks like "thati burelu" (a traditional product of Andhra Pradesh). Thati burelu is a deep fat fried snack (Rice flour + Palmyrah palm ripe fruit juice) which is a delicious snack sold in five star hotels.

Flour of tender seedlings: When the seedlings are 2-3 months old, the tender shoots, which are starchy, are edible and sometimes flour is made from them. The starchy edible shoots as a whole are well relished but the use of the flour has not been mentioned.

The reported chemical composition of the edibles of palmyrah palm by Mitra and Mittra (1940) is given in the Table 3.

Table 3. Nutritive value of edibles from palmyrah palm (per 100 g)

Nutrients	Neera	Targur	Coty- ledon	Pulp of ripe fruit	Flour (tender seedlings)
Moisture (g)	85.94	8.61	80.99	77.22	12.06
Protein (g)	0.23	1.03	0.75	0.67	4.51
Fat (g)	0.02	0.08	0.12	0.15	0.31
Mineral water (g)	0.29	1.81	0.85	0.68	1.91
Carbo- hydrates (g)	13.52	88.47	17.29	21.28	80.91
Calcium (mg)	6.00	225.00	24.00	9.00	10.00
Phosphorus (mg)	7.00	44.00	116.00	33.00	155.00
Total sugars(g)	12.60	84.00	NR	NR	NR
Reducing sugars (g)	0.40	2.00	NR	NR	NR
Disaccharides	11.60	79.90	NR	NR	NR
Total calorie value (Kcal)	56.60	367.70	75.10	91.40	354.20

NR : Not recorded.

2.4 MEDICINAL VALUE OF PALMYRAH PALM FRUITS AND EDIBLES OF PALMYRAH PALM

Palmyrah palm trees are useful not only in providing edibles and non-edible products to improve the economy but also have medicinal importance. The medicinal value of palm fruit and some of the edibles have been reviewed by Rama Krishna Rao (1994).

Tender palmyrah palm fruit: Palmyrah palm fruit was found to have certain medicinal values where it was reported to have diuretic effect in the body. Water in the palmyrah palm fruits was reported to have effect on maintenance of body temperature. Water in the fruits was also supposed to increase the spermatogenesis in males and in females it increased the milk production during lactation.

Edibles of palmyrah palm with medicinal value other than palmyrah palm fruit are neera, fresh toddy, targur, palm kalakand, cotyledons in germinating seeds, juice of young leaves, ripe palmyrah fruit and shoots of germinating seeds. The medicinal importance of each edible is given below:

Neera: Neera is a refreshing sweet drink and is also credited with medicinal values. It is used as a stimulant and antiphlegmatic. It is also considered to be useful in inflammatory infections and it is also reported to provide relief from cough in Tuberculosis.

Fresh toddy: Fresh toddy is found to increase the appetite and also it is reported to have a drowsy or sleepy effect on the body. But fermented toddy is found to have harmful effect on the body.

Targur: Targur is reported to correct the heat balance (maintenance of body temperature) in the body. It can act as a body stimulant but excess eating may cause drowsiness.

Palm kalakand: Palm kalakand is reported to have a beneficial effect of increasing the digestion power in the body.

Cotyledons: Cotyledons of germinating seeds are sweet and pleasant in taste and mostly liked by children. These cotyledons are easily digestible and is reported to improve the regulation of bowels avoiding constipation.

Young leaf juice: Juice of young leaf when taken as such or along with honey is reported to have curing effect on some of the brain problems including madness etc.

Palmyrah palm (ripe) fruit: Palmyrah palm fruit (ripe) is sweet in taste and it is found to increase sexual activity and spermatogenesis in males. It is also found to eliminate constipation. It is reported to regulate body temperature.

Shoots of germinating palm seedlings: Shoots of germinating seedlings are also reported to have medicinal value as that of palm fruit (ripe) in increasing sexual activity and spermatogenesis in males. It was reported to regulate body temperature and also regulate free bowel movements.

2.5 PRESERVATION AT DIFFERENT TEMPERATURES

Most of fruits and vegetables are perishable in nature and their storage possess a major problem. Shelf life varies for every fruit and vegetable. Some can be stored for one or two days while some for weeks at room temperature. The effect of temperature to improve the shelflife of some of the perishable fruits and vegetables is reviewed.

Jack fruits (Artocarpus heterophyllus) are relished, both as vegetable and fruit. Tender jack fruit are used as vegetable and ripe fruits are used as fruit. The storage life of the fruit is dependent on the initial quality and stage of maturity on harvest. The fruits may be kept well in cold storage for 3-6 weeks at 11.1°C to 12.7°C and relative humidity 65-95 per cent (Berry and Kalra, 1988).

Apart from Jack fruits storage studies on jamun (Syzygium cumini) by Shukla (1979) have showed that jamun had shelflife of 6 days at room temperature (24-30°C) but was able to store for 3 weeks at low temperature (9°C±1°C

and relative humidity 90 per cent) when pre cooled fruits were kept in perforated bags. The preservative treatment on jamun fruits with the combination of citric acid (100 ppm) and ethrel (100 ppm) improved the shelf life upto 12 days at room temperature (24-30°C) when compared to the untreated fruits which showed cent per cent spoilage on the sixth day of storage as reported by Banik et al. (1986).

Apricot fruits (Prunus asmeriaca) being highly perishable have limited storage life under ambient conditions unless handled properly, fruit is rendered unfit for local marketing within a short span of 4-5 days after harvesting and its shelf life under low temperature storage conditions (0°C) and high relative humidity (90-95 per cent) was about 2-4 weeks compared to 4-5 days at room temperature (Sharma et al., 1992).

Not only fruits but vegetables also show increased shelf life at low temperature compared to room temperature. Studies conducted on fresh cauliflower (Brassica oleracea, var. botrytis) by Bawa and Saini (1986) on different varieties of cauliflower have showed that fresh vegetables stored better at refrigeration temperature (4°C) as compared to room temperature (20-30°C). The period of study was only for 72 hours.

Apart from fresh fruits and vegetables products from them like juices and squashes stored well at low temperatures compared to room temperatures. Litchi juice/pulp was found to be acceptable organoleptically for 6 months at room temperature (25-35°C) and upto 12 months at low temperature (4-5°C) when it was heated to 85°C and then preserved either with 500 ppm of SO₂ or 500 ppm SO₂ and 1 per cent citric acid and SO₂ along showed less browning during storage. So low temperature was found better than room temperature for long term storage of litchi juice (Vijaysethi, 1985). Jain et al. (1986) in their studies on Litchi (Nephelium litchi) squash, phalsa (Grewia asiatica) and kaphal squashes stored better at low temperature (6-11°C) than at room temperature. Phalsa (Grewia asiatica) and kaphal squashes stored for a period of twelve months when treated with sulphur dioxide and latter for a period of six months when treated with sodium benzoate.

2.6 PRESERVATION BY USE OF CHEMICAL PRESERVATIVES

Chemical preservatives are used in fruits and vegetable products according to the permissible limits suggested by FPO to increase the shelf life and to preserve its natural taste, colour, aroma. The commonly used preservatives are sulphur dioxide and its salt potassium metabisulfite. Use of chemical preservatives have been adopted in preserving the palmyrah fruit. So a

few studies carried out on different fruits and vegetables using benzoic acid or its salt sodium benzoate, potassium metabisulfite and combination of preservatives have been given below:

Urmil Mehta and Satinder Bajaj (1983) reported the preservation of juices of three varieties of citrus fruits with pasteurization, potassium metabisulphite and sodium benzoate. Their juices stored well in glass bottles at room temperature for eight months and evaluated at monthly interval for acceptability and nutritional quality. Colour retention during storage was better in samples preserved with potassium metabisulfite in comparison with other methods of preservation.

Jain et al. (1986) studied on squashes prepared from phalsa (Grewia asiatica), kaphal and litchi fruits (Nephelium litchi) where they were stored using sodium benzoate in case of phalsa and kaphal and sulphurdioxide in case of litchi. The products stored well for a period of six months in phalsa (Grewia asiatica) and kaphal squashes and twelve months in case of litchi (Nephelium litchi) squash and stored well at low temperature (6-11°C). Similar result in the preservation of litchi squash was reported by Vijay Sethi (1985).

Upasana Rani and Bhatia (1986) reported on the preservation of Bagugosha pear by steeping in sugar syrup

containing 70-72°Brix containing 200 ppm KMS and the product showed excellent texture and characteristics. Preserve packed in polyethylene bags showed satisfactory shelflife for about 40 weeks under ambient conditions.

Preservatives not only increase the shelf life of products but also efficient in controlling the fermentation occurring during storage period. In a study reported by Vijay Sethi and Anand (1984) the growth of bacteria, heat resistant spore forming Bacillus cereus was checked by using sulphur dioxide, sodium benzoate, sodium propionate and potassium sorbate at various concentrations in carrot and amla preserves. Use of combination of preservatives (400 ppm of KMS and 800 ppm of sodium benzoate) showed synergistic action and reduced the quantity of preservatives needed individually.

2.7 PRESERVATION BY CANDY PROCESSING

In candied fruit, the sugar is impregnated in fruit with cane sugar, glucose and subsequently drained and dried. And it is given a transparent coating of sugar to impart to it a glossy appearance. Similar technology of impregnating fruit with cane sugar and draining the syrup and drying the fruit is adopted to prepare candy fruit from palmyrah palm fruit. So studies on technologies pertaining to candy making for fruits have been reviewed.

Raw papaya (Carica papaya) fruits were used for tuti-fruitti preparation where syruling of the fruit was done and then drying the fruit at room temperature for 24 hours produced an excellent product according to Khedkar et al. (1980). Sand pear and Bagugosha pears were preserved by similar techniques. It is by dipping in 40°Brix initially and then increasing the Brix till 70° Brix. The candy pieces were allowed for surface drying and then rolled in powdered sugar and packed in cellophane/polyethylene bags. The candies stored well for about 16 weeks at 37°C and 40 weeks under ambient (27-30°C) conditions as reported by Upasana Rani and Bhatia (1985).

3.8 PRESERVATION BY DEHYDRATION

Preservation by drying is perhaps the oldest method known to man kind. The foods preserved by drying can be stored well for longer periods. Prior to drying, pre-preparation of the fruit like hot water blanching and sulphiting is needed. Pre treatment improves the quality of the product when reconstituted.

Sulphur dioxide treatments are widely used in the food industry as SO₂ absorbed by the fruit intended to maintain an attractive colour, prevent spoilage and preserve certain attributes until marketed (Roberts and

McWeeny, 1972). Sulphur dioxide treatments were found essential and sulphiting was adopted by Bhatia et al. (1956) for green jack fruit (Artocarpus heterophyllus). Sulphiting was done by steeping the jack fruit in 0.1 per cent KMS solution for 30 min to improve quality. Similarly ber fruits have also been sulphited at 2g sulphur/kg fruit to obtain a good dehydrated product (Chavan et al., 1993) and the reconstitution was in 40 per cent sugar solution to improve the taste. Longer sulphiting period (30 min) helps in better retention of SO₂ as reported by Khedkar and Susanta (1983) in raw mango slices by steeping the slices in 1.0, 2.0, 3.0 and 4.0 per cent KMS solution for 15-30 min. Absorption and retention of sulphurdioxide increased with increasing concentration of KMS and also the duration of steeping.

Next to sulphiting, water blanching was found essential before drying of fruits. According to Sterling and Shimazu (1961) water blanching increased the amorphous content of the cell wall cellulose in dried carrots which in turn allowed the intact cell walls to more rapidly absorb the water, swell and assume their original shape resulting in improved reconstitutability.

Cabinet drying is adopted for various fruits and vegetables. Cabinet drying was found beneficial over sun drying. Khedkar and Susanta (1980) in the histological studies revealed that higher reconstitution ratio was

observed in cabinet dried raw mango slices as compared to sundried slices due to less rupture of cells during drying in cabinet drier than sun drying. The studies showed thinner and less continuous cell wall in dried and dehydrated raw mango slices after reconstitution as compared to fresh raw mango slices. The thinner walls could possibly be due to degradation of pectic substances (Lee et al., 1966).

2.9 MICROBIOLOGICAL EVALUATION OF PALMYRAH FRUITS AND THEIR PRODUCTS

Microbiological evaluation is needed to check the safety of the product (to see the permissible levels) as for human consumption. Microbiological evaluation of papaya products like papaya nectar, thandra, toffee, cheese and cereal based papaya powder (Aruna, 1995) showed lower counts during the storage period of 9 months and was well accepted. The low count in the products was attributed to the high concentration of sugar and non-availability of optimum moisture for growth and sterile conditions followed during preparation. Microbiological evaluation is an important aspect not only in the acceptability but also in the safety standards of the product.

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MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present study was conducted to develop preservation techniques for palmyrah palm fruit (Borassus flabellifer Linn.). Fresh fruits collected from the trees of near by villages were used for the storage study for a period of 10 days. The methodology used for the development of techniques for the preservation of palmyrah palm fruits is briefly described in this section.

3.1 COLLECTION OF SAMPLE

Fresh palmyrah palm fruits with skin collected in midmorning hours from Bandlaguda village, Rajendranagar mandal, Ranga Reddy district were transported to laboratory in thermocoal containers packed in ice. A representative sample was collected for analysis of proximate composition from palmyrah palm fruit which was not too tender or too hard.

Initial chemical analysis was done in the following parameters:

The moisture content in the fruit was determined by AOAC (1965) method, protein content was estimated by Microkjeldahl method of AOAC (1975). The fat content in the fruit was estimated by AOAC (1965) method. Apart from these, minerals such as calcium, magnesium, zinc, iron,

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Plate 3: Preserved samples stored at room temperature

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copper, manganese were estimated in Atomic Absorption Spectrometer (Lindsay and Norvell, 1978). Total sugar and reducing sugars in the fresh palmyrah fruit were estimated by Nelson Somogyii method (Raghuramulu et al., 1983).

Pre-preparation of palmyrah palm fruit for storage

Fresh fruits from the collected lot with optimum tenderness and in good condition were selected and kept in a bowl containing clean water (at room temperature). The skin was peeled off with hand and kept ready for the study after complete removal of skin. Pin pricking was done for the fruits to facilitate the absorption of syrup. Food grade polyethylene containers (150-200 guage) of half litre capacity were used after thorough cleaning and drying. A total of 16 fruits with four fruits in each polyethylene container were taken for the study of each preservation technique. The preserved products were stored in the laboratory at room temperature (Plate 3).

3.2 DEVELOPMENT OF PRESERVATION TECHNIQUES FOR STORAGE OF PALMYRAH PALM FRUIT

The following preservation techniques were employed for the study:

- * Ambient temperature (37-40°C)
- * Refrigeration temperature (4-6°C)
- * Preservation in sugar syrup

- * Preservation in honey
- * Candy preparation
- * Dehydration (dry heat)

3.2.1 Preservation at ambient temperature (37-40°C)

Fresh palmyrah palm fruits without peel were placed in polyethylene containers and kept at ambient temperature (37-40°C) in the laboratory. The keeping quality of the fruits was evaluated at six hourly interval for a period of 24 hours.

3.2.2 Storage under refrigeration (4-6°C)

Fresh palmyrah palm fruits were kept in refrigeration (4-6°C) and the keeping quality was studied at two days interval for a period of 10 days (2, 4, 6, 8, 10 days interval).

3.2.3 Preservation in sugar syrup

Sugar syrups of 50°Brix and 70°Brix with or without class II preservatives were used for storage of palmyrah palm fruits at ambient temperature.

Preparation of 50°Brix sugar syrup: The amount of water and sugar required for the preparation of 50°Brix were calculated using square method (refer Appendix 3). Syrup was prepared by hot process (Girdharilal et al., 1986).

Preservation of palmyrah fruits in 50°Brix sugar syrup: Palmyrah palm fruits were added to the sugar syrup two to three minutes before the end of boiling process (so as to facilitate sterilization of fruits and better penetration of syrup into fruits) and later the fruits were separated immediately. Syrup was filtered, cooled and filled in jars upto the brim (1-2 cm head space) along with fruits. The lids of jars were tightly fixed and sealed with polyvinyl chloride tape (to avoid contamination from outside). They were labelled and kept in a place free from rodents, insects etc. in the laboratory.

Preservation in 50°Brix sugar syrup with Class II preservatives: Palmyrah fruits were preserved in 50°Brix sugar syrup as mentioned in the above procedure after adding preservatives sodium benzoate (600 ppm) or potassium metabisulfite (350 ppm) or a combination of both preservatives as per the specifications of FPO (FPO, 1955).

Preservation in 70°Brix sugar syrup: The sugar syrup of 70°Brix prepared by open kettle one period process and open kettle slow process (Girdharilal et al., 1986) were used for preservation of palmyrah palm fruits.

Preparation of 70°Brix sugar syrup by open kettle one period process: To start, lower concentration i.e., 50° Brix sugar syrup was prepared and the boiling was

continued with gentle heating until the syrup became sufficiently concentrated so as to contain about 70°Brix.

Preservation of palmyrah fruits in 70°Brix sugar syrup:
The palmyrah palm fruits were added to the boiling syrup for 2-3 minutes before the end of boiling process. Then the fruits were separated. The hot syrup was filtered and filled in glass bottles of half litre capacity along with fruits (as hot syrup cannot be canned in polyethylene containers glass bottles were used). The bottles were closed air tight and sealed with polyvinyl chloride tape when the temperature at the centre of the can was not less than 65°C.

Preparation of 70°Brix sugar syrup by open kettle slow process and preservation of palmyrah fruits: The palmyra palm fruits were cooked in boiling water for 2-3 minutes. Sugar equal to half the weight of fruit was taken and added to the processed fruits in alternate layers in a stainless steel vessel and the mass was allowed to stand for 24 hours at room temperature. On the next day the Brix of the syrup was measured by pocket refractometer and the concentration of the syrup was increased upto 50° Brix by adding required amounts of sugar by boiling process and allowed to stand for 24 hours. The brix of the syrup was again measured and required amount of sugar was added to get about 60°Brix on boiling process (Citric acid was added at the rate of 1 g/kg of the product to prevent

crystallization of syrup). Subsequently the concentration of syrup was increased to 70°Brix, increasing by 50°Brix every day. Finally the syrup was filtered, cooled and filled in polyethylene containers upto the brim. Lids were closed tightly and sealed with polyvinyl chloride tape.

Preparation of candy with palmyrah palm fruit: The fruits processed in open kettle slow process with 70°Brix sugar syrup were separated from the syrup and kept at room temperature for 2-3 days in shade for drying. The dried fruit was rolled in sugar crystals and individually the fruits were wrapped in butter paper and later with aluminium foil and stored in air tight containers.

3.2.4 Preservation in honey

Honey with 40°Brix and 80°Brix were used for preservation of palmyrah palm fruits.

Preservation of palmyrah palm fruits in 80°Brix honey syrup: Honey collected by tribals of Vizag district and marketed through Khadi and Village Industries Commission, was used for the study. It was found to have 80°Brix. Palmyrah palm fruits were added to the honey syrup and the syrup filled into the brim in polyethylene containers and were closed air tight with lids and sealed with polyvinyl chloride tape and labelled.

Preparation of 40°Brix honey syrup: To prepare 40°Brix honey the volume of water to be added to honey was calculated using square method (Appendix 3). Honey was diluted with distilled water to get desired brix by boiling.

Preservation of palmyrah palm fruits in 40°Brix honey syrup: Palmyrah palm fruits were added to the honey syrup 2-3 minutes before the end of the boiling process. The jars were filled with syrup upto the brim along with fruits and closed air tight with lid, sealed with polyvinyl chloride tape and labelled.

3.2.5 Preservation by dehydration

Dehydration of palmyrah palm fruits: Water in the fresh palmyrah palm fruits were first drained out by slitting them with stainless steel knife. They were kept in boiling water for 2-3 minutes followed by sulphiting at the rate of 1 g sulphur/kg of fruits. Sulphiting was done by dipping the fruits tied in muslin cloth in boiling metabisulfite solution. Fruits were dried in hot air oven by slowly increasing the temperature at the rate of 5°C from 50°C to 70°C for a period of 48 hours.

Preservation of dried palmyrah palm fruits: The dried fruits were placed in polyethylene containers and closed air tight and sealed.

Reconstitution of dried palmyrah palm fruits: Reconstitution of the product for sensory evaluation was done in lukewarm water (40-50°C). To improve the taste of reconstituted product sugar was added to lukewarm water.

3.3 ORGANOLEPTIC EVALUATION ON KEEPING QUALITY OF STORED PALMYRAH PALM FRUITS

The processed palmyrah fruits were stored in food grade polyethylene jars and stored at room temperature or refrigerated temperature. The processed fruits were organoleptically evaluated by a trained panel of 6 members using score card (Appendix 4). Five point scale score card was used for organoleptic evaluation. In order to rank the sensory profiles, ordinal scoring method (ranking) was used. Organoleptic evaluation was done at 2 days interval for a period of 10 days between 10.00 AM and 11.00 AM.

3.4 CHEMICAL ANALYSIS OF PRESERVED PRODUCTS OF PALMYRAH FRUIT

The stored products of palmyrah fruit were analysed for the total and reducing sugars using Nelson-Somogyii method (Raghuramulu et al., 1983). Minerals such as calcium, magnesium, iron, zinc, copper and manganese were analysed using Atomic Absorption Spectrometer (Lindsay and Norvell, 1978). The analysis was carried out at the end of the storage period.

3.5 MICROBIOLOGICAL EVALUATION OF KEEPING QUALITY OF PRESERVED PALMYRAH PALM FRUITS

The viable count of bacteria was determined by pour-plate method (Cruickshank et al., 1975) at the end of the storage period (The methodology is given in Appendix 5). Presence of yeast was identified under microscope.

3.6 STATISTICAL ANALYSIS

The effect of storage on different sensory parameters of the stored palmyrah fruits is determined by one way analysis of variance. The critical differences was calculated as per the procedure of Snedecor and Cochran (1967).

RESULTS

CHAPTER IV

RESULTS

The tender palmyrah fruit and the preserved products of palmyrah fruits have been analysed for their chemical composition, organoleptic evaluation and microbiological evaluation and the results obtained are presented in this chapter under the following sections.

- 4.1 CHEMICAL COMPOSITION OF TENDER PALMYRAH FRUIT
- 4.2 ORGANOLEPTIC EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT
- 4.3 MICROBIOLOGICAL EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT
- 4.1 CHEMICAL COMPOSITION OF TENDER PALMYRAH FRUIT

The chemical composition of tender palmyrah fruit is presented in Table 4. As can be seen from table that the tender palmyrah fruit has high moisture i.e 89.9 per cent; whereas protein and fat are in the lower amounts i.e 0.96 and 0.1 per cent respectively. Total sugars and reducing sugars in the tender fruit were 12.50 and 7.50 g/100g respectively, which are in minimum quantities. However, the tender palmyrah fruit is rich in mineral contents. The analysed mineral contents of calcium, magnesium, zinc, iron, copper and manganese in tender

Table 4. Chemical composition of tender palmyrah palm fruit

Nutrient	Composition (per 100 g)
Moisture (g)	89.90
Protein (g) (N x 6.25)	0.96
Fat (g)	0.10
Total sugars (g)	12.50
Reducing sugars (g)	7.50
Calcium (mg)	119.20
Magnesium (mg)	286.80
Zinc (mg)	4.50
Iron (mg)	6.42
Copper (mg)	0.77
Manganese (mg)	1.74

fruit are 119.2, 286.80, 4.50, 6.42, 0.77 and 1.74 mg per 100 g respectively.

4.1.1 Total sugars and reducing sugars of preserved products of palmyrah fruit

Various preservation methods i.e (a) use of different temperatures, (b) use of different concentrations of sugar syrups, (c) use of honey and (d) use of sugar syrup with chemical preservatives have been studied. The total sugars and reducing sugars in the preserved samples were analysed and presented in Table 5.

Table 5. Total sugars and reducing sugars in the preserved palmyrah fruit using different preservation techniques (per 100 g)

S.No.	Preservation method	Total sugars (g)	Reducing sugars (g)
I.	Fresh fruit	12.50	7.50
II.	Temperatures		
A.	Ambient temperature (37-40°C)	12.50	7.50
B.	Refrigeration temperature (4-6°C)	8.75	0.80
C.	Dehydration (50-70°C)	187.50	144.50
III.	Sugar syrup		
A.	50°Brix sugar syrup	172.00	123.50
B.	70°Brix sugar syrup (open kettle one period process)	204.00	61.00
C.	70°Brix sugar syrup (open kettle slow process)	172.00	140.00
D.	Candy preparation	86.50	58.00
IV.	Honey		
A.	40°Brix honey syrup	188.00	150.00
B.	80°Brix honey syrup	204.00	172.00
V.	50°Brix sugar syrup with class II preservatives		
A.	50°Brix sugar syrup with potassium metabisulfite (350 ppm)	187.50	49.50
B.	50°Brix sugar syrup with sodium benzoate (600 ppm)	51.00	8.70
C.	50°Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate (350:600 ppm)	79.50	5.00

The total and reducing sugars of fresh fruit are 12.50 and 7.50 g/100 g respectively.

The total sugars in the products preserved at different temperatures are ranging from 8.75 - 187.50 g/100 g whereas the reducing sugars are in the range of 0.80 - 144.50 g/100 g. The estimated contents of total and reducing sugars of fruits at ambient temperatures are similar to that of the fresh fruit. The total sugars and reducing sugars in the dehydrated product are high i.e 187.50 g and 144.50 g/100 g respectively. While the sugars in dehydrated product are high when compared to the sugars in the fruits stored at ambient temperatures (12.50 g per 100g and 7.50 g per 100g respectively) and fresh fruit. When the samples are kept at refrigeration temperatures the total sugar content was 8.75 g/100g and reducing sugars content was found to be 0.80 g/100 g which is low compared to the total sugars and reducing sugar content in fresh fruit.

The second method of preservation of the samples is by using sugar syrups of different concentrations (Table 5). The total sugars are in the range of 86.50 - 204.00 g/100 g content of total sugars in candy is observed to be low i.e., 86.50 g/100 g and higher content is observed in fruits preserved in 70⁰ Brix sugar syrup open kettle one period process i.e 204.00 g/100 g.

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Reducing sugars are ranging from 58.00 - 140.00 g/100 g. Candy has a lesser quantity of reducing sugar i.e., 58.00 g/100 g compared to the products preserved in sugar syrup.

Table 5 shows that the total sugars as well as the reducing sugars in fruits stored in honey are high. Total sugars and reducing sugars in fruits preserved in 40⁰Brix honey are 188.00 g/100 g and 150.00 g/100 g respectively, whereas in fruits preserved in 80⁰ Brix honey are 204.00 g/100 g and 172.00 g/100 g. The values show that the sugars are comparatively high in fruits preserved in honey, than in any other preservation methods.

The total sugars in the fruits preserved in sugar syrup with chemical preservatives are ranging from 51.00 - 187.50 g/100 g (Table 5). Total sugars in the fruits preserved in sugar syrup with sodium benzoate showed lower content (51.00 g/100 g), and higher content (187.50 g/100 g) is recorded in fruits in 50⁰Brix sugar syrup with potassium metabisulfite. Reducing sugars are also less and the values are ranging from 5.00 - 49.50g/100 g respectively.

4.1.2 Mineral content of preserved products of palmyrah fruit

Calcium and magnesium contents in fruits preserved at ambient temperature are 118.20 mg/100 g and

288.80 g/100 g respectively. These amounts are found to be similar to that of minerals in fresh fruits (119.20 and 286.80 mg/100 g, respectively). Refrigerated sample also showed almost similar values for calcium and magnesium i.e 125.40 mg and 284.90 mg/100g respectively. In dehydrated sample calcium level is almost similar but magnesium level drastically decreased. Trace minerals, such as zinc, iron, copper, manganese in fruits preserved at ambient temperature were similar to those in the fresh fruits. But trace minerals in refrigerated and dehydrated samples decreased but not of significant difference.

From the Table 6 it is clear that the fruits preserved in different concentration of sugar syrup had low calcium and magnesium levels compared to fruits stored at different temperatures. Calcium content is ranging from 47.00 - 60.60 mg/100 g and magnesium content is ranging from 18.50 - 42.12 mg/100 g. It is observed that the trace minerals are low in the fruits preserved in sugar syrup compared to those preserved at different temperatures and fresh fruit.

It is evident from Table 6 that the major minerals and trace minerals in the fruits preserved in honey syrup are observed to be less in amounts compared to those in fresh fruits and fruits preserved at different temperatures.

Table 6. Mineral content of palmyrah fruits in preserved products using different preservation techniques (per 100 g)

S.No.	Preservation method	Calcium (mg)	Magnesium (mg)	Zinc (mg)	Iron (mg)	Copper (mg)	Manganese (mg)
I.	Fresh fruit	119.20	286.80	4.50	6.42	0.77	1.74
II.	Temperature						
A.	Ambient temperature (37-40°C)	118.20	288.80	4.55	6.40	0.78	1.77
B.	Refrigeration temperature (4-6°C)	125.40	284.90	3.98	5.60	0.73	2.09
C.	Dehydration (50-70°C)	111.60	29.50	3.97	7.40	0.59	1.72
III.	Sugar syrup						
A.	50° Brix sugar syrup	54.80	42.12	1.54	4.50	0.37	0.39
B.	70° Brix sugar syrup (open kettle on period process)	47.00	18.50	1.46	6.60	0.53	0.40
C.	70° Brix sugar syrup (open kettle slow process)	60.60	20.70	1.16	4.30	0.30	0.32
D.	Candy preparation	50.40	33.98	1.88	6.60	0.53	0.40
IV.	Honey						
A.	40° Brix honey syrup	63.00	80.64	2.84	7.00	0.33	0.56
B.	80° Brix honey syrup	24.60	15.88	0.72	1.50	0.12	0.29
V.	50° Brix sugar syrup with class II preservatives						
A.	50° Brix sugar syrup with potassium metabisulfite (350 ppm)	44.00	27.20	2.60	4.00	0.26	0.29
B.	50° Brix sugar syrup with sodium benzoate (600 ppm)	82.60	73.08	3.59	5.50	0.57	0.40
C.	50° Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate (350:600 ppm)	46.00	33.62	2.88	6.20	0.34	0.37

The fruits preserved in 50°Brix sugar syrup with chemical preservatives (Table 6) had low calcium and magnesium contents compared to those stored at different temperatures. Calcium and magnesium levels in fruits stored in 50°Brix sugar syrup with sodium benzoate are high (82.60 mg and 73.08 mg/100 g respectively) compared to the fruits in sugar syrup with potassium metabisulfite (44 mg and 27.20 mg/100 g respectively) and the combined use of preservatives (46.00 mg and 32.62 mg/100 g respectively). As seen from the table 6 the trace minerals are observed to be low in quantities in the fruits preserved in 50°Brix sugar syrup with chemical preservatives when compared to fresh fruits.

4.2 ORGANOLEPTIC EVALUATION OF PALMYRAH FRUITS PRESERVED BY DIFFERENT METHODS

Organoleptic evaluation was done for the fresh fruits and the preserved products at regular intervals. The organoleptic qualities such as colour, flavour, texture, taste and overall acceptability were observed for all the preserved products and the scores have been tabulated and discussed in this section. The five point scale score card adopted for evaluating the acceptability of the products is given in Appendix IV. The detailed calculations for statistical analysis were given in Appendix VI, VII, VIII and IX.

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4.2.1 Ambient temperature (37-40°C)

It is clear from the Table 7 that the organoleptic evaluation was done only for a period of 18 hours (at 6 hourly interval) and was not continued further as the fruits were not acceptable at 18 hours of storage at ambient temperature. Initially the fresh fruits were highly acceptable (5) and at 6 hours also similar observations were noticed. At 12 hours of storage there was a significant difference in all the sensory parameters except colour (4.6). The fruit had good overall acceptability (4) at 12 hours of storage. Significant difference ($P < 0.05$) was observed in all the sensory parameters at 18 hours of storage. Colour was appealing (3) but fermented flavour had dominated and so the scores for taste are low and overall acceptability was very poor. This shows that the palmyrah fruit stored well for only 12 hours with good acceptability and are found unacceptable at 18 hours of storage. It is evident from the Fig.1 that the fruits stored at ambient temperatures showed a significant change in the overall acceptability at 18 hours of storage period.

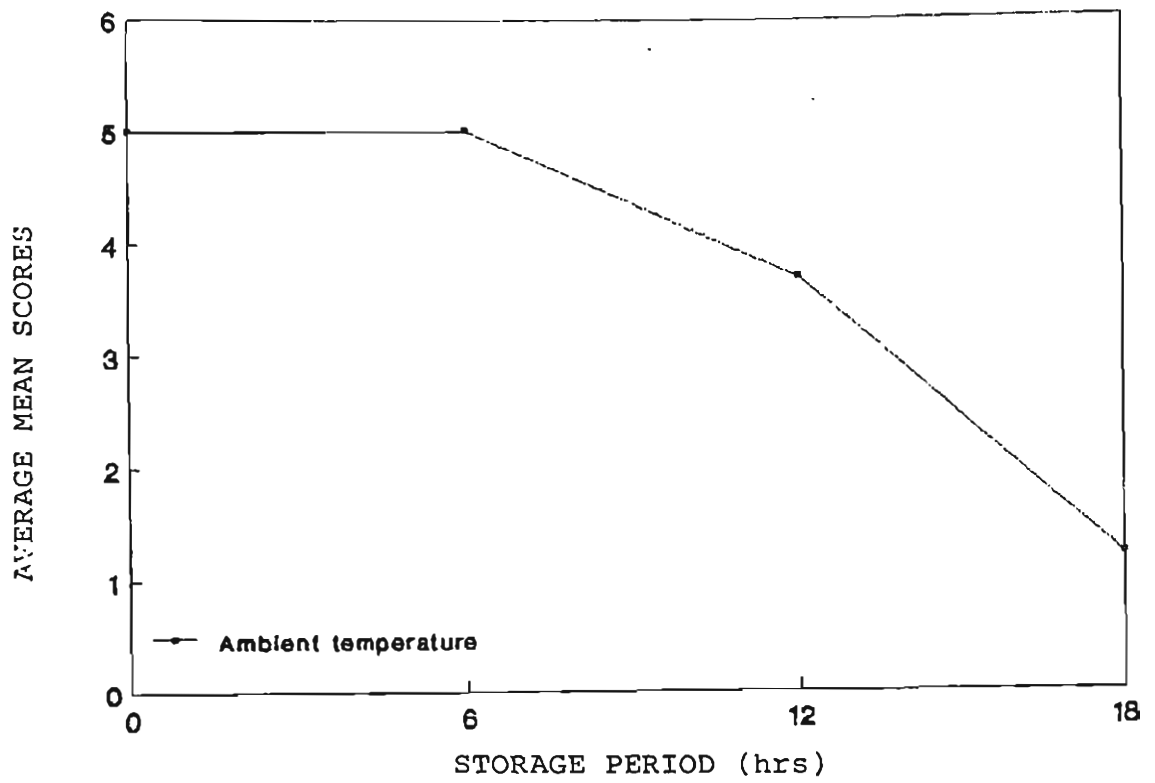


Fig.1: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRESERVED AT AMBIENT TEMPERATURE (37-40°C)

Table 7. Organoleptic evaluation of palmyrah fruits preserved at ambient temperature (37-40°C).

Sensory parameters	Storage period (hours)			
	0	6	12	18
Colour	5.0 ^a	5.0 ^a	4.6 ^a	2.7 ^b
Flavour	5.0 ^a	5.0 ^a	3.3 ^b	1.1 ^c
Texture	5.0 ^a	5.0 ^a	4.5 ^b	3.7 ^c
Taste	5.0 ^a	5.0 ^a	3.0 ^b	1.2 ^c
Overall acceptability	5.0 ^a	5.0 ^a	3.7 ^b	1.2 ^c

Values bearing same superscripts in rows do not differ significantly (P<0.05)

4.2.2 Refrigeration (4-6°C) and dehydration (50-70°C) temperatures

The preservation of palmyrah fruits at refrigeration temperatures was for a period of 8 days (Table 8) and study was not conducted further due to unacceptability of the product. The fruits were highly acceptable (5) till 4 days of storage with no change in sensory parameters whereas on 6th day of storage there was a significant change (P<0.05) in texture and overall acceptability compared to initial days of storage. However on 8th day of storage significant change (P<0.05) was found in all the sensory parameters.

The fruits preserved by Dehydration method had fairly good initial scores for all the sensory parameters

and were ranging from 3.5 to 4.7 (Table 8). Similar observation was noticed throughout the storage period. Significant change in colour was observed, but it had no effect on the overall acceptability (Plate 4). The

Table 8. Organoleptic evaluation of palmyrah fruits preserved at refrigeration temperature (4-6°C) and dehydration temperature (50-70°C)

Sensory parameters	Storage period (days)					
	0	2	4	6	8	10
A. Refrigeration temperature						
Colour	5.0 ^a	5.0 ^a	4.8 ^a	4.7 ^a	3.6 ^b	-
Flavour	5.0 ^a	5.0 ^a	5.0 ^a	5.0 ^a	2.5 ^b	-
Texture	5.0 ^a	5.0 ^a	4.8 ^{ab}	4.5 ^b	3.8 ^c	-
Taste	5.0 ^a	5.0 ^a	5.0 ^a	4.8 ^a	1.0 ^b	-
Overall acceptability	5.0 ^a	5.0 ^a	4.8 ^a	4.3 ^b	3.0 ^c	-
B. Dehydration temperature						
Colour	4.7 ^a	4.6 ^{ab}	4.6 ^{ab}	4.5 ^b	4.5 ^b	4.5 ^b
Flavour	3.5	3.5	3.6	3.8	3.3	3.7
Texture	3.6	3.6	3.8	3.7	3.6	3.6
Taste	3.7	3.7	3.8	3.5	3.7	3.8
Overall acceptability	4.2	4.2	4.5	4.5	4.5	4.5

Values bearing same superscripts in rows do not differ significantly (P<0.05)

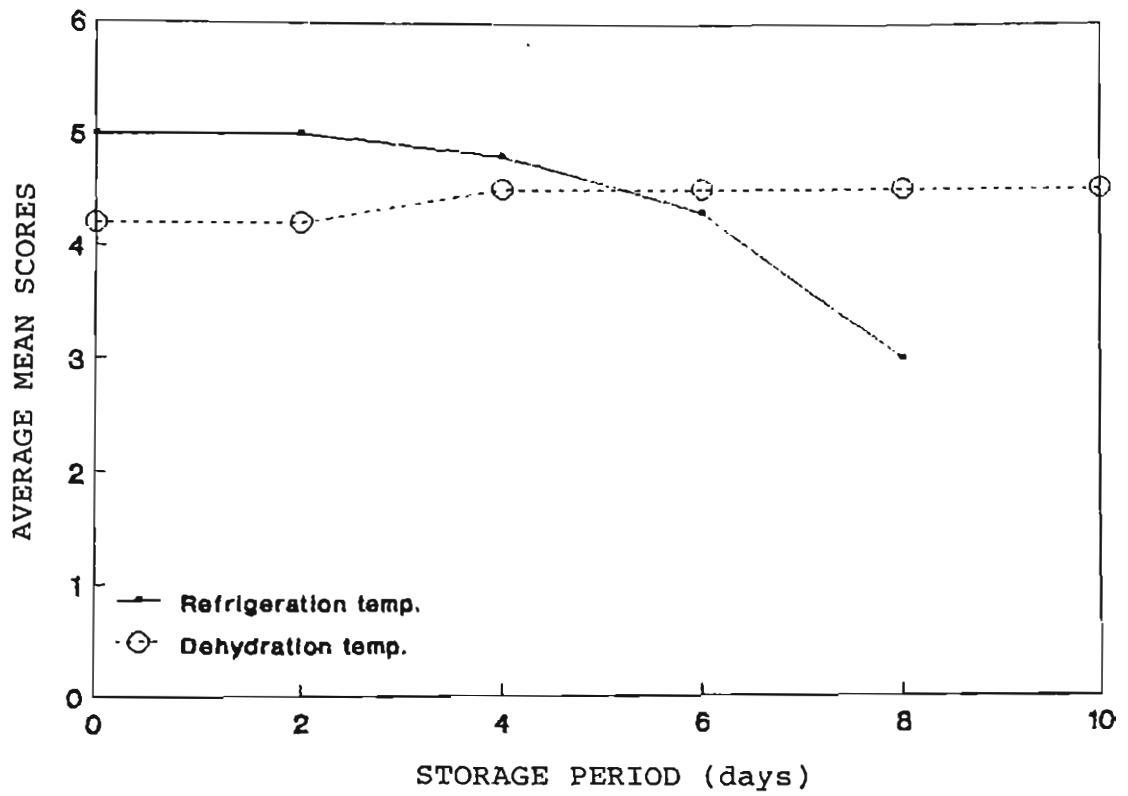


Fig.2: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRE-SERVED AT REFRIGERATION (4-6°C) AND DEHYDRATION (50-70°C) TEMPERATURES



Plate 4: Palmyrah fruits preserved by
dehydration process

- A. Dehydrated palmyrah fruit
- B. Reconstituted palmyrah fruit

product was acceptable till 10 days of storage period. Storage period could not be extended further since the work was planned only for that period. The overall acceptability curve of palmyrah fruits in (Fig. 2) shows that the fruits preserved by dehydration method were better than those preserved at refrigeration temperature throughout the storage period.

4.2.3 50°Brix and 70°Brix sugar syrup

The organoleptic mean scores for fruits preserved in 50°Brix sugar syrup were presented in Table 9 and (Plate 8,A). The fruits preserved in 50°Brix sugar syrup had good initial scores on the day of preparation. On second day of storage there was significant ($P < 0.05$) difference in colour and overall acceptability compared to the initial day. Flavour and taste remained unchanged and they were sweet (4). Texture was not effected throughout the storage period. On fourth day all the sensory parameters showed significant change ($P < 0.05$) except texture. On sixth day the changes in colour, flavour, taste and overall acceptability were similar to that on fourth day and no significant differences ($P < 0.05$) were observed. On eighth day a significant difference ($P < 0.05$) was observed in colour, flavour and taste. Overall acceptability had remained same as that on the fourth day and it was fairly acceptable (3). Changes observed on tenth

Table 9. Organoleptic evaluation of palmyrah fruits preserved in 50°Brix sugar syrup and 70°Brix sugar syrup

Sensory parameters	Storage period (days)					
	0	2	4	6	8	10
A. 50°Brix sugar syrup						
Colour	4.2 ^a	3.7 ^b	3.3 ^c	3.2 ^c	2.3 ^d	2.3 ^d
Flavour	4.0 ^a	4.0 ^a	3.6 ^{ab}	3.3 ^b	3.0 ^{bc}	2.8 ^c
Texture	4.0	3.8	3.6	3.6	3.5	3.5
Taste	4.0 ^a	4.0 ^a	3.5 ^b	3.3 ^{bc}	3.2 ^c	3.1 ^c
Overall acceptability	4.0 ^a	3.6 ^b	2.6 ^c	2.6 ^c	2.6 ^c	2.5 ^c
B. 70°Brix sugar syrup - Open kettle one period process						
Colour	4.7	4.7	4.5	4.5	4.3	4.3
Flavour	4.0	4.0	3.8	3.8	3.8	3.8
Texture	3.8 ^a	3.1 ^a	2.0 ^b	2.1 ^b	1.3 ^c	1.3 ^c
Taste	4.0	3.7	3.7	3.7	3.7	3.7
Overall acceptability	4.8	4.5	4.5	4.3	4.3	4.3
C. 70°Brix sugar syrup - Open kettle slow process						
Colour	4.6	4.1	4.1	4.0	4.0	4.0
Flavour	4.0	4.0	4.0	4.0	4.0	4.0
Texture	1.8	1.3	1.3	1.2	1.2	1.2
Taste	3.8	3.8	3.8	3.8	3.8	3.8
Overall acceptability	4.7	4.0	4.0	4.0	4.0	4.0
D. Candy preparation						
Colour	4.0	3.7	3.7	3.7	3.6	3.7
Flavour	4.0	4.0	4.0	4.0	4.0	4.0
Texture	2.0	2.0	2.0	2.0	2.0	2.0
Taste	3.8	3.3	3.3	3.7	3.7	3.7
Overall acceptability	4.7	4.7	4.7	4.5	4.7	4.5

Values bearing same superscripts in rows do not differ significantly (P<0.05)

day were similar to those observed on eighth day of storage. Overall acceptability was also fair (3) on the tenth day of storage. The results show that the product could be satisfactorily stored for 10 days.

The organoleptic mean scores of the palmyrah fruits preserved in 70° Brix sugar syrup - open kettle one period (Plate 5) process were given in Table 9. Initial scores were ranging from 3.5 to 4.8. The scores remained almost same without significant difference throughout the storage period of 10 days. Colour was moderately appealing (4), and overall acceptability was good (4). Sweet (4) taste and flavour were observed in the stored product. Texture on initial day of storage was slightly tender (4) but slowly on storage it had changed to moderately hard texture (1), on tenth day with significant difference ($P < 0.05$). Though texture had slightly changed, overall acceptability was good and the product stored well till 10 days of storage period.

The palmyrah fruits preserved in 70° Brix sugar syrup open kettle one period (Plate 5,B) process were organoleptically evaluated and the mean scores are given in Table 9. Initial scores were ranging from 3.5 to 4.8. The scores remained almost same without significant difference throughout the storage period of 10 days. Colour was moderately appealing (4), and overall accepta-

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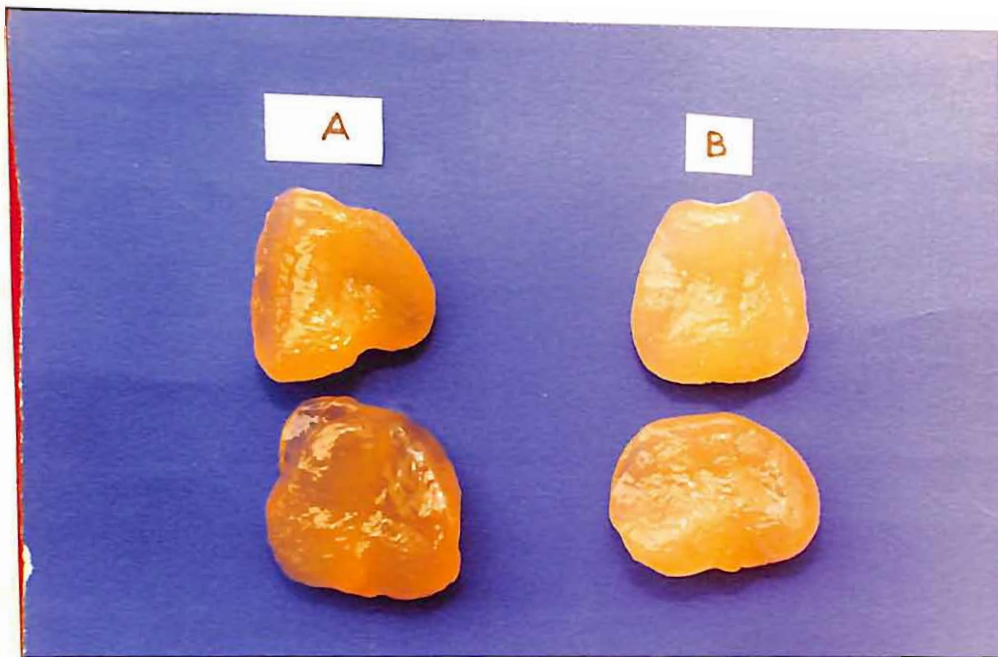


Plate 5: Palmyrah fruits preserved in 70° Brix sugar syrup

- A. 70° Brix sugar syrup - open kettle slow process
- B. 70° Brix sugar syrup - open kettle one period process

bility was good (4). Sweet (4) taste and flavour were observed in the stored product. Texture on initial day of storage was slightly tender (4) but slowly on storage it had changed to moderately hard texture (1) on tenth day with significant difference ($P < 0.05$). Though texture had slightly changed, overall acceptability was good and the product stored well till 10 days of storage period.

The organoleptic mean scores for the palmyrah fruits preserved in 70°Brix sugar syrup open kettle slow (Plate 5,A) process were presented in Table 9. The initial scores were ranging from 1.8 to 4.7. Texture had the lowest score of 1.8 (i.e.) slightly hard texture was observed. There was significant difference ($P < 0.05$) in all the sensory parameters throughout the storage period. Colour was moderately appealing (4) and over all acceptability was good (4) throughout the storage period. Sweet (4) flavour and taste were observed throughout the storage period. Texture had changed slightly but showed no significant change compared to initial day of storage. Change in texture was from slightly hard (2) to moderately hard (1) texture. The product stored well for 10 days of storage and with good (4) overall acceptability throughout the storage period.

Candy (Plate 6) prepared from palmyrah fruit showed excellent (5) acceptability (Table 9). The organoleptic mean scores for candy initially were ranging from

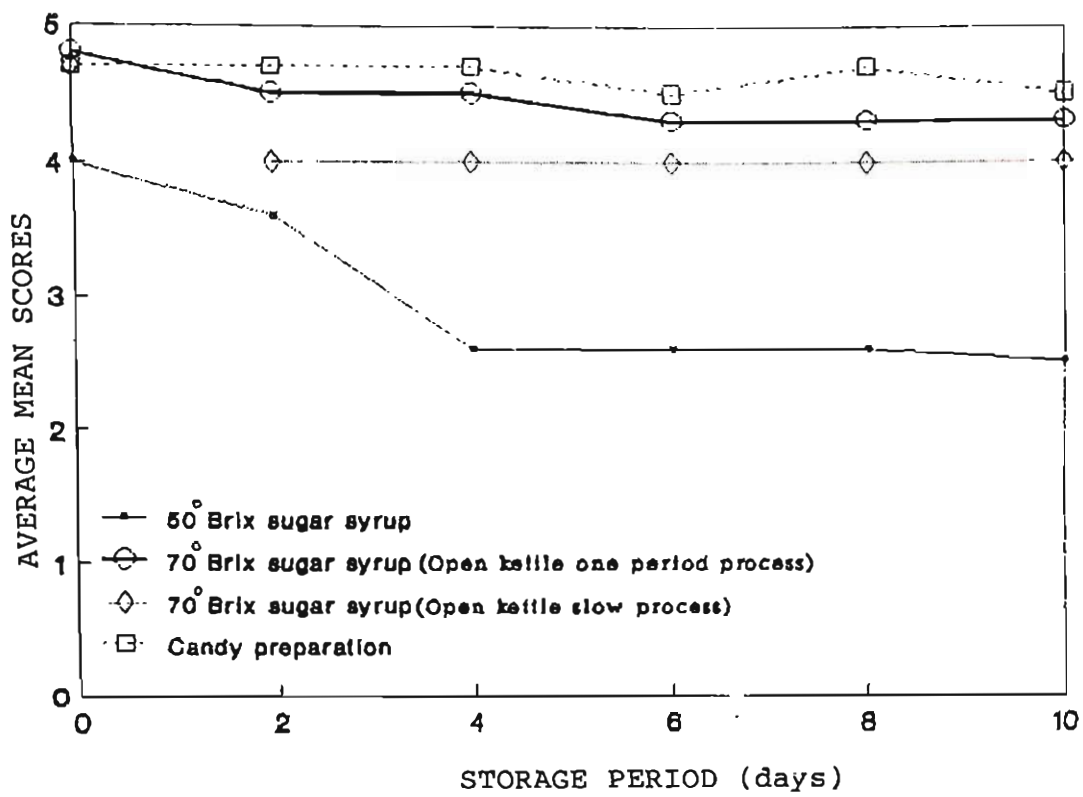


Fig.3: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRE-SERVED IN 50° BRUX AND 70° BRUX SUGAR SYRUP

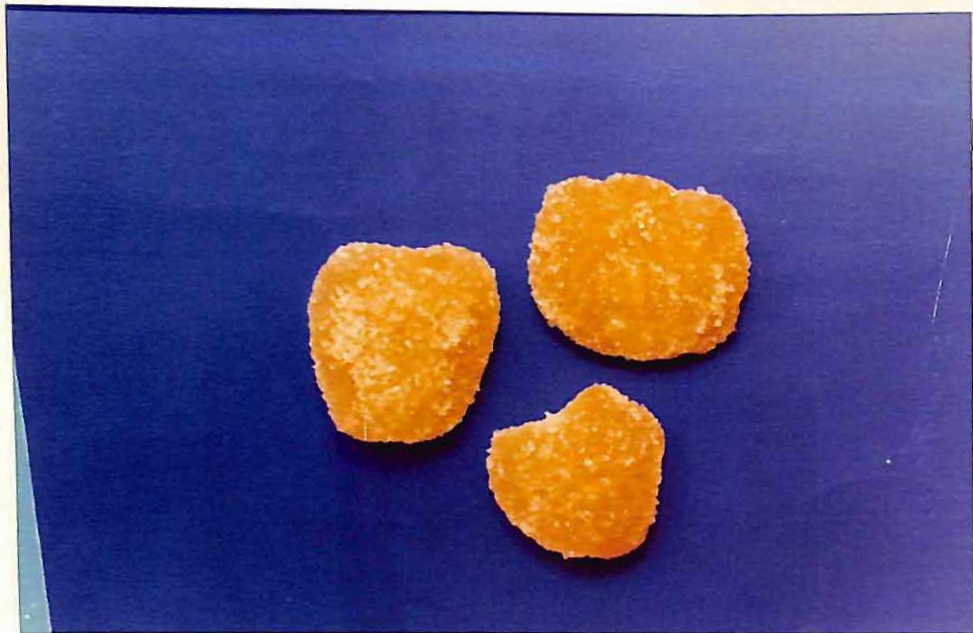


Plate 6: Palmyrah fruits preserved by candy preparation

2.0 to 4.7. There were no significant differences ($P < 0.05$) observed in all the sensory parameters. Colour was found to be moderately appealing (4), sweet (4) taste and flavour were observed in the candy. Texture was slightly hard (2). The overall acceptability of the product was excellent (5). The changes observed initially were present upto 10 days of storage without significant differences. The product had excellent shelf life for 10 days of storage period.

The palmyrah palm fruits stored in different concentrations of sugar had different degrees of acceptability. The decreasing order of acceptance of palmyrah fruits stored in different concentrations of sugar syrup are Candy > Fruits preserved in 70° Brix sugar syrup - open kettle one period process > Fruits preserved in 70° Brix sugar syrup - open kettle slow process and > Fruits preserved in 50° Brix sugar syrup.

The over all acceptability curves in Fig.3 show the above similar observations.

4.2.4 Honey

The organoleptic qualities of palmyrah palm fruits preserved in 40° Brix and 80° Brix honey are given in Table 10.

Table 10. Organoleptic evaluation of palmyrah fruits preserved in honey

Sensory parameters	Storage period (days)					
	0	2	4	6	8	10
A. 40°Brix honey						
Colour	4.0 ^a	3.1 ^b	2.5 ^c	2.1 ^c	-	-
Flavour	4.0 ^a	4.0 ^a	3.3 ^b	1.6 ^c	-	-
Texture	4.8 ^a	4.1 ^b	4.5 ^b	4.5 ^b	-	-
Taste	3.6 ^a	3.5 ^a	3.5 ^a	3.0 ^b	-	-
Overall acceptability	3.7 ^a	2.7 ^b	2.3 ^b	1.7 ^c	-	-
B. 80°Brix honey						
Colour	2.6 ^a	2.2 ^b	2.2 ^b	1.8 ^c	1.8 ^c	1.8 ^c
Flavour	4.0	3.7	3.7	3.7	3.7	3.7
Texture	4.7 ^a	4.2 ^b	4.3 ^b	3.7 ^c	3.7 ^c	3.7 ^c
Taste	3.7	3.5	3.5	3.5	3.5	3.5
Overall acceptability	3.5 ^a	3.0 ^b	3.0 ^b	3.0 ^b	3.2 ^c	3.0 ^d

Values bearing same superscripts in rows do not differ significantly (P<0.05)

The organoleptic mean scores for the fruits stored in 40°Brix honey are given in Table 10 (Plate 7,B). It is evident from the table that the study was conducted only for 6 days and further study could not be conducted due to unacceptability of the product. Initially the product scored well and the scores are ranging from 3.6-4.8. On second day of storage there was a significant

change in colour, texture and overall acceptability but no change was observed in flavour and taste compared to the initial day observations. Colour was fairly appealing (3) on the fourth day of storage and change was also observed in flavour. But there was no significant change in texture, taste and overall acceptability compared to the second day of storage. On sixth day there was a significant change in flavour, taste and overall acceptability. Colour was fairly appealing (3) and moderately tender texture (5) was observed on sixth day of storage. Overall acceptability had decreased but the product was found to be acceptable on sixth day of storage. The product had stored well for six days.

The palmyrah palm fruits have been preserved in 80°Brix honey (Plate 7,A) and the fruits were evaluated organoleptically at 2 days interval for 10 days and the mean scores are presented in Table 10. Initial scores were found to be ranging from 2.6-4.7. Colour was found to be appealing (3) on the initial day and significant changes ($P < 0.05$) were observed throughout the storage period. From second day onwards colour was found to be less appealing (2) till the end of the storage period. Sweet (4) flavour and taste were observed throughout the storage period without significant differences. Moderately tender texture (5) was observed on initial day of storage but on second day it had changed to slightly tender

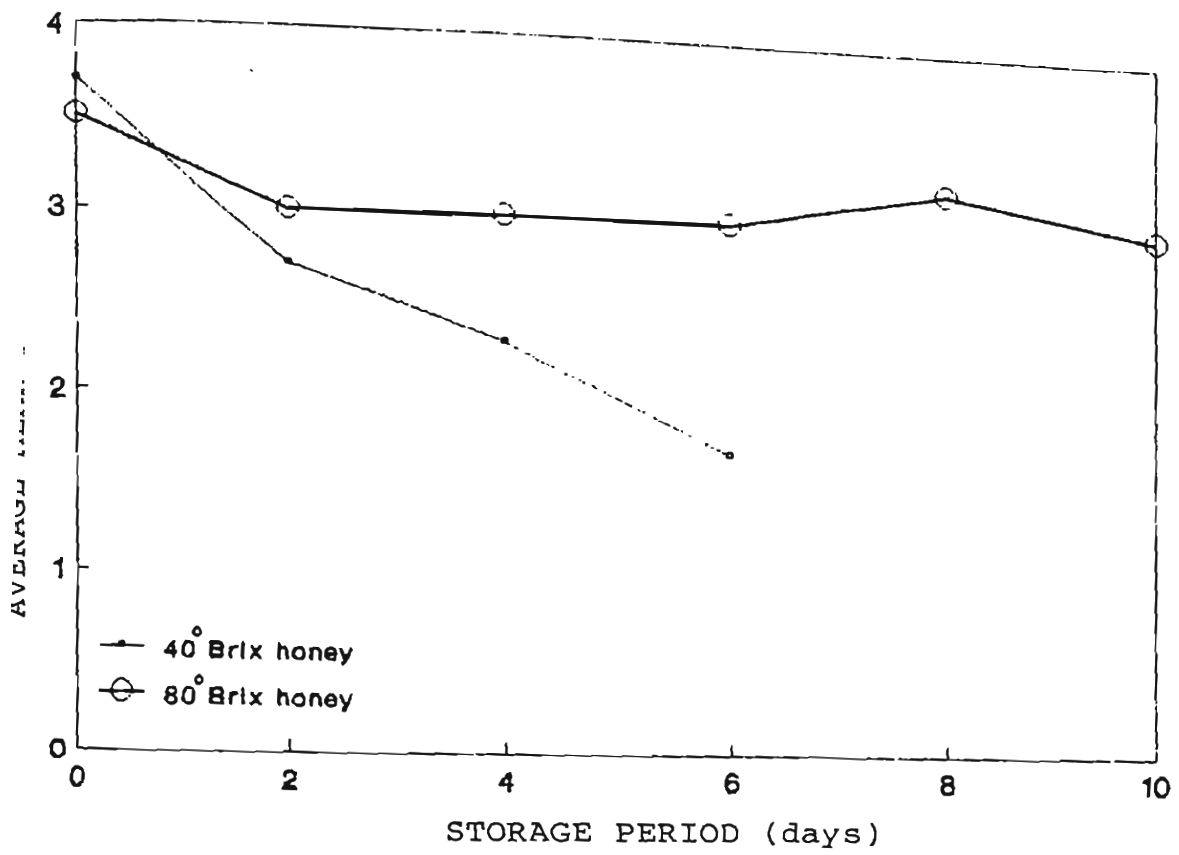


Fig.4: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRESERVED IN HONEY

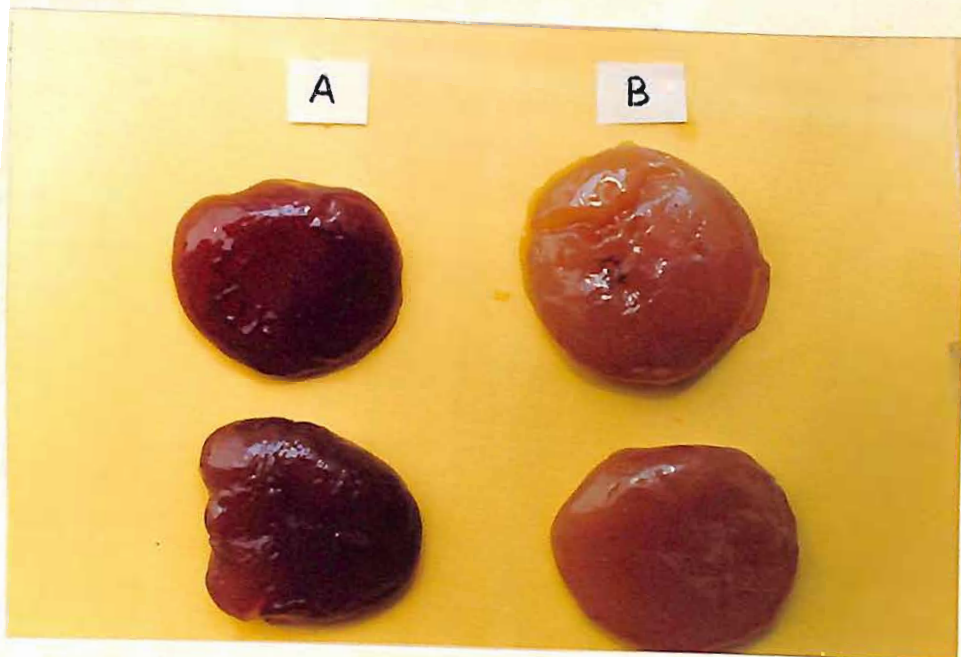


Plate 7: Palmyrah fruits preserved in honey

A. 80° Brix honey

B. 40° Brix honey

texture (4) and it remained same on fourth day of storage. No significant changes were observed from sixth day onwards though slightly tender texture was observed during the storage period. Good (4) overall acceptability of the product was observed on the initial day of storage but significant changes were observed from second day onwards with fair (4) acceptability.

The results show that the fruits stored in 80°Brix honey preserved well compared to the fruits preserved in 40°Brix honey and similar observations were noticed in Fig.4.

4.2.5 50°Brix sugar syrup with class II preservatives

The mean scores of the organoleptic evaluation for the palmyrah fruits preserved in 50° Brix sugar syrup with potassium metabisulfite (Plate 8, B) are given in Table 11. The sensory parameters initially ranged from 3.0-4.0 and the overall acceptability was observed to be fair (3). The observations on the other days of storage showed no significant difference ($P < 0.05$) compared to the initial days of storage. Observations show that colour was moderately appealing (4) till sixth day of storage and decreased on eighth day of storage. Flavour was given a score of 3 throughout the storage period due to the persistent flavour of the chemical used. Slightly tender texture (4) and sweet (4) taste were observed with fair

texture (4) and it remained same on fourth day of storage. But significant changes were observed from sixth day onwards though slightly tender texture was observed during the storage period. Good (4) overall acceptability of the product was observed on the initial day of storage but significant changes were observed from second day onwards with fair (4) acceptability.

The results show that the fruits stored in 80°Brix honey preserved well compared to the fruits preserved in 40°Brix honey and similar observations were noticed in Fig.4.

4.2.5 50°Brix sugar syrup with class II preservatives

The mean scores of the organoleptic evaluation for the palmyrah fruits preserved in 50° Brix sugar syrup with potassium metabisulfite (Plate 8, B) are given in Table 11. The sensory parameters initially ranged from 3.0-4.0 and the overall acceptability was observed to be fair (3). The observations on the other days of storage showed no significant difference ($P < 0.05$) compared to the initial days of storage. Observations show that colour was moderately appealing (4) till sixth day of storage and decreased on eighth day of storage. Flavour was given score of 3 throughout the storage period due to the persistent flavour of the chemical used. Slightly tender texture (4) and sweet (4) taste were observed with

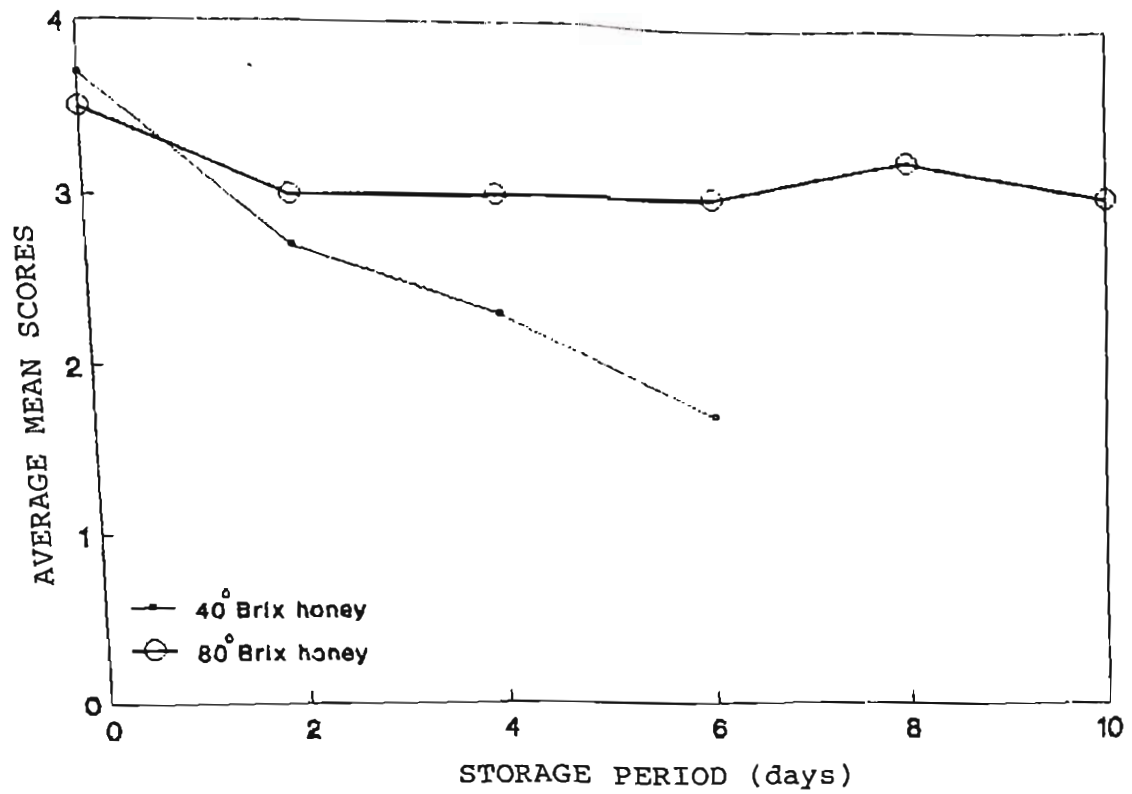


Fig.4: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRESERVED IN HONEY

texture (4) and it remained same on fourth day of storage. But significant changes were observed from sixth day onwards though slightly tender texture was observed during the storage period. Good (4) overall acceptability of the product was observed on the initial day of storage but significant changes were observed from second day onwards with fair (4) acceptability.

The results show that the fruits stored in 80°Brix honey preserved well compared to the fruits preserved in 40°Brix honey and similar observations were noticed in Fig.4.

4.2.5 50°Brix sugar syrup with class II preservatives

The mean scores of the organoleptic evaluation for the palmyrah fruits preserved in 50° Brix sugar syrup with potassium metabisulfite (Plate 8, B) are given in Table 11. The sensory parameters initially ranged from 3.0-4.0 and the overall acceptability was observed to be fair (3). The observations on the other days of storage showed no significant difference ($P < 0.05$) compared to the initial days of storage. Observations show that colour was moderately appealing (4) till sixth day of storage and decreased on eighth day of storage. Flavour was given a score of 3 throughout the storage period due to the persistent flavour of the chemical used. Slightly tender texture (4) and sweet (4) taste were observed with fair

Table 11. Organoleptic evaluation of palmyrah fruits preserved in 50°Brix sugar syrup with class II preservatives

Sensory parameters	Storage period (days)					
	0	2	4	6	8	10
A. 50°Brix sugar syrup with potassium metabisulfite						
Colour	4.0	3.7	3.7	3.6	3.3	3.3
Flavour	3.0	3.0	3.0	3.0	3.0	3.0
Texture	3.7	3.6	3.5	3.6	3.6	3.6
Taste	3.5	3.6	3.6	3.6	3.6	3.6
Overall acceptability	3.0	2.8	2.8	2.7	3.0	2.8
B. 50°Brix sugar syrup with sodium benzoate						
Colour	4.0 ^a	3.8 ^a	4.0 ^a	3.5 ^{ab}	3.0 ^b	2.8 ^b
Flavour	4.0	3.7	3.8	3.6	3.6	3.6
Texture	4.6 ^a	4.1 ^b	3.6 ^c	3.5 ^c	3.7 ^c	3.5 ^c
Taste	3.6	3.6	3.6	3.6	3.5	3.6
Overall acceptability	3.2	3.2	3.1	3.0	3.0	3.1
C. 50°Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate						
Colour	4.0	3.7	3.7	3.6	3.1	3.1
Flavour	4.0 ^a	3.8 ^a	3.8 ^a	3.8 ^a	3.0 ^b	3.0 ^c
Texture	4.0	4.0	4.3	4.2	4.5	4.5
Taste	3.6	3.3	3.2	3.3	3.2	3.2
Overall acceptability	3.6	3.5	3.2	2.7	2.8	3.0

Values bearing same superscripts in rows do not differ significantly (P<0.05)

overall acceptability (3). The product stored well with fair acceptability throughout the storage period of 10 days.

Sodium benzoate was used as a chemical preservative in 50° Brix sugar syrup to preserve the palmyrah fruit (Plate 8,C). The results of the organoleptic evaluation (Table 11) show that significant differences were observed in colour and texture during the storage period. No significant differences were observed in flavour, taste and overall acceptability throughout the storage period. Colour was found to be moderately appealing (4) from initial day to sixth day of storage. Later it changed from moderately appealing (4) to appealing score (3) and it lasted till the tenth day of storage. Sweet (4) taste and flavour were observed throughout the storage period without significant differences ($P < 0.05$). Texture had changed from moderate tenderness (5) on initial day to slight tenderness (4) on second day of storage with significant difference. Slight tenderness was observed on other days of storage but significant difference ($P < 0.05$) were observed compared to initial and second day of storage. The overall acceptability of the product was fair (3) throughout the storage period. This shows that the product stored well with fair (3) overall acceptability throughout the storage period for 10 days.

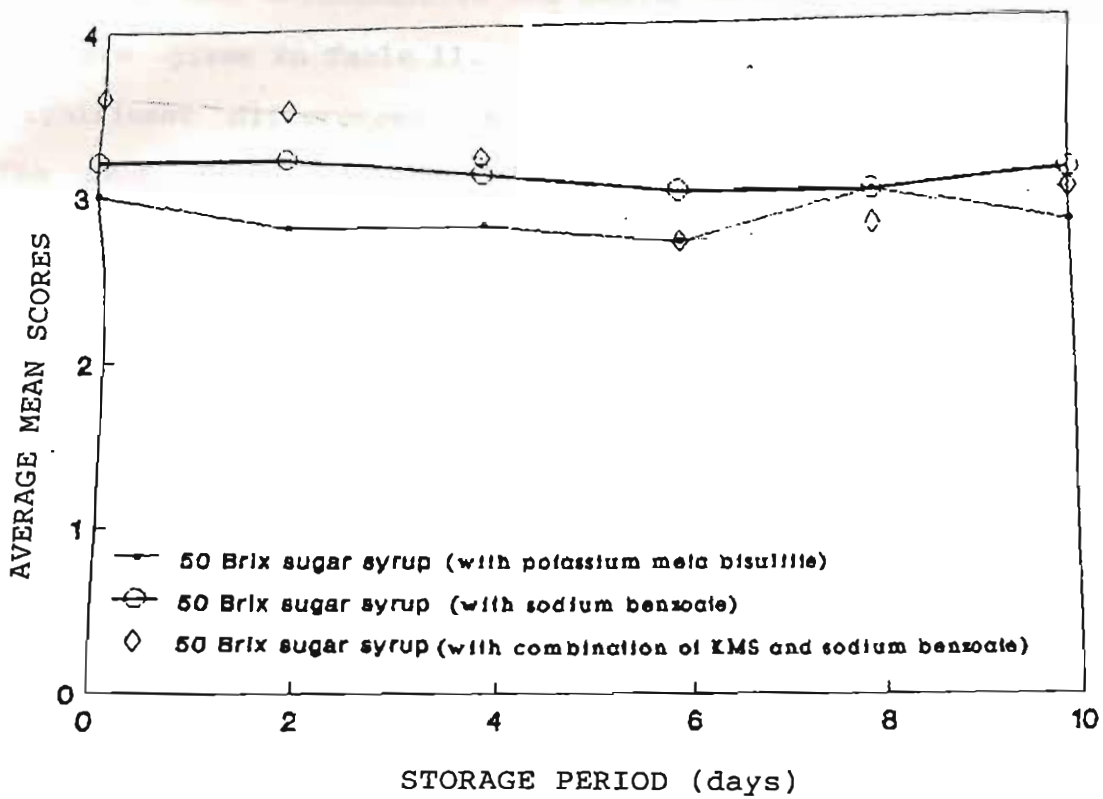


Fig.5: OVERALL ACCEPTABILITY OF PALMYRAH FRUITS PRESERVED IN 50^c BRIX SUGAR SYRUP WITH CHEMICAL PRESERVATIVES

The organoleptic mean scores of palmyrah palm fruits preserved in 50° Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate (Plate 8, D) are given in Table 11. The results show that the significant differences were observed in flavour only. The mean scores initially ranged from 3.6-4.0. Colour changes were observed but not with significant differences during storage period. Sweet (4) flavour was observed on initial day of storage and it was present till the sixth day of storage but from eighth day significant differences were observed in flavour and they were present on tenth day also. Very sweet (3) taste was observed in the product throughout the storage period. Slightly tender (4) to moderate tender texture (5) was observed during the storage period. Initially the product had good acceptability (4) upto second day of storage but decreased to fair acceptability (3) from fourth day of storage. The results show that the product stored well for 10 days.

The overall acceptability curves for the palmyrah palm fruits preserved in 50° Brix sugar syrup with chemical preservatives are shown in figure 5. The overall acceptability curves show that the fruits preserved in 50° Brix sugar syrup with combination of preservatives (Potassium metabisulfite and sodium benzoate) were found to be better than the other two methods of preservation using chemicals individually in 50° Brix sugar syrup. It

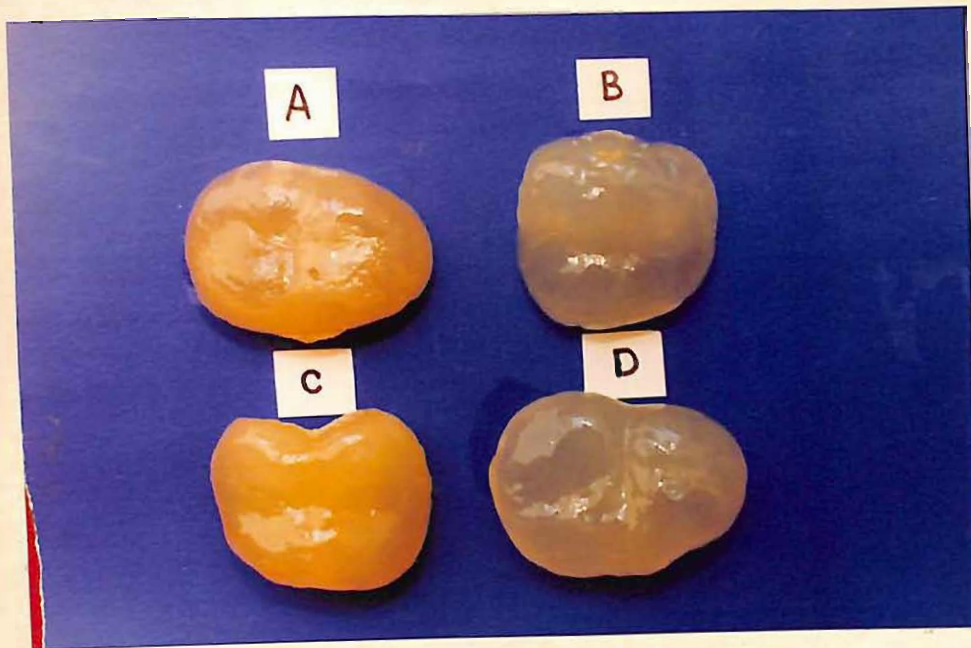


Plate 8: Palmyrah fruits preserved in 50° Brix sugar syrup

- A. 50° Brix sugar syrup
- B. 50° Brix sugar syrup with potassium metabisulfite
- C. 50° Brix sugar syrup with sodium benzoate
- D. 50° Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate

is clearly evident from plate 8 that colour change was not noticed when potassium metabisulfite (Plate 8, B) and the combination of preservatives (Plate 8, D) were used. However, colour change was observed when sodium benzoate was used (Plate 8, C) as preservative.

4.3 MICROBIOLOGICAL EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT

Microbiological evaluation of the product is a necessity to assess the safety of the product for human consumption. The standard plate count was done for the preserved products at the end of the storage period. The standard plate count (log 5/g) values for the preserved products are given in Table 12.

It is evident from the Table 12 that the fruits preserved at ambient temperature and refrigeration temperature showed higher counts compared to dehydrated product. So, the product stored by using higher temperatures showed low microbial counts.

The fruits preserved in different concentrations of sugar syrup showed the microbial count to be low in the fruits preserved at higher concentrations of sugar syrup (i.e., 70° Brix sugar syrup and candy) compared to the fruits preserved in 50° Brix sugar syrup. It is evident that the higher concentration of sugar syrup showed lower

Table 12. Microbiological counts (in log₅/g) of stored palmyrah fruits using different preservation methods

Preservation method	Storage period	SPC count (in log ₅ /g) (Bacterial count)
I. Temperature		
A. Ambient temperature (37-40°C)	18 hrs	4.0 x 10 ⁵
B. Refrigeration temperature (4-6°C)	8 days	2.0 x 10 ⁴
C. Dehydration temperature (50-70°C)	10 days	7.9 x 10 ²
II. Sugar syrup		
A. 50° Brix sugar syrup	10 days	8.0 x 10 ³
B. 70° Brix sugar syrup (Open kettle one period process)	10 days	2.3 x 10 ²
C. 70° Brix sugar syrup (Open kettle slow process)	10 days	6.0 x 10 ²
D. Candy preparation	10 days	6.3 x 10 ²
III. Honey		
A. 40° Brix honey syrup	6 days	8.3 x 10 ⁴
B. 80° Brix honey syrup	10 days	9.0 x 10 ¹
IV. 50° Brix sugar syrup with class II preservatives		
A. 50° Brix sugar syrup with potassium meta bisulfite (350 ppm)	10 days	6.0 x 10 ³
B. 50° Brix sugar syrup with sodium benzoate (600 ppm)	10 days	5.0 x 10 ³
C. 50° Brix sugar syrup with combination of potassium meta-bisulfite and sodium benzoate (350:600 ppm)	10 days	5.8 x 10 ³

bacterial counts. Similar observations were noticed in fruits preserved using honey. The bacterial counts were observed to be less in the fruits preserved using higher concentration of sugar syrup compared to those fruits preserved at ambient and refrigeration temperatures.

The fruits preserved in 50° Brix sugar syrup with class II preservatives showed counts ranging from 5.0×10^3 to 6.0×10^3 . The bacterial counts in the fruits preserved using chemical preservatives were found to be higher than those fruits preserved in higher concentrations of sugar syrup but less when compared to those stored at ambient and refrigeration temperatures.

It can be observed that the fruits stored at higher concentrations of sugar syrup had low bacterial counts compared to those stored at refrigeration and ambient temperatures.

DISCUSSION

CHAPTER V

DISCUSSION

The results obtained for the tender palmyrah fruit and the preserved products is discussed in this chapter with the limited data available under the following subheadings.

- 5.1 CHEMICAL COMPOSITION OF TENDER PALMYRAH FRUIT
- 5.2 ORGANOLEPTIC EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT
- 5.3 MICROBIOLOGICAL EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT

5.1 CHEMICAL COMPOSITION OF TENDER PALMYRAH FRUIT

The analysed chemical composition of the tender palmyrah fruit (Table 4) shows that the moisture level in the palm fruits is high i.e 89.9 per cent. The estimated moisture content compares well with that reported previously by Mitra and Mittra, (1940) and Gopalan et al. (1994) i.e, 92.6 per cent and 92.3 per cent levels respectively. The protein content estimated was 0.9 per cent and the amounts reported by Mitra and Mittra, (1940) and Gopalan et al. (1994) are 0.6 per cent. The estimated fat content was 0.1 per cent which is similar to the amount reported by Mitra and Mittra (1940) and Gopalan

et al. (1994). The analysed contents of total and reducing sugars were found to be 12.50 and 7.50 g/100 g respectively. No reported values are available in literature to compare the analysed amounts. The fruit was found to be rich in minerals. The estimated amounts (Table 4) for calcium is 119.20 mg/100 g which is very high as compared to the content reported by Mitra and Mittra, (1940) and Gopalan et al. (1994) (i.e., 5.00 mg/100 g and 10.00 mg/100 g). The iron content observed in the present study is 6.42 mg/100g which is high compared to the amounts given by Gopalan et al., (1994) (i.e., 5.0 mg/100 g). Other minerals such as zinc, copper and manganese have not been compared due to unavailable data. The amounts obtained in this study are in near proximity of the available data except in case of protein, calcium and iron contents. The variation in the chemical composition may be attributed to the soil conditions and the stage of maturity of the fruit.

5.1.1 Total sugars and reducing sugars of preserved products of palmyrah fruit

The total sugars in the products preserved at different temperatures (Table 5) are ranging from 8.70 g - 187.50 g/100 g; whereas, the reducing sugars are in the range of 0.80g - 144.50g/100g. The total and reducing sugars of fruits in the present study at ambient temperature are similar to that of fresh fruit. The total sugars

in the refrigerated sample (Table 5) are low which may be due to the higher oxidation of the total sugars. The sugars in the dehydrated product (Table 5) are high which may be attributed to the concentrated effect due to reduction of water.

Fruits preserved in sugar syrup had higher amounts of total sugars and reducing sugars (Table 5). The higher amounts of total sugars may be due to the incorporation of sugar into the product (Vaghani and Chundawat, 1986). As the total sugars increased reducing sugars have also increased which could be due to the inversion of non-reducing sugars by hydrolysis. The total sugars and reducing sugars varied based on the different concentration of sugar syrup used as a media for preserving the fruits. Similarly fruits preserved in honey also showed higher amounts which may be due to the high concentration of honey.

The amounts of total sugars in fruits preserved in sugar syrup with chemical preservatives are ranging from 51.00 g - 18.70 g/100 g. The lower amounts of total sugars in the fruits preserved in 50° Brix sugar syrup with sodium benzoate may be due to oxidation of sugars and high value in fruits preserved in 50° Brix sugar syrup with potassium metabisulfite may be due to less oxidation of sugars.

5.1.2 Mineral content of preserved products of palmyrah fruit

Calcium and magnesium content in fruits preserved at ambient temperature (Table 6) are similar to that of minerals in the fresh fruits. Refrigerated samples also showed similar amounts. In dehydrated sample, calcium level is almost similar but magnesium level had decreased (Table 6) which may be due to the formation of magnesium salts during sulphiting and its leaching into processing water during blanching by ex-osmosis. The low levels of trace minerals may also be due to leaching of minerals into the processing water by ex-osmosis.

The fruits preserved in different concentrations of sugar syrup had low calcium and magnesium amounts compared to fruits preserved at different temperatures. The trace minerals were also found to be low (Table 6) which may be attributed to the leaching of minerals into the processing water by ex-osmosis. Similar observation was found in fruits preserved in honey.

Preservation of fruits in 50° Brix sugar syrup with chemical preservatives showed lower amounts compared to those preserved at different temperatures. Calcium and magnesium levels observed in fruits preserved in 50° Brix sugar syrup with sodium benzoate (Table 6) were high compared to those preserved in 50° Brix sugar syrup with

potassium metabisulfite and the use of combination of preservatives. The reason for low calcium and magnesium contents may be due to the increased formation of sulphate salts (by combining with sulphur in the potassium metabisulfite) and their leaching into the processing water by ex-osmosis. The lower amounts of trace minerals (Table 6) are also due to the similar observation as mentioned above.

5.2 ORGANOLEPTIC EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT

Organoleptic evaluation was conducted for the fresh fruit and the preserved products at regular intervals. The organoleptic qualities such as colour, flavour, texture, taste and overall acceptability were assessed for all the preserved products.

5.2.1 Ambient temperatures (37-40°C)

The fruits stored at ambient temperature were found to be highly acceptable till six hours of storage, but later changes have occurred (Table 7). The gradual change in colour may be due to enzymatic browning reaction (Aurand and Woods, 1973) in the fruits. Significant changes ($P < 0.05$) were observed in the sensory parameters of the fruits preserved at ambient temperature which may be due to the onset of fermentation of sugars in the

fruits. Flavour changes may be attributed to the acid formation due to the onset of fermentation. Change in taste may be due to the acid and alcohol production during fermentation in the fruit. Over all changes observed in the fruit can be attributed to the onset of fermentation in the fruit at 12 hours of storage.

5.2.2 Refrigeration (4-6°C) and dehydration (50-70°C) temperatures

The palmyrah palm fruits stored at refrigeration temperature (Table 8) were stored for only 8 days as they were not further acceptable. The fruits were highly acceptable till four days of storage with no changes in the sensory parameters, whereas on sixth day there were changes in texture and overall acceptability. Significant changes were observed in all the sensory parameters on eighth day of storage. The changes in colour may be due to the enzymatic browning reaction (Aurand and Woods, 1973) in the fruits. The bitter taste in the fruits may be attributed to the alcohol production on fermentation of sugars in the fruits. Change in texture may be due to the formation of acid on fermentation of sugars in the fruits. The overall changes in the fruit may be attributed to the onset of fermentation of sugars in the fruits. The palmyrah fruits stored only for eight days.

The organoleptic mean scores for the fruits preserved by dehydration method showed fairly good (4) initial scores. Similar observation was made throughout the storage period. Significant difference ($P < 0.05$) were observed in colour though the fruits were highly appealing (5) throughout the storage period. The highly appealing colour of the fruit may be because of the sulphiting process, where sulphur dioxide absorbed during sulphiting process preserves the colour of the fruit. According to Roberts and McWeeny (1972) Sulphur dioxide absorbed by the fruit intends to maintain an attractive colour, and prevent spoilage of the product. Absorption and retention of the sulphur dioxide during dehydration depends on increased concentration of potassium metabisulfite solution during sulphiting and duration of steeping (Khedkar and Susanta, 1983) Longer steeping (30 min) helps better retention of sulphur dioxide. Sweet (4) flavour and taste were observed which may be due to the use of sugar solution to reconstitute the dehydrated product. Chavan et al. (1993) recommended that the reconstitution of dried ber fruit in 40 per cent sugar solution was better. The reconstituted palmyrah fruit, in the study had slightly tender texture which was well compared to that of the fresh fruit. The better reconstitution of the dehydrated fruit may be due to the water blanching process adopted during the dehydration process. Sterling and Shimazu (1961) showed that water blanching increased the

amorphous content of the cell wall cellulose in dried carrots which in turn allowed the intact cell walls to more rapidly absorb the water, swell and assume their original shape resulting in improved reconstitutability. Histological evidences by Khedkar and Susanta (1980) showed that higher reconstitution ratio was observed in cabinet dried raw mango slices as compared to the sundried slices which was due to less rupture of the cells during drying in cabinet drier. So cabinet drying process was preferred over sun drying process of the palmyrah palm fruits.

5.2.3 50°Brix and 70°Brix sugar syrup

The palmyrah palm fruits preserved in 50° Brix sugar syrup (Table 9) had good initial scores. Significant changes were observed in all the sensory parameters except texture throughout the storage period. The colour change observed may be due to the browning reactions of sucrose (Judic, 1986). Sweet (4) taste and flavour may be due to the sugar syrup used in preservation of the fruit. The mean scores for the texture show that the fruit was slightly tender (4) throughout the storage period which may be attributed to the sucrose functional property i.e texture tenderizer (Judie, 1986). The fair acceptability of the product may be due to the changes observed in the sensory parameters.

The organoleptic mean scores for palmyrah fruits preserved in 70°Brix sugar syrup open kettle one period process (Table 9) had good initial scores and no significant changes were observed in all the sensory parameters throughout the storage period. Colour was found to be highly appealing (5) though it was golden yellow in colour (i.e different from the original colour of the fruit) which may be due to the browning reactions of sucrose (Judie, 1986). Sweetness and flavour enhancement in the stored product may be due to the use of cane sugar syrup for preserving the fruit. Firming of the fruit and shrinkage of the fruit was observed. Shrinkage in the fruit may be due to the removal of water from fruit by ex-osmosis due to high concentration of sugar syrup surrounding the fruit. Firming of the fruit may be due to the disposition of sugar in cooked fruit tissue. Sterling and chichester (1968) showed that sugar from syrup around the cooked fruit may be found in higher concentration in the cell walls than in the fruit within the cells leading to the firming of the fruit.

The organoleptic mean scores for the palmyrah palm fruits preserved in 70° Brix sugar syrup open kettle slow process (Table 9) show that the initial scores were good. But the texture was slightly hard (2) i.e, it had the lowest score. There were no significant differences ($P < 0.05$) observed in all the sensory parameters throughout

the storage period. Colour was moderately appealing (4) and the golden yellow colour of the fruit may be due to the higher concentration of the sugar syrup used as a media for preservation of the fruit. Sweet (4) taste and flavour may be attributed to the sugar syrup used in the preservation of fruits. Hardening and shrinkage were observed in the fruits which can be observed from Plate 5. Shrinkage observed in the fruits may be due to the loss of water from fruit by ex-osmosis. Hardening of the fruit may be due to the disposition of sugar in cooked fruit tissue. Sterling and Chichester (1968) showed that sugar from syrup around the cooked fruit was found in higher concentration in the cell wall than in the fluid within the cells leading to firming of the fruit.

Candy prepared from palmyrah palm fruit was organoleptically evaluated (Table 9) and the initial scores for candy were observed to be good (4). There was no significant difference ($P > 0.05$) observed in all the sensory parameters. The initial score for texture was low i.e., slightly hard (2). Colour of the fruit was found to be moderately appealing (4) and the golden yellow colour of the fruit may be due to the higher concentration of the sugar syrup used as a media in the pre-preparatory process of candy making. The sweet (4) taste and flavour can be attributed to the sugar syrup used in the preservation of fruit. Slightly hard (2) texture of the fruit and

shrinkage in the fruit were observed. Shrinkage in the fruit may be due to the osmosis effect i.e removal of water from the fruit by higher concentration of the sugar syrup. Hardening of the fruit may be due to the disposition of sugar in the cooked fruit tissue (sterling and Chichester, 1968) the overall acceptability of the product was excellent and the shelflife life was for 10 days (as per the scheduled work in synopsis). The product can be stored for longer periods also. Similar type of studies carried out by Upasana Rani and Bhatia (1985) on the candy prepared from sand pear and bagugosha pear stored well for about 16 weeks at 37° C and 40 weeks under ambient temperatures (30-35°C).

Out of all the products prepared by using sugar syrup, candy ranked first followed by fruits preserved in 70°Brix sugar syrup open kettle one period process, fruits preserved in 70° Brix sugar syrup open kettle slow period process, and lastly fruits preserved in 50° Brix sugar syrup.

5.2.4 Honey

The organoleptic mean scores for the fruits stored in 40°Brix honey (Table 10) show that significant changes were observed in all the sensory parameters. Brownish colour of the fruit (Plate 7) was observed and it was found to be slightly appealing (3) in nature. The

colour obtained for the fruit may be due to the colour of the honey used as a preservative for the fruits. Sweet (4) flavour was observed till second day of storage but from fourth day change was observed which may be due to the onset of fermentation in the fruit, due to the insufficient syrup strength to preserve the fruit. Slightly tender texture (4) was observed in the fruit with significant changes which might be due to low syrup strength leading to the softness of the fruit. Sweetness observed may be due to the honey taste. The overall acceptability shows that the product satisfactorily stored only for 6 days as the quality had degraded, which might be due to the onset of fermentation. The spoilage of the fruit may be due to the low syrup strength used to preserve the fruit.

The palmyrah palm fruits preserved in 80° Brix honey were organoleptically evaluated and the mean scores show that (Table 10) significant changes were observed in the sensory parameters. Brownish colour of the fruit was observed and the colour changes were found to be significant and these changes may be attributed to the colour of the honey used as a syruping agent for preserving the fruit. Sweet (4) flavour and taste were observed which may be due to honey used as a syruping agent. Moderate (5) to slightly tender (4) texture was observed in the fruits. Overall acceptability also showed significant

changes ($P < 0.05$) which may be due to the less acceptability of honey as a syruping agent.

It is clear that the fruits preserved in 80°Brix honey were better from those preserved in 40°Brix honey.

5.2.5 50°Brix sugar syrup with class II preservatives

The mean scores of the organoleptic evaluation of the palmyrah palm fruits preserved in 50° Brix sugar syrup with potassium meta bisulfite (Table 11) shows that the sensory parameters initially were ranging from 3.0-4.0; with fair (3) overall acceptability. No significant differences were observed on the other days of storage compared to the initial days of storage. Colour retention was better in the preserved fruits which may be due to the sulphur present in potassium metabisulfite, as sulphur dioxide was found to maintain attractive colour and prevent spoilage (Roberts and Mcweeny, 1972). The low score for flavour may be due to the persistant smell of sulphur dioxide from the chemical preservative (potassium metabisulfite) used in the preservation of fruits. Slightly tender (4) texture was observed throughout the storage period which may be due to the sulphur present in the potassium metabisulfite used and it was found to preserve certain attributes of the preserved products until marketed (Roberts and Mcweeny, 1972). Sweet (4) taste of the preserved product may be due to the sugar

colour obtained for the fruit may be due to the colour of the honey used as a preservative for the fruits. Sweet (4) flavour was observed till second day of storage but from fourth day change was observed which may be due to the onset of fermentation in the fruit, due to the insufficient syrup strength to preserve the fruit. Slightly tender texture (4) was observed in the fruit with significant changes which might be due to low syrup strength leading to the softness of the fruit. Sweetness observed may be due to the honey taste. The overall acceptability shows that the product satisfactorily stored only for 6 days as the quality had degraded, which might be due to the onset of fermentation. The spoilage of the fruit may be due to the low syrup strength used to preserve the fruit.

The palmyrah palm fruits preserved in 80° Brix honey were organoleptically evaluated and the mean scores show that (Table 10) significant changes were observed in the sensory parameters. Brownish colour of the fruit was observed and the colour changes were found to be significant and these changes may be attributed to the colour of the honey used as a syruping agent for preserving the fruit. Sweet (4) flavour and taste were observed which may be due to honey used as a syruping agent. Moderate (5) to slightly tender (4) texture was observed in the fruits. Overall acceptability also showed significant

changes ($P < 0.05$) which may be due to the less acceptability of honey as a syruping agent.

It is clear that the fruits preserved in 80°Brix honey were better from those preserved in 40°Brix honey.

5.2.5 50°Brix sugar syrup with class II preservatives

The mean scores of the organoleptic evaluation of the palmyrah palm fruits preserved in 50° Brix sugar syrup with potassium meta bisulfite (Table 11) shows that the sensory parameters initially were ranging from 3.0-4.0; with fair (3) overall acceptability. No significant differences were observed on the other days of storage compared to the initial days of storage. Colour retention was better in the preserved fruits which may be due to the sulphur present in potassium metabisulfite, as sulphur dioxide was found to maintain attractive colour and prevent spoilage (Roberts and Mcweeny, 1972). The low score for flavour may be due to the persistant smell of sulphur dioxide from the chemical preservative (potassium metabisulfite) used in the preservation of fruits. Slightly tender (4) texture was observed throughout the storage period which may be due to the sulphur present in the potasium metabisulfite used and it was found to preserve certain attributes of the preserved products until marketed (Roberts and Mcweeny, 1972). Sweet (4) taste of the preserved product may be due to the sugar

syrup used for the preservation of the fruits. Fair (3) overall acceptability of the product was observed and the low score for acceptability may be due to the persistent flavour of sulphur from the chemical preservative (potassium meta bisufite) used in the preserved product. The product kept well without spoilage throughout the storage period. Vijaysethi and Anand (1984) reported that fermentation was checked by the use of sulphur (in the form of potassium metabisulfite) in carrot and amla preserves. Satisfactory shelf life was observed in litchi (*Nephelium litchi*) squash preserved using sulphur dioxide by Jain et al (1986). Similarly bagugosha pear had shelf life for about 40 weeks when stored by steeping in sugar syrup (70-72^o Brix) with 200ppm of potassium meta bisulfite (Upasana Rani and Bhatia, 1986). This shows that the use of sulphur dioxide had not only prevented the spoilage of the product but also increased the shelf life.

The palmyrah palm fruits preserved in 50^o Brix sugar syrup with sodium benzoate were organoleptically evaluated and (Table 11) the results show that significant differences were observed in colour and texture during storage period. No significant changes were observed in flavour, taste and overall acceptability through out the storage period. Change in colour from moderately appealing (4) to appealing (3) was observed which way be due to the browning reactions of sucrose (Judie, 1986) and

may be due to the absence of sulphur to preserve the colour of the fruit (Roberts and Mcweeny, 1972). Sweet (4) flavour and taste may be due to the sugar syrup used as a preservative. Texture tenderizing is one of the functional properties of sucrose (Judie, 1986) and the changes in texture may be attributed to the above reason. Overall acceptability of the product was fair (3) which shows that the product stored well till 10 days without any spoilage. The use of preservative may be the reason for the absence of spoilage of the product. The use of preservatives can prevent the spoilage of the product which can be supported by studies conducted by Urmil Mehta and Satinder Bajaj (1983) where the use of sodium benzoate had preserved the juices of citrus fruits for eight months without spoilage. Similar study on the use of sodium benzoate as preservative in the storage of phalsa (*Grewia asiatica*) and kaphal squashes was done by Jain et al. (1986) where squashes were stored for six months. Preservatives not only increase the shelf life of the products, but are also efficient in controlling the fermentation occurring during storage period as supported by a study by Vijay Sethi and Anand (1984) on the use of sodium benzoate in carrot and amla preserves to prevent fermentation of the product. So the use of sodium benzoate not only increase the shelflife of the product but also prevents fermentation of the product.

The organoleptic mean scores of palmyrah fruits preserved in 50°brix sugar syrup with combination of preservatives (potassium metabisulfite and sodium benzoate) (Table 11) show that the significant differences were observed in flavour only. Colour was found to be better appealing (3) as compared to the fruits stored using sodium benzoate (as preservative) which may be due to the presence of sulphur dioxide (in the potassium metabisulfite used) as it contributes to colour retention in the preserved product (Roberts and Mcneeny, 1972). The changes observed in flavour may be due to the use of chemicals as preservative (sulphur smell had persisted). Very sweet (3) taste may be due to the use of sugar syrup as a media. Sucrose as a texture tenderizer (Judie, 1986) was found to have effect on texture of the fruit preserved in 50°Brix sugar syrup with combination of chemical preservatives. The results show that the product stored well for 10 days without spoilage, which shows that the use of preservatives not only increase shelflife but also prevent the fermentation of the preserved products (Vijay Sethi and Anand, 1984). The combined use of preservatives was found to be better in the preservation of fruits compared to the use of chemicals individually.

5.3 MICROBIOLOGICAL EVALUATION OF THE PRESERVED PRODUCTS OF PALMYRAH FRUIT

Microbiological evaluation of the preserved products (Table 12). show that in general, bacterial counts were observed to be less which might be due to the sterile conditions employed during preparation of the product. The fruits preserved at ambient temperature and refrigeration temperature showed higher counts compared to the dehydrated product. The products preserved using higher temperature showed low microbial counts. The higher counts in fruits preserved at ambient and refrigeration temperature may be due to the availability of moisture for the growth of microorganisms. The use of high temperature reduces the moisture content thereby decreasing the suitable conditions for the growth of bacteria.

The fruits preserved at different concentrations of sugar syrup shows that the microbial counts were low in fruits preserved at higher concentrations of sugar syrup i.e., at 70°Brix sugar syrup and candy (Table 12). The higher the concentration of sugar syrup, lower was the bacterial count which may be due to the low level of moisture and high concentration of sugar and the sterile conditions followed during preservation of products (Aruna, 1994). Similar observations were seen in fruits preserved using 80°Brix honey syrup. The higher bacterial count in fruits preserved in 40°Brix honey syrup may be

due to the lower concentration of syrup evidently insufficient for proper storage of fruits. At 80°Brix honey the low bacterial counts were observed which may be due to the low moisture availability and the high concentration of syrup. The bacterial counts in the fruits preserved using sugar syrup and honey (80°Brix) were observed to be less, compared to those fruits preserved at ambient and refrigeration temperatures.

The fruits preserved in 50°Brix sugar syrup with preservatives showed slightly higher bacterial counts than those fruits preserved using higher concentration of sugar syrup but less when compared to those preserved at ambient and refrigeration temperatures.

It is evident that the fruits preserved using higher temperatures and high sugar concentrations were found to have low bacterial counts which may be due to the low moisture availability for the growth of microorganisms. The use of preservatives have also reduced the bacterial count which may be because of the preservative effect of the chemicals used in the preservation of fruits.

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SUMMARY

CHAPTER VI

SUMMARY AND CONCLUSIONS

The present study was conducted to preserve the palmyrah palm fruits (tender) as they being highly perishable in nature. Because of its short span of life and its seasonal disparity and wide acceptability during summer, attempt was made to preserve the palmyrah palm fruits by developing suitable preservation methods.

Fresh palmyrah palm fruits of moderate tenderness for the study were collected from the near-by-village and they were initially used to analyse the chemical composition of the fruit by using standard procedures.

Preservation methods have been developed and the methods used are (a) use of different temperatures i.e. ambient temperature ($37-40^{\circ}\text{C}$), Refrigeration temperature ($4-6^{\circ}\text{C}$) and dehydration temperatures ($50-70^{\circ}\text{C}$) (b) use of different concentrations of Sugar syrup i.e. 50°Brix Sugar syrup, 70°Brix sugar syrup-open kettle one period process, 70°Brix Sugar syrup-open kettle slow proces, and Candy preparation . (c) use of honey as Syruping agent - 40°Brix and 80°Brix honey (d) use of 50°Brix Sugar syrup with chemical preservatives. The preservatives used are Potassium metabisulfite and Sodium Benzoate. The processed fruits were stored in food grade polyethylene containers of half litre capacity and tightly sealed. Storage study

was conducted for a period of 10 days. Organoleptic evaluation was done by a trained panel of 6 members at 2 days interval for 10 days. The acceptability of the products were recorded by the panelists using score card (Appendix IV). The sensory scores for colour, flavour, texture, taste and overall acceptability were recorded.

The preserved products at the end of the storage period were analysed for total and reducing sugars and also minerals such as calcium, magnesium, iron, zinc, copper and manganese using standard procedures. Standard plate count was also done for the preserved products to assess the safety of the products.

The estimated chemical composition shows that the palmyrah palm fruits were found to be low in protein, fat and high in moisture content. Fruit was observed to be rich in minerals i.e. calcium, magnesium, iron, zinc, copper and manganese.

Organoleptic evaluation showed that the fruits preserved at ambient temperature ($37-40^{\circ}\text{C}$) stored for only 12 hours and the changes observed in the sensory parameters may be due to the onset of fermentation. The fruits preserved at refrigeration temperature ($4-6^{\circ}\text{C}$) showed shelf life for 8 days. The dehydrated product stored well till 10 days without spoilage and when reconstituted it was found to be better over fruits at ambient and

refrigeration temperatures. Use of different concentrations of sugar syrup as an other preservation method showed that candy was excellently accepted compared to fruits in 70° Brix sugar syrup and fruits in 50° Brix sugar syrup. Fruits preserved in 50° Brix sugar syrup stored well for 10 days with fair acceptability. Fruits preserved in 70° Brix sugar syrup - open kettle one period and open kettle slow process had good acceptability and no significant changes were observed in sensory parameters but texture had changed from slightly tender to moderately hard which may be due to the disposition of sugar in cooked fruit tissue. Shrinkage was also observed in these fruits which may be attributed to the ex-osmosis. But the products had stored well till 10 days period. Candy was excellently accepted though hard texture was observed and it stored well till 10 days of storage period. Fruits preserved in 80° Brix honey were found to have better acceptability than the fruits in 40° Brix honey. The fruits in 40° Brix honey were acceptable only for 6 days which may be, due to insufficient syrup strength to preserve the fruit. Fruits preserved in 80° Brix honey stored with fair acceptability which may be due to unacceptability of honey as a media for preserving the fruit. The fruits preserved in 50° Brix sugar syrup with chemical preservatives showed that the colour retention was better in the products stored using potassium metabisulfite but the drawback was the smell of sulphur which

was persisting. The products using preservatives stored well for 10 days without spoilage which may be due to the preservative action of the class II preservatives used. The combined use of chemical (Class II) preservatives was found to have better preservation effect compared to the individual use of preservatives.

The estimated amounts of total sugars and reducing sugars in the preserved products were high in products preserved using high concentration of sugar syrup whereas fruits at ambient (37-40°C) and refrigeration (4-6°C) temperatures showed lower sugar values which may be due to the oxidation of sugars in these fruits. The analysed mineral amounts were in low concentrations compared to amounts observed in fresh fruit which may be due to leaching of minerals into the processing water by ex-osmosis.

Microbiological evaluation of the preserved products show that the bacterial count was high in fruits at ambient (37-40°C) and refrigeration (4-6°C) temperatures. The fruits preserved using higher temperatures, high concentration of sugar syrup had low bacterial counts which may be due to low moisture availability. Use of preservatives have showed lower bacterial counts compared to those preserved at ambient (37-40°C) and refrigeration (4-6°C) temperatures.

In the present study, it is observed that the palmyrah fruits preserved using different preservation methods showed increased shelflife of the fruit. Though the original characteristics were not noticed, the palmyrah fruit stored well. The fruits preserved by dehydration process, and by candy making had excellent storage.

The fruits preserved by using higher concentrations of syrup i.e., 70°Brix sugar syrup and 80°Brix honey had good acceptability. Preservatives were also found to have increased the shelf life and also prevented the spoilage at 50°Brix sugar syrup. Refrigeration was also found to be a better method of preservation. To further improve the shelf life of the fruits, work has to be conducted in the area of preservation by adopting methods such as osmotic dehydration, canning etc. and also the use of palmyrah fruit in desserts.

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APPENDI

APPENDICES

APPENDIX - I

FOOD SAMPLE PREPARATION FOR MINERAL ESTIMATION

Material required

Food sample : 1 g
*Triacid mixture : 10 ml

Procedure: One gram finely powdered sample was accurately weighed into a 100/150 ml conical flask (Pyrex or Corning) 10 ml of the triacid mixture was added to the sample and a funnel was kept over the flask. The contents were left overnight for cold digestion. Next day the contents were digested at low temperature for about 2-3 hours (50-60°C) on a hot plate. The temperature of the hot plate was increased to 200°C till the contents became white and the major portion of the perchloric acid was expelled i.e., the dense white fumes of perchloric acid ceases to appear on heating. Then the flask was removed from the hot plate, cooled and diluted to 10 ml and filtered through Whatman No.1 filter paper. This solution was used for determination of zinc, copper, iron and manganese. Atomic Absorption Spectrometer was used to read the amounts of the minerals.

Hundred fold dilution was needed for calcium, manganese, potassium. So half a gram of the finely powdered sample was exactly weighed into a 100/150 ml conical flask and the rest of the procedure was same as

under micro-nutrients (Zn, Cu, Fe and Mn) except that the digested sample was diluted to 50 ml and shaken thoroughly before filtration.

*** Triacid mixture**

Acids used in the trials were concentrated nitric acid, concentrated sulphuric acid and perchloric acid (72 per cent concentration). The acids were of analar grade/guaranteed reagent/E - merck standard. The acids were mixed in the proportion of 10.0:0.5:2.0 (HNO_3 : H_2SO_4 : HClO_4) by volume and stored in a pyrex/corning reagent bottle.

APPENDIX - II

ESTIMATION OF TOTAL AND REDUCING SUGARS

Principle: Reducing substances other than sugars are precipitated by lead acetate. Excess lead acetate was removed by potassium oxalate.

The filtered extract gives reducing sugar when this extract was treated with Hydrochloric acid, the non-reducing sugars, like sucrose gets inverted to give total sugars. The extracts are heated with alkaline copper reagents and the reduced copper formed is treated with arsenomolybdate reagent resulting in the formation of violet colour.

Reagents used

- 1) 45 per cent neutral lead acetate
- 2) Potassium oxalate
- 3) Concentrated hydrochloric acid
- 4) 0.10 per cent phenolphthalein
- 5) Standard glucose: 50 mg in 100 ml water
- 6) Copper reagent A: 25 g anhydrous sodium bicarbonate, 25 g of sodium potassium tartarate, 20 g of sodium bicarbonate, 200 g of anhydrous sodium sulphate were dissolved in 1 litre of distilled water.

Copper reagent B: 15 g of copper sulphate was dissolved in 100 ml of water, with 1 or 2 drops of concentrated H_2SO_4 .

Alkaline copper reagent: 25 g of Ammonium molybdate was dissolved in 450 ml of distilled water and 20 ml of concentrated H_2SO_4 . Solution was mixed well. 3 g of sodium arsenate was dissolved in 25 ml of water and added to above solution, mixed and incubated at $37^{\circ}C$ for 24-28 hours.

Sample extraction

To one gram of sample, 25 ml of water was added and simmered for 20 minutes. After cooling, 5 ml of 45 per cent neutral lead acetate was added and was kept for 30 minutes. Three small spatulas of potassium oxalate was added or the solution was made upto 50 ml and filtered. This is reducing sugar extract 1.

10 ml of the extract was taken, 1 ml of concentrated HCl was added and boiled for 5 minutes. After cooling few drops of phenolphthalein was added followed by 1 N sodium hydroxide for neutralization. This is the total sugar extract 2.

Nelson-Somogyii method of sugar estimation

To each 0.1 ml of extract (1), (2) and standard glucose (0.1 - 0.5 ml) 1 ml of alkaline copper reagent was added and simmered in a water bath for 20 minutes cooled

and then 1 ml of arsenomolybdate solution was added and made upto 25 ml and read at 520 nm (nanometer).

Calculations

X = mg of glucose obtained from standard graph

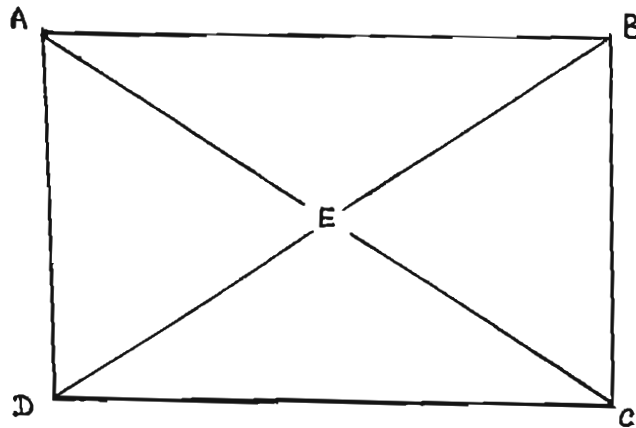
$$\text{Total sugars} = X \times \frac{10}{0.1} \times \frac{50}{10} \times \frac{100}{\text{sample weight}} \times \frac{1}{1000}$$

$$\text{Reducing sugars} = X \times \frac{50}{0.1} \times \frac{100}{\text{sample weight}} \times \frac{1}{1000}$$

APPENDIX - III

PEARSON'S METHOD / SQUARE METHOD

In order to increase the strength of any syrup the most common method adopted in the trade is the Pearson's method which is also known as square method which consist of a square ABCD drawn with centre marked E.



At A, Brix reading of heavy syrup and pounds of sugar present per gallon were noted and at D Brix degree of light syrup and pounds of sugar per gallon of syrup were noted. This was marked zero when water only was to be added for dilution and 100 when sugar was to be added. At E. Brix degree and sugar present per gallon of desired syrup were noted. Working diagonally across the square, smaller number was subtracted from the larger number and the difference was written at the corners C and B. These numbers represent the ratio in which the two syrups are to be mixed by volume to get the desired strength of syrup at E.

Testing syrup strength

It becomes necessary to measure the syrup strength as for the uniformity of canned product so a pocket refractometer is conveniently employed to measure syrup strength.

APPENDIX - IV
SENSORY EVALUATION SHEET

Name :

Date : Time :

Evaluate the products by assessing appropriate scores both for physical and organoleptic characteristics

Code of the product	Score	Colour	Flavour	Texture	Taste	Overall acceptability
	5	Highly appealing	Characteristic	Very tender	Characteristic	Very good
	4	Moderately appealing	Sweet	Moderately tender	Sweet	Good
	3	Appealing	No flavour	Slightly tender	Very sweet	Fair
	2	Slightly appealing	Odd flavour	Slightly hard	Sour	Acceptable
	1	Not appealing	Fermented flavour	Moderately hard	Bitter/ any other	Not acceptable

SIGNATURE OF THE JUDGE

APPENDIX - V
MICROBIOLOGICAL EXAMINATION

The procedure of Cruick's Bacterial count was used for total bacterial count in the samples. The viable count of bacteria was determined by pour plate method (Cruickshank et al., 1975).

Total bacterial count (TBC) by pour plate method

Reagents :

Normal saline : 0.85 per cent

Standard plate count agar

Viable count of bacteria

Principle

The number of living bacteria or groups of bacteria in a liquid culture or suspension is counted by a cultural method such as the pour plate method. A measured amount of the suspension is mixed with molten agar medium in a petri-dish. After setting and incubation, the number of colonies are counted. As a compromise between sampling and over crowding errors, counts of pure cultures should be made on plates inoculated to yield between 30 and 300 colonies.

Procedure

Serial tenfold dilution of the bacterial suspension was prepared over a range ensuring that one dilution contained between 30 and 300 viable bacteria per ml. Normal saline was used as a diluent for the organism. 9 gm of the diluent was pipetted into several sterile test tubes. The bacterial suspension was uniformly mixed. Using a sterile 1 ml pipette, 1 ml of the suspension was transferred into the first tube of diluent by touching the tip of the pipette to the wall of the tube. The first dilution was mixed thoroughly using another sterile pipette by filling and emptying the contents several times. From this mixed dilution 1 ml was transferred to the next diluent. Similar dilutions were made in same way using fresh pipettes.

One ml of each dilution (from the greatest dilution) was pipetted into three petridishes. Into each dish, 10 ml of standard plate count agar was poured which was melted earlier and cooled to 45-50°C. The agar was immediately distributed by gently swirling the petridish in circular movements while flat on the bench, for 2 seconds. The agar was allowed to set evenly and the inverted petridishes were incubated for two days at 37°C.

Calculations

The colonies which were inoculated under different dilutions were counted for 30 and 300 colonies per plate and the average number per plate was multiplied by the dilution factor to obtain the viable count per ml in the original suspension.

Number of colonies x dilution factor = count per ml of the sample

Note : For powders and semisolids 1 g of sample was dissolved in 10 ml of saline used.

Appendix VI

Analysis of variance (one way) of organoleptic evaluation of
palmyrah fruits preserved at different temperatures

S. No.	Preservation method	Sensory parameters	Degrees of freedom		Mean sum of squares		F calculated	Critical difference
			TSS	ESS	TSS	ESS		
1.	Ambient temperature (37-40°C)	Colour	3	28	9.28	0.33	27.29	0.49
		Flavour	3	28	26.91	0.24	111.68	0.41
		Texture	3	28	2.79	0.13	22.32	0.30
		Taste	3	28	26.12	0.34	77.06	0.49
		Overall acceptability	3	28	25.00	0.11	233.64	0.28
2.	Refrigeration temperature (4-6°C)	Colour	4	35	2.71	0.41	6.67	0.52
		Flavour	4	35	10.00	0.06	175.43	0.19
		Texture	4	35	1.84	0.22	8.29	0.39
		Taste	4	35	25.22	0.025	1009.00	0.13
		Overall acceptability	4	35	5.79	0.19	30.14	0.36
3.	Dehydration temperature (50-70°C)	Colour	5	42	0.09	0.02	4.50	0.11
		Flavour	5	42	0.27	0.24	1.13	-
		Texture	5	42	0.08	0.23	0.34	-
		Taste	5	42	0.15	0.19	0.70	-
		Overall acceptability	5	42	0.14	0.35	0.40	-

TSS : Treatment sum of squares

ESS : Error sum of squares

- : No significant difference

Appendix VII
Analysis of variance (one way) of organoleptic evaluation of
fruits preserved in different concentrations of sugar syrup

S. No.	Preservation method	Sensory parameters	Degrees of freedom		Mean sum of squares		F calculated	Critical difference
			TSS	ESS	TSS	ESS		
1.	50° Brix sugar syrup	Colour	5	42	4.47	0.24	18.55	0.40
		Flavour	5	42	1.87	0.49	3.81	0.58
		Texture	5	42	6.34	0.21	1.64	-
		Taste	5	42	1.13	0.14	8.10	0.31
		Overall acceptability	5	42	3.30	0.22	15.00	0.39
2.	70° Brix sugar syrup - Open kettle one period process	Colour	5	42	0.23	0.26	0.92	-
		Flavour	5	42	0.03	0.08	0.43	-
		Texture	5	42	26.28	1.23	202.10	0.80
		Taste	5	42	0.10	0.18	0.56	-
		Overall acceptability	5	42	0.30	0.25	1.20	-
3.	70° Brix sugar syrup - Open kettle slow process	Colour	5	42	0.48	0.94	0.50	-
		Flavour	5	42	0.00	0.00	0.00	-
		Texture	5	42	0.48	0.22	2.18	-
		Taste	5	42	0.02	0.10	0.20	-
		Overall acceptability	5	42	0.75	1.46	0.51	-
4.	Candy	Colour	5	42	0.12	0.19	0.60	-
		Flavour	5	42	0.00	0.00	0.00	-
		Texture	5	42	0.00	0.00	0.00	-
		Taste	5	42	0.43	0.20	2.14	-
		Overall acceptability	5	42	0.13	0.33	0.40	-

TSS : Treatment sum of squares

ESS : Error sum of squares

- : No significant difference

Appendix VIII
 Analysis of variance (one way) of organoleptic evaluation of fruits
 preserved in honey

S. No.	Preservation method	Sensory parameters	Degrees of freedom		Mean sum of squares		F calculated	Critical difference
			TSS	ESS	TSS	ESS		
1.	40° Brix honey	Colour	3	28	5.37	0.27	19.47	0.44
		Flavour	3	28	10.08	0.63	16.00	0.68
		Texture	3	28	0.75	0.21	3.65	0.38
		Taste	3	28	0.64	0.17	3.67	0.35
		Overall acceptability	3	28	5.62	0.37	15.20	0.51
2.	80° Brix honey	Colour	5	42	0.75	0.09	8.33	0.24
		Flavour	5	42	0.10	0.18	0.56	-
		Texture	5	42	1.42	0.22	6.42	0.38
		Taste	5	42	0.56	0.19	2.90	0.35
		Overall acceptability	5	42	0.35	0.04	8.75	0.16

TSS : Treatment sum of squares
 ESS : Error sum of squares
 - : No significant difference

Appendix IX

Analysis of variance (one way) of organoleptic evaluation of fruits preserved in 50 Brix sugar syrup with chemical preservatives

S. No.	Preservation method	Sensory parameters	Degrees of freedom		Mean sum of squares		F calculated	Critical difference
			TSS	ESS	TSS	ESS		
1.	50° Brix sugar syrup with potassium metabisulfite	Colour	5	42	0.47	0.30	1.50	-
		Flavour	5	42	0.00	0.00	0.00	-
		Texture	5	42	0.05	0.54	0.09	-
		Taste	5	42	0.03	0.27	0.01	-
		Overall acceptability	5	42	0.08	0.53	0.14	-
2.	50° Brix sugar syrup with sodium benzoate	Colour	5	42	2.03	0.61	3.30	0.64
		Flavour	5	42	0.20	0.28	0.71	-
		Texture	5	42	1.57	0.07	22.44	0.22
		Taste	5	42	0.02	0.27	0.09	-
		Overall acceptability	5	42	0.10	0.49	0.20	-
3.	50° Brix sugar syrup with combination of potassium metabisulfite and sodium benzoate	Colour	5	42	1.04	0.68	1.50	-
		Flavour	5	42	1.78	0.39	4.40	0.52
		Texture	5	42	0.42	0.44	0.96	-
		Taste	5	42	0.17	0.41	0.42	-
		Overall acceptability	5	42	0.98	0.52	1.90	-

TSS : Treatment sum of squares

ESS : Error sum of squares

- : No significant difference

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