# STUDY ON DEHYDRATION OF BER
## (*Zizyphus mauritiana* Lamk.)

By

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***Research project submitted to Chaudhary Charan Singh Haryana Agricultural University in the partial fulfillment of the requirements for the degree of***

**MASTER OF SCIENCE**
**IN**
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**CENTRE OF FOOD SCIENCE AND TECHNOLOGY CHAUDHARY CHARAN SINGH HARYANA AGRICULTURAL UNIVERSITY**
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**Dedicated To**

**My Parents**

## CERTIFICATE-1

This is to certify that this research project entitled **"Study on dehydration of ber (*Zizyphus mauritiana* Lamk.)"** submitted for the degree of M.Sc., in the subject of Food Science and Technology to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Mr. Naresh Kumar** under my supervision and that no part of this research project has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

**Dr. Saleem Siddiqui**

Major Advisor

## CERTIFICATE-II

This is to certify that this research project entitled **"Study on dehydration of ber (*Zizyphus mauritiana* Lamk.)"** submitted by **Mr. Naresh Kumar** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, in partial fulfillment of the requirements for the degree of Master of Science, in the subject of Food Science and Technology has been approved by the student's advisory committee, after an oral examination on the same.

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***HISAR*** ***(NARESH Kumar)***

# CONTENTS

# CHAPTER–1

## *INTRODUCTION*

Ber (*Zizyphus mauritiana* Lamk.) is one of the most ancient and common fruit of India. It is an ideal fruit for cultivation in arid and semi-arid regions of India where most of other fruits cannot be grown either due to lack of irrigation facilities or adverse climatic conditions. It is indigenous to India belonging to family Rhamnaceae. It is one of the hardy fruit tree and cultivated in Northern parts of India especially in the states of Punjab, Haryana, Rajasthan, Utter Pradesh and also in Maharastra and Gujrat. Total area under ber cultivation in India is around 61284 hectares (Bose *et al.*, 2001). The recent statistics of Haryana reveal that it occupies 4173 hectare of land with a production of 41753 MT (Anon. 2001).

The ber fruits are rich in nutritive value, so called "a poor man's apple." It is a rich source of ascorbic acid, 65.8 – 76.0 mg/100 g of fruit pulp (Bal and Mann, 1978), rich source of protein (0.8 g/100g) and minerals such as phosphorus (26.8 mg/100g) and iron (0.76-1.8 mg/100g), as reported by Bal *et. al.*, 1979. Ber extract can be used in Ayurvedic and Yunani Medicines, which are said to be blood purifiers and also help in digestion (Tomatov, 1963).

Ber fruits are mostly consumed as fresh and the whole produce is sold in the market in month of March-April. Since the fruit has a short shelf-life (2-4 days) and there is a glut in the market during the peak harvest period, as a result the growers do not get remunerative returns of their produce. More over the post-harvest losses in our country are up to 20-30%, because of poor post harvest management practices. The increased production of ber needs to the supplemented by the proper utilization.

Processing is the best mean to save growers from losses and wastages. But in India, only 1-2 % of total fruit production is used for processing. At present ber is not processed commercially except drying of fruit at home scale level in some villages of Haryana and Rajasthan. The processing aspects of this crop have been receiving some attention in the recent past. Processing of ber for the preparation of various products at small scale can play significant role in proper utilization of the fruit and in reducing the wastage. Therefore, there is an urgent need to develop suitable processing techniques for its processing to solve the marketing problems. In out country, fruits are processed in the form of different products like dehydrated fruits, fruit candy, pulp, fermented and non-fermented beverages, etc. Possibilities of canning, dehydration, candy making and pulp making form ber were suggested by Khurdiya and Singh (1975).

Since ber is a seasonal fruit, dehydration is the best technique for making it available throughout the year. It is an old process in this area of our country, where ripe fruits are dried under sun. Dehydration is the method of removal of moisture under carefully controlled conditions of airflow RH and temperature. The dried fruit has unlimited shelf-life, stable and can resist microbial and enzymatic activities. It is the cheapest method of preservation. There is considerable reduction in transportation, handling, packaging and storage cost.

Even though some of the dehydrated fruits such as raisins, fig, banana and apple slices are popular (Shrivastava and Sanjeev Kumar, 1998), not much efforts have been made to standardize the dehydration techniques and popularize dried ber till now. There is an urgent need to standardize the techniques for production of dehydrated ber fruit. Therefore the present investigation has been undertaken for dehydration of ber with following objective:

To standardize various pretreatments for dehydration of ber fruits.

# CHAPTER–II

## *REVIEW OF LITERATURE*

Fruits are processed by different methods of preservation and dehydration is one of the common most method. However the information regarding the dehydration of ber fruit is limited. Therefore, in the present chapter, literature relevant to dehydration of other fruits has also been reviewed.

### 2.1 General

The jujube (*Zizyphus* spp.) commonly known as ber, is a hardy fruit plant and can be grown even on poor and marginal soils and adverse climatic condition and gives good returns( Yamdagni, 1984). Ber fruit has a high nutritive value especially carbohydrates and vitamin C with good amount of minerals like calcium, phosphorus and iron and a high sugar to acid ratio at ripe stage. These characteristics are ideal for a fruit to be used for dehydration. However in India, most of the ber fruit are consumed as fresh for table purpose. Ber fruit can be canned, candied and made in to pulp (Khurdiya and Singh, 1975), can be preserved and bottled (Dhawan, 1980) and can also be dried (Khurdiya, 1980; Dhawan, 1980; Khurdiya and Roy, 1986).

## 2.2 Physico-chemical composition of fresh ber fruit

Fruits of different variety differ in their physico-chemical characteristics. Khera and Singh (1976) studied the chemical composition of some ber cultivars and reported that cultivar Umran has maximum total sugars (7.86 %), non-reducing sugars (4.83 %) and protein (1.54 %) closely followed by Katha Phal which also contained highest reducing sugars (5.22 %). Cultivars Kaithli and Sanori no. 5 had maximum ascorbic acid (104 mg/100 g pulp) content, maximum mineral content was observed in cultivar Seo. Rohtak sufeda showed the minimum value of all these chemical constituents.

Khurdiya (1980) recorded the chemical composition of fresh fruit of different ber cultivar while studying on dehydration of ber. He reported that cultivar Umran contained moisture content (77.8 %), acidity (0.29 %), reducing sugars (4.38 %), total sugars (14.84 %) and ascorbic acid content (150.99 mg/100 g), whereas variety Illaichi was found to have moisture (73.97 %), acidity (0.22 %), reducing sugars (3.91 %), total sugars (16.98 %) and ascorbic acid (129.41 mg/100g) while Katha variety was found to have moisture content (74.33 %), acidity (0.10 %), reducing sugars (4.54 %), total sugars (19.65 % ) and ascorbic acid content (97.76 mg/100 g).

Gadakh *et al.*.(1999) in his experiment found the chemical composition of ber fruit (cv. Umran) to have T.S.S. (18.9 %), acidity (0.24 %), vitamin-C (110.2 mg/100 g ), total sugars (10.2 %), reducing sugars (4.7 %) and non-reducing sugars (5.5 %).

Marimuthu and Thirumaran (2001) during their study, analyzed the fresh ber fruit (cv. Umran) for various physico-chemical characteristics. Fresh ber fruit was found to have moisture content (80.21 %), total sugars (9.96 %), reducing sugars (4.53 %), acidity (0.223 %), ascorbic acid content (95.63 mg/100 g pulp) and ash (0.61 %).

## 2.3 Dehydration pretreatments

Blanching is the basic step in preservation of fruits by canning, freezing and dehydration. It is an essential step and carried out for centuries. It is a thermal process done before freezing, dehydration or canning to preserve the colour flavour or texture of the fruits, vegetables and meat products. Food is thermally heated to deactivate the enzymes which could result in imparting certain undesirable properties to the food during storage. It causes some changes in composition of fruits which are not of much importance, skin/peel tissues are disturbed and outer wax layer is removed partially or totally, hence facilitating moisture evaporation from outer surface and easy transfer from inner tissue to the surface tissue because of difference in concentration of soluble material in the adjoining tissues.

Khurdiya (1980) by study on dehydration of different varieties reported that optimum blanching time needed was 2 min for 'Illaichi', 4 min for 'Bagwari' and 'Chhuara' and 6 min for 'Katha' and 'Umran'. Khurdiya and Roy (1986) blanched the fruit of Katha variety of ber for five minutes in boiling water.

Amla fruit was blanched for 4 min before drying (Sethi, 1986) for maximum retention of ascorbic acid and other nutrients in the dehydrated product. Bajaj *et al.* (1993) gave different blanching treatments to fenugreek leaves to get better quality dried product and reported that ascorbic acid retention was highest in potassium metabisulphite (0.5 %) treated sample while chlorophyll retention and quality scores were highest in water-blanched samples, immediately after dehydration. Six month storage showed best retention of ascorbic acid in unblanched samples, while retention of chlorophyll was maximum in magnesium oxide (0.1 %) treated samples.

Sagar and Khurdiya (1999) standardized a simple method of preparing dehydrated ripe mango slices by using cabinet dying technique. The mango slices heated for two minutes in equal amount of $70^0$ Brix sugar syrup in the presence of 0.1 % KMS at $90^0$C and after drying in a cabinet drier at $58\pm2^0$C gave the best dehydrated product. The addition of sugar to the slices improved the solid contents and chewing characteristics of dehydrated mango slices. Gadakh *et. al.* (1999) studied the effect of pretreatments like blanching and sulphuring on drying behaviour and quality of ber and found that overall acceptability of untreated fruit was low (5.4) and ber slices using sulphuring pretreatment was found to have the highest (7.67) organoleptic score.

Gowda (2000) evaluated various pretreatments and their combination consisting of lye (boiling in 0.3 % NaOH for 3 sec.) dipping oil (2.0 % for 5 min) either prior to sulphuring or after sulphuring (3 g/kg for 3h) and dipping oil alone (1.5 % or 2.0 % initially and again 4 days later) followed by shade drying, to find out best method for raisin making from ‘Arkavati’ hybrid and

‘Thompson Seedless’ varieties. He found that treatment combinations consisting of the lye treatment + dipping oil + sulphuring + shade drying or the lye treatment + sulphuring + dipping oil + shade drying was found to be the best for producing good quality raisins.

Kaur and Kapoor (2001) studied the effect of low temperature long time (LTLT), high temperature short time ( HTST) and mixed methods (LTLT/HTST) on the physico-chemical qualities of carrots and French beans and compared with micro-wave blanching. They reported that quality of vegetables blanched by mixed and microwave method was found to be superior over those blanched by HTST and LTLT methods. Further, vegetables blanched by mixed and micro wave methods showed least residual activity of peroxidase, high retention of ascorbic acid and total carotenoids and better texture as compared to HTST and LTLT.

Baig and Chakraverty (2002) conducted a study to see the effects of pretreatments namely blanching, sulphiting, dipping in sucrose solution and sodium chloride solution on carrot slices dried at temperature of 40, 50 and 60$^{0}$C at an air velocity of 0.75 m/s and to study the effects of above treatments on the quality characteristics such as colour and rehydration ratio of the dehydrated carrot slices. They reported that a combination of hot water blanching at 80$^{0}$C for 3 min followed by treatment with 2 % NaCl solution for 30 min at ambient conditions and then drying of pretreated carrot slices at an air temperature of 50$^{0}$C to the storage moisture level appeared to be suitable for a dehydration system of carrot slices.

Devaraju (2003) studied the influence of different dehydration treatments, viz. steeping in sugar solution, steeping in sugar solution + KMS, blanching + steeping in sugar solution, blanching + steeping in sugar solution + KMS, on ber slices with respect to certain physico-chemical parameters and organoleptic characteristics and found that dehydration treatments improved the dehydration percent, dehydration ratio, total sugar and organoleptic characters over the untreated control. Narayana *et al.* (2003) gave different pretreatments to banana like dipping in 1% KMS solution for 5 min, blanching in hot water ($80^{0}$C) for 5 min, blanching in hot water ($80^{0}$C) for 2 min followed by dipping in 100 ppm KMS solution for 5 min, KMS (100 ppm) infiltration for 5 min at 760 mm Hg negative pressure and ascorbic acid infiltration (100 ppm for 5 min at 760 mm Hg negative pressure) and then drying in an oven at $50^{0}$C for 48 h. They reported that maximum output and better shelf life along with acceptable quality of banana could be produced by adopting treatments like infiltration of either KMS (1000 ppm) or ascorbic acid (1000 ppm) at 760 mm Hg negative pressure before dehydration of fruit.

Tandon *et. al.* (2003) studied the effect of blanching and lye peeling on the nutritional quality of six anola cultivars and reported that the effect of blanching was less severe than that of lye peeling on nutritional parameters like acidity, tannins and reducing sugars.

Mousa *et al.* (2004) subjected brinjal to different pre-treatments to standardize the best treatment for preparing dehydrated slices in cabinet drier and recorded that treatment without peeling (WP) with blanching followed by dipping in KMS solution was found to have high titrable acidity and anthocyanin content but at the same time retention of ascorbic acid and dehydration ratio as well as rehydration ratio were low compared to other treatments. Non-enzymatic browning (NEB) and anthocyanin contents were higher in WP. KMS treatment gave better retention of ascorbic acid and sensory characteristics but it considerably influenced anthocyanin colour. Treatments peeled with blanching (PB) + 1.5 % KMS and PB + 1.75 % KMS recorded highest mean scores for sensory characteristics.

## 2.4 Osmo-dehydration

Partial removal of water from the material by dipping in a saturated sugar is carried out through the process of osmosis and is termed as osmotic dehydration. Moisture is reduced to some extent after which it is further dried in open sun or in cabinet or in vacuum drier.

Nanjundaswamy *et al.* (1978) standardized osmo-air dehydration technique for pineapple, papaya and apple and reported that osmo-air dried product was having good colour and flavour. Ramamurthy *et al.* (1978) reported osmotic dehydration to be the possible alternative to freeze drying, a costly method of drying. They compared the osmotic dried and freeze dried Alphanso mango slices with regard to aroma and physico-chemical characters and found osmotic dried product comparable with freeze dried slices.

Bhuvaneswari *et al.* (1999) studied the osmotic dehydration of peas using osmotic solution of different concentration such as sucrose 30 %, sucrose 40 %, sucrose 30 % + trisodium citrate 20 % and sucrose 40 % + trisodium citrate 20 % at temperature ranging from 50-70$^0$C. It was observed that rate of osmosis increased with increase in solution concentration and temperature. The rehydration ratio of osmosed sample was higher as compared to non-osmosed samples. Sensory evaluation showed that quality of osmo-air dried samples was good compared to non-osmosed samples.

Kaleemullah *et al.* (2002) conducted study to investigate the effect of solute concentration (50, 60 and 70$^0$C Brix) and temperature (32, 50 and 60$^0$C) on osmotic dehydration of papaya and reported that the osmotic (60$^0$ Brix, 60$^0$C), air (60$^0$C) drying method saved 8 h in drying papaya from 6.58 to 0.24 kg water/kg dry matter as compared to the one dried by drying (60$^0$C) method.

Jain *et al.* (2003) conducted study on osmo-connective drying of papaya and concluded that osmosis in sucrose solution extracted water out from the papaya cubes thereby reducing the moisture content of the product. It also imparted an appealing dark pink colour to the cubes. It increased the sweetness of the product, so the product becomes tastier. The concentration of sugar syrup and time of osmotic treatment reduced the tray drying time.

Devaraju *et al.* (2003) studied influence of different treatments on ber slices with respect to certain physico-chemical parameters and organoleptic scores and found that treatment, blanching + slicing + steeping in 60$^0$C sugar syrup for 24 hrs improved dehydration percent, dehydration ratio, total sugars and organoleptic characters over the untreated control.

## 2.5 Drying methods

Drying is the process of removing water from the food stuff to such an extent so that none of the micro-organisms may perpetuate to cause spoilage. According to Dayanand (1978) the concentration of solids as in case of fruits is increased to 70 % or more so that osmotic pressure within the dried fruit would check the growth of micro organisms. The removal of moisture from food involves mass transfer to remove water and heat transfer to replace latent heat of vaporization. Air moment is also required by energy involved driers or solar driers. Different drying systems are used according to the variety.

Pawar *et al.* (1985) dried pumpkin under sun and in cabinet drier to desired moisture level and stored for 3 months at $27^{0}$C. The leaching losses with respect to ascorbic acid, total carotenoids reducing sugars and ash of each lot after blanching and sulphitation, drying and storage were studied. The losses were more in shreds dried under sun than cabinet dried and sulphited samples. The blanched, sulphited and cabinet dried samples were found more organoleptically acceptable to a test panel than unblanched, unsulphited and sun dried samples.

Mandhyan *et al.* (1988) dehydrated winter vegetables like peas, spinach, carrot and cabbage in the sun and in solar cabinet drier and drying constants were calculated and reported that reduction in the drying time was observed to be 15-20 % when solar cabinet drier was used in place of direct sun drying.

Gadakh *et al.* (1999) dried ber (cv. Umran) using three drying methods (tray, solar cabinet and sun) and observed that maximum drying rate was found in case of mechanical (tray) drying (187 g/h/100 g dry matter), whereas minimum drying rate was observed during sun drying of whole ber fruit (3.6 g/hr/100 g dry matter). The sun dried fruits lost almost all ascorbic acid (vitamin C). Sagar and Khurdiya (1999) standardized a simple method of preparing dehydrated ripe mango slices by using cabinet drying technique. The mango slices heated for 2 minutes in an equal amount of $70^0$ Brix sugar syrup in presence of 0.1 % KMS at $90^0$C and after drying in a cabinet drier at $58\pm2^0$C gave the best dehydrated product.

Banga and Bawa (2002) studied the drying behaviour of carrots gratings. The grated carrots were divided into tow equal portions and one of them was blanched in water while other was blanched in 3 % NaCl solution and then samples were dried at $50^0$C, $60^0$C and $70^0$C in a cabinet dryer. The dehydration ratio was maximum for samples dehydrated at $50^0$C in case of blanched while the unblanched ones had the maximum dehydration ratio for $70^0$C dehydrated samples. Kaleemullah *et al.* (2002) found that overall drying rate of papaya by connective drying, followed by osmotic dehydration was more (0.528 kg water/kg dry matter /h) than one dried by connective method (0.318 kg water/kg dry matter/h). The osmotic drying method saved 8 h in drying as compared to air drying method.

Kar *et al.* (2003) compared different drying methods for banana and reported that MACD (micro wave assisted connective drying) was quicker method of drying (45 min) with high sensory score and excellent energy use efficiency (56.73 %), where as freeze dried product was found to be the best in terms of retention of total and reducing sugars (89 % and 93 %), tannin contents, NEB and total carbohydrate content (81%).

## 2.6 Physico-chemical characteristics of dehydrated fruits

When fruits are dried, certain things happen to the nutrients in them. Drying means dehydrating and when water goes out, the other nutrients become more concentrated. In other words, dried fruits are more nutrient dense than fresh fruits. While carbohydrates, most minerals, fibres and proteins get concentrated in the dried fruit, these nutrients remain otherwise unaffected by the drying process. Because of the exposure to heat and air when drying, there are serious losses to vitamin C and to lesser extent of some vitamins and beta-carotene.

**(i) Moisture content**

Moisture play important role in the growth of micro-organism on product. So, generally optimum moisture content that inhibits microbial growth is maintained in the dehydrated product. Khurdiya (1980) reported that dried ber (cv. Umran) contained moisture (14.3 %). The moisture content in dried fig was reported to vary from 16.8 to 24 % (Norman and Desrosier, 1982 and Gebhardt *et al.* 1982). The moisture content of whole ber fruit (cv.

Umran) decreased to 12.4 to 21.9 % (db) (Gadakh *et al.*, 1999). Sagar and Khurdiya (1999) reported that moisture content was reduced to 5.84 % during dehydration of Dashehari mango slices. Similarly Marimuthu and Thirumaran (2001) reported moisture content (12.00 %) in dehydrated ber. Moisture content in dried banana was found to be 28 % (Narayana *et al.* 2003).

**(ii) Total sugars**

Increase in total sugars due to concentration has been reported in dried fruits. Khurdiya (1980) reported increase in sugar content to 55.6 % in dried ber. Total sugars were found to vary from 38.5 % to 65.2 % in dried guava slices treated differently (Mehta and Tomar, 1980). Thonte and Patil (1988) reported that sugar treated dried fig fruits contained 41.5 % to 59.0 % sugars. Dried ber fruits were found to have 20.8-23.0 % sugars (Gadakh *et. al.* 1999). Similarly, dehydrated mango slices were found to contain 66.33 % sugars (Sagar and Khurdiya 1999). Marimuthu and Thirumaran reported 20.40 % sugar in dehydrated ber (cv. Umran). Dried banana figs were found to contain 46.43 to 59.00% sugar (Narayana *et. al. 2003*).

**(iii) Ascorbic acid content:**

It is reported that significant amount of ascorbic acid is lost during drying. KMS reduces losses of ascorbic acid content in dried fruit. Dried ber (cv. Umran) was found to contain 60 % mg/100 g ascorbic acid (Khurdiya, 1980). Pawar *et al.* (1985) reported that dehydrated pumpkin shreds contained 8.10 mg/100g ascorbic acid content in sun dried samples and 12.78 mg/100g ascorbic acid in cabinet dried sample. Mali (1997) reported 0.21 to 21.5 mg/100g ascorbic acid in dried Poona fig. Similarly, Gadakh *et al.* (1999) reported that dried ber contained 42.77 mg/100 g ascorbic acid. Dried ber (cv. Umran) was found to contain 46.44 mg/100 g ascorbic acid (Marimuthu and Thirumaran, 2001). Sagar and Khurdiya (1999) reported 6.13 mg/100 g ascorbic acid content in dehydrated Dashehari mango slices.

**(iv) Acidity**

Acidity increases on dehydration. Dried ber fruits were found to contain 1.2 % acidity (Khurdiya, 1980). Similarly, dried ber fruit was found to contain acidity varying from 0.62-0.89 % (Gadakh *et. al.*, 1999). Marimuthu and Thirumaran (2001) reported that acidity increased to 0.61 % in dried ber. Acidity varied from 0.92 % to 1.75 % in dehydrated guava slices subjected to different pretreatments (Mehta and Tomar, 1980). Sagar and Khurdiya (1999) reported that dehydrated Dashehari mango slices contained 1.0 % acidity. Similarly dried banana figs contained acidity varying from 0.49 % to 1.36 % (Narayana *et. al.*, 2003).

# CHAPTER–III

## *MATERIALS AND METHODS*

The present investigation entitled "Study on dehydration of ber" was carried out in the Centre of Food Science and Technology, CCS Haryana Agricultural University, Hisar.

### 3.1 Materials

The following materials were collected to undertake the present study.

### 3.1.1 Raw Materials

Firm ripe ber fruit (Cv. Umran) at yellow green stage were procured from an orchard near Hisar. The fruits were sorted on the basis of uniformity in size, shape, colour and maturity stage.

### 3.1.2 Chemicals

The chemical used in investigation were Analytical Reagents (A.R.) from standard supplier e.g. B.D.H. chemicals, E. Merck India Ltd., etc.

### 3.1.3 Equipments

Various equipments used in present investigation were -

#### 3.1.3.1 Tray dryer

Tray dryer (Macro Scientific Works, MSW 216) having capacity of 18 trays was used. It had a fan and motor for circulating air inside the dryer. The material was spread on aluminum trays in single layer and dried at $65^0$C temperature.

#### 3.1.3.2 Thermometer

Temperature was measured with the help of standard mercury glass thermometer (0-$110^0$C).

#### 3.1.3.3 Microwave oven

Basic principle of microwave oven is that dipolar water molecules in the food absorb the micro wave energy and orient themselves with electromagnetic field of microwaves. The field changes each half cycle and the polar molecules oscillate. The rapid oscillation generates heat.

#### 3.1.3.4 Freezer

Deep freezer was used for slow freezing of fruits.

#### 3.1.3.5 Spectrophotometer

The UV visible spectrophotometer (Model SL 159, Elico India Ltd.) was used with tungsten lamp and glass cuvette.

## 3.2 Methods

### 3.2.1 Procurement, cleaning and washing of raw material.

The details of the procurement of raw material is given at 3.1.1. The raw material was washed with tap water to remove dust.

### 3.2.2 Standardization of blanching time

Blanching times were standardized by testing peroxidase activity (Qualitatively).

**Procedure**

To the crushed sample, added 1% guaicol solution to wet all the surface. Immediately same amount of $H_2O_2$ (1 part of 30% $H_2O_2$ + 2 parts of water) was added. Development of red-brown colour within three min indicated peroxidase activity.

No colour – Negative

Red brown patches – Traces

### 1.1.3 Pretreatments

Fruits were divided into seven lots of 4 kg for the following pretreatment –

a) No blanching (control)
b) Blanching in boiling water (7 min)
c) Blanching in 0.5 % KMS solution (5 min)
d) Blanching in 0.5 % KMS solution (5 min) + slow freezing.
e) Blanching in 0.5 % NaOH solution (5 min) and then washing with 0.5 % citric acid.
f) Microwave blanching (for 60 g sample load at 150 W for one min repeated thrice with one min. interval).
g) Osmo dehydration by dipping in 50 Brix sugar solution containing 0.1 % KMS and 0.2 % citric acid for 4 h.

### 3.2.4 Drying

Pretreated ber fruits were dried in a tray dryer at $65^0$C temperature.

### 3.2.5 Observations recorded

1. Drying rate
2. Moisture content (at regular intervals)
3. Bulk density

4. Browning
5. Dehydration ratio
6. Rehydration ratio
7. T.S.S.
8. Acidity
9. Ascorbic acid
10. Total sugars
11. Organoleptic rating

## 3.3 Analytical Methods

Fresh and dried ber were analysed by following the methods.

### 3.3.1 Drying rate

Period of drying was recorded in hours. Rate of drying was expressed as moisture removed in g/h/100 g dry weight.

$$\text{Drying rate} = \frac{\text{Amount of moisture removed (g) X 100}}{\text{Time (h) X dry weight of sample (g)}}$$

### 3.3.2 Drying curves

Drying curves were drawn by plotting graph between

a) Moisture ( % db) vs time (h)
b) Drying rate vs time (h)

### b)1.4 Moisture content

Moisture content of samples was determined at 6 h interval. In each case sample was dried to a constant weight and final moisture content was recorded. Moisture content was estimated by method of AOAC (1990).

**Procedure**

10 g of fruit pulp/product was weighed in a petridish and dried in an oven at 60-65$^0$C to a constant weight. The weight of sample was taken after cooling in a desiccator.

$$\text{Moisture per cent} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100$$

### 3.3.4 Bulk density

Took 500 g of ber and put them into measuring cylinder and noted the volume. It was expressed as kg/L.

$$\text{Bulk density} = \frac{0.5\ \text{kg}}{\text{Volume occupied in cylinder (L)}}$$

### 3.3.5 Browning

The increase in absorbance of the sample at 440 nm was taken as measure of non-enzymatic browning as described by Ranganna (1977).

**Procedure**

Five g of sample from fresh fruit or one g from processed product was macerated in appropriate amount of 60 % ethyl alcohol. The resulting solution was kept over night and filtered through Whatman filter paper no. 1 to obtain a clear solution. The colour of solution was measured at 440 nm on spectrophotometer using 60% aqueous alcohol as a blank.

### 3.3.6 Dehydration ratio (DR)

Dehydration ratio was determined according to procedure described by Ranganna (1977).

Dehydration ratio was obtained by taking ratio of weight of ber loaded in the dryer to that of leaving the dryer.

**Calculation**

$$DR = \frac{W_1}{W_2}$$

Where – $W_1$ –> wt. before dehydration

$W_2$ –> wt. after dehydration

### 3.3.7 Rehydration ratio (RR)

Weighed sample of dehydrated ber was soaked in distilled water for 24 h. The water was drained and flesh was air dried on the filter paper and rehydrated flesh was weighed. The rehydration ratio was expressed as ratio of the weight of rehydrated product to the weight of dried product.

**Calculation**

$$RR = \frac{W_1}{W_2}$$

Where – $W_1$ –> wt. of sample (g) after rehydration

$W_2$ –> wt. of sample (g) before rehydration

### 3.3.8 Total Soluble Solids

T.S.S. were observed by Erma Hand refrectometer and expressed in percent (w/w).

### 3.3.9 Acidity

Total acids were extracted in water and were estimated by titration against 0.1 N sodium hydroxide (A.O.A.C., 1990).

Five g of macerated sample was weighed and after adding distilled water (1:5 w/v) it was kept on boiling water bath for one hour. It was filtered, cooled and volume made to 100 ml. A suitable aliquot was titrated against 0.1 N sodium hydroxide. From the volume of alkali used, acidity was calculated and results were expressed as g citric acid per 100g.

$$\% \text{ acidity} = \frac{\text{titre volume (ml) x 0.007 x volume made x 100}}{\text{volume taken for titration (ml) x sample wt.}}$$

### 3.3.10 Ascorbic acid

The ascorbic acid content was determined as given by A.O.A.C. (1990).

**Reagents**

1. <u>Metaphosphoric acid (3 %)-</u>

| | |
|---|---|
| Metaphosphoric acid ($HPO_3$) | 15 g |
| Glacial acetic acid | 40 ml |
| Volume | 500 ml |

2. <u>2,6- dicholorophenol indophenol dye-</u>

| | |
|---|---|
| 2,6-dicholorophenol indophenol dye | 50 mg |
| Sodium bicarbonate | 42 mg |
| Volume | 200 ml |

**Preparation of standard ascorbic acid solution-**

Fifty mg of ascorbic acid was weighed and volume made to 50 ml with metaphosphoric acid reagent. One ml of standard ascorbic acid solution was used to standardize the dye with the appearance of light pink colour as end point.

**Extraction**

Ascorbic acid was extracted from the pulp/ product by macerating 5 g of sample with 3 % metaphosphoric acid. The extract was filtered and appropriate volume was made.

**Estimation**

A suitable aliquot was titrated against 2,6-dicholorophenol indophenol dye till the appearance of pink colour.

The results were expressed in terms of mg ascorbic acid per 100 g.

$$\text{Ascorbic acid(mg/100g)} = \frac{\text{Titre volume x dilution x100}}{\text{X x 5 x Y}}$$

Where

X –volume used for standard

Y---volume taken for titration

### 3.3.11 Sugars (Total and Reducing)

**Sugars:** Sugars were estimated by the method of Hulme and Narain (1931).

**Reagents**

| | | |
|---|---|---|
| (i) | Potassium ferricyanide solution: | |
| | Potassium ferricyanide | 8.25 g |
| | Anhydrous sodium carbonate | 10.6 g |
| | Volume | 1 L |
| (ii) | Potassium iodide solution: | |
| | Potassium iodide | 12.5 g |
| | Zinc sulphate | 25.0 g |
| | Sodium chloride | 125.0 g |
| | Volume | 500 ml |
| (iii) | 5 % Acetic acid solution (v/v) | |
| | Glacial acetic acid | 50 ml |
| | Volume | 1 L |
| (iv) | Sodium Thiosulphate solution: | |
| | Sodium thiosulphate | 2.482 g |
| | Volume | 1 L |
| (v) | Starch solution (indicator): | |
| | Soluble starch | 1.0 g |
| | Sodium chloride | 20.0 g |
| | Volume | 100 ml |

**Extraction**

Weighed 10 g and 5 g macerated sample of fresh fruit and processed product, respectively .To it was added 40 ml of distilled water .The extraction of sugars was done by heating it on water bath for about 90 min. After the extraction volume was made to 50 ml with distilled water. Five ml of the extract was then transferred to a volumetric flask and diluted to 50 ml. The diluted extract was used for estimation of sugars.

**Estimation**

**a) Reducing sugars**

To five ml of extract, added 5 ml of potassium ferricyanide solution in a test tube (1" wide x 7" long). The tubes were covered and kept for 15 minutes in boiling water bath. The tubes were then cooled under the tap water and to this added 5 ml of iodide-zinc solution followed by 3 ml of acetic acid solution (5% v/v). The liberated iodine was titrated with sodium thiosulphate (0.01N) using starch as an indictor. The end point was the disappearance of blue colour and appearance of milky colour. A blank with 5 ml of distilled water was also run simultaneously. The results were calculated by the following formulae and expressed as g sugar per 100 g.

% age of sugar = [(ml of sodium thiosulphate used in blank –
ml of sodium thiosulphate used in unknown)
+ 0.05] × 0.338

**b) Total sugars**

To 25 ml of sugar extract, 4 ml of concentrated hydrochloric acid was added and kept for 15 minutes at $68^{0}$C in boiling water bath. The acidity was neutralized by adding a little anhydrous sodium carbonate till the effervescence stopped. After the volume was made to 50 ml, total sugars were then determined as described in reducing sugars.

### 3.3.12 Organoleptic Evaluation

Dehydrated products, were subjected to sensory evaluation by a panel of 5 judges (See appendix-1 ) as described by Ranganna (1977). The products were evaluated for colour, flavour, consistency/texture/feel and taste.

The characters with mean scores of 5 or more out of 9 marks were considered acceptable. The overall acceptability of products was based upon the mean scores obtained from all these characters studied under the test.

### 3.3.13 Statistical design used

The data obtained in the present investigation was subjected to statistical analysis of variance (ANOVA) techniques using single factorial completely randomized design (CRD). The critical difference value at 5 % level was determined.

# CHAPTER–IV

## *RESULTS AND DISCUSSION*

Research work on the evaluation of dehydration techniques for ber was carried out. During the course of investigation, the effect of different pre-treatments and drying on ber was studied. The preparation of results and discussion has been arranged under the following heads: -

1. Physico-chemical characteristics of fresh ber fruit (cv. Umran).
2. Physical characteristics of dehydrated ber
3. Chemical characteristics of dehydrated ber.
4. Effect of pretreatments on moisture content during drying.
5. Effect of pretreatments on drying rates.
6. Effect of pretreatments and moisture content on sensory score of dehydrated ber.

### 6.1 Physico-chemical characteristics of fresh ber fruit (cv. Umran)

The data with respect to colour, T.S.S moisture content, sugars content, acidity and ascorbic acid contents were recorded and are presented in Table 1.

The data reveal that Umran variety at yellow-green stage had moisture content (82±0.1 %) and T.S.S. (10.5±0.1 %). Khurdiya (1980), reported moisture content (77.81 %) and T.S.S. (22.7 %) in the same variety. Marimuthu and Thirumaran (2001) also reported around 80.2 % moisture in Umran variety.

**Table 1. Physico-chemical characteristics of fresh ber fruit (cv. Umran)**

| S.No. | Fruit characters (on fresh weight basis) | Mean value |
|---|---|---|
| 1 | Colour | Yellowish-green |
| 2 | Moisture content (%) | 82.01 ± 1.01 |
| 3 | Total soluble solids (%) | 10.5 ± 0.10 |
| 4 | Acidity (%) | 0.27 ± 0.02 |
| 5 | Ascorbic acid content (mg/100 g pulp) | 114.0 ± 4 |
| 6 | Total sugars (%) | 6.32 ± 0.12 |
| 7 | Reducing sugars (%) | 3.11 ± 0.05 |

The chemical composition of ber fruit as presented in Table 1. show that fresh ber fruit had acidity (0.27± 0.02 %) and ascorbic acid content (114.0±4 mg/100 g). Khurdiya (1980) reported that Umran variety contained acidity (0.29 %) and ascorbic acid content (150.9 mg/100g). Unde *et al.* (1998) also reported Umran variety to have 0.24 % acidity and 110.2 mg/100 g ascorbic acid content. Similar observations were recorded by Gadakh *et al.* (1999) in fresh Umran variety.

Total sugars and reducing sugars in fresh fruit were found to be 6.32±0.12 % and 3.11±0.05 % respectively, which are in accordance with total sugars (7.86%) and reducing sugars (3.03%) reported by Khera and Singh (1976). Marimuthu and Thirumaran (2001) reported 9.96 % total sugars and 4.53 % reducing sugars in fresh ber fruit (cv. Umran).

The variations in chemical composition of the fruit in present investigation and that reported in literature could be due to variation in the age, location and other environmental and cultural factors.

## 6.2 Effect of different pretreatments on physical characteristics of dehydrated ber:

The changes in physico-chemical composition of ber fruits were studied after the application of pre-drying treatments and dehydration. The results obtained are presented in Tables 1 and 2.

### 6.2.1 Bulk density

The data pertaining to bulk density of dehydrated ber are presented in Table 2.

**Table 2. Effect of various pretreatments on bulk density, browning, dehydration and rehydration ratios and organoleptic score of dehydrated ber**

| Treatments | Bulk density(kg/L) | Browning (O.D.at 440 nm) | Dehydration Ratio | Rehydration ratio | Organoleptic score (9 point basis) |
|---|---|---|---|---|---|
| **Fresh fruit** | 0.64 | 0.29 | - | - | - |
| **Control (unblanched)** | 0.55 | 0.34 | 5.22 | 2.04 | 5.15 |
| **Water blanching** | 0.55 | 0.31 | 5.01 | 1.99 | 5.71 |
| **KMS blanching** | 0.53 | 0.27 | 5.15 | 1.94 | 6.28 |
| **KMS+Slow freezing** | 0.51 | 0.26 | 4.99 | 2.19 | 7.00 |
| **NaOH + citric acid treatment** | 0.65 | 0.31 | 5.38 | 2.15 | 5.72 |
| **Micro-wave blanching** | 0.59 | 0.29 | 4.96 | 1.80 | 5.45 |
| **Osmo-dehydration** | 0.57 | 0.26 | 4.76 | 2.01 | 7.36 |
| **C.D. at 5%** | 0.005 | 0.01 | 0.05 | NS | 0.44 |

The data reveal that bulk density of dehydrated fruits was lower than the fresh fruits. Bulk density of fresh fruit was 0.64 kg/L. The bulk density of dehydrated fruits was affected significantly by all the pretreatments. Among the various pretreatments, NaOH + citric acid pretreated, dehydrated fruits had the maximum (0.65 kg/L) bulk density followed by microwave blanched dehydrated fruits (0.59 kg/L). Minimum bulk density (0.51 kg/L) was recorded in dehydrated fruits with KMS + slow freezing pretreatments and it was followed by KMS blanching pretreated (0.57k kg/L), fruits. Higher bulk density in NaOH + Citric acid pretreated, dehydrated fruits could be attributed to more shrinkage during dehydration by affecting the permeability of peel and thus higher and faster removal of water.

### 6.2.2 Browning

The non-enzymatic browning (NEB) in fresh and dehydrated fruits was estimated (in terms of 0.D. at 440nm) and the data are presented in Table 2.

NEB in fresh fruit was 0.29 (O.D. at 440 nm). There was increase in browning as the fruits were dehydrated. This could be assumed to be due to increase in Millard type of reactions at higher temperature during dehydration. Browning was significantly affected by pre-treatments. The browning was maximum in the control (0.336) followed by water blanched and NaOH + citric acid pretreated fruits, whereas it was minimum in osmo dehydrated (0.263) and KMS + slow freezed (0.262) fruits. Similar, results were obtained by Teaotia *et al.* (1976), Mehta & Tomar (1980) and Sagar and Khurdiya (1999) when they compared unblanched fruits with

**Control** **Water Blanching** **KMS**

**Blanching**

**KMS + Slow Freezing** **NaOH + Citric acid**

Microwave Blanching

Osmodehydration

**Effect of various pre treatments on dehydration of ber fruits**

osmosed fruits. Mousa *et al.* (2004) obtained similar results in Dashehari mango slices when they compared unblanched fruits with KMS treated fruits.

Minimum browning in KMS treated fruits could be attributed to the fact that, KMS treatment had influence in controlling both enzymatic and non-enzymatic browning reactions, which prevented the Millard type of browning reactions and oxidation of ascorbic acid.

### 6.2.3 Dehydration ratio

Dehydration ratios for the dehydrated fruits subjected to various pre-treatment were estimated and the data are presented in Table 2.

It is evident from the data that there was significant difference in dehydration ratio between the pre-treatments. Maximum dehydration ratio (5.38:1) was recorded for NaOH + citric acid pretreated fruits, followed by unblanched (5.22:1) fruits whereas minimum dehydration ratio was recorded for osmo-dehydrated followed by microwave blanched fruits. Devaraju *et al.* (2003) reported higher dehydration ratio in control (unblanched) ber slices as compared to slices subjected to different sugar concentrations. Minimum dehydration ratio in osmo dehydrated fruits could be due to diffusion of sugar syrup to the tissue during osmo-dehydration.

### 6.2.4 Rehydration ratio

Rehydration ratio of the pre-treated dehydrated fruits was recorded and the data are presented in Table 2.

There was no significant difference in rehydration ratio of fruits subjected to various pretreatments. The rehydration ratio of pretreated, dehydrated fruits ranged from 1:1.80 to 1: 2.19.

Maximum rehydration ratio was recorded in KMS + slow freezed fruits followed by NaOH + citric acid treated fruits. Minimum rehydration ratio was recorded in micro-wave blanched fruits.

Devaraju *et al.* (2003) observed higher rehydration ratio in control as compared to other treatments in ber fruit, indicating that the treatments like blanching might have affected the structure of the cells. Curry *et al.* (1976), observed that rehydration ratio of unsugared slices of guava was higher than osmosed slices which is in correlance with our results. This could be due to the fact that sucrose has negative effect on rehydration.

## 6.3 Effect of pretreatments on chemical characteristics of dried ber

The results showing effect of pretreatments on chemical characteristics of dehydrated are presented in Table 3.

### 6.3.1 T.S.S.

The data pertaining to T.S.S. of dehydrated fruits were recorded and presented in Table 3.

T.S.S. content of fresh fruits was 57.75 %. T.S.S. content of dehydrated fruits subjected to various pretreatments showed wide range from 45.00 to 66.75 %. There was significant difference in T.S.S. of the dehydrated fruits subjected to various pretreatments. Maximum T.S.S. (66.75 %) was recorded in osmo dehydrated fruits

**Table 3. Effect of various pretreatments on TSS, acidity, ascorbic acid and sugar contents of ber (dry weight basis)**

| Treatments | TSS (%) | Acidity (%) | Ascorbic acid (mg/100 g) | Reducing sugar (%) | Total sugar (% ) |
|---|---|---|---|---|---|
| Fresh fruit* | 57.75 | 1.58 | 632.71 | 17.21 | 35.09 |
| Control (unblanched) | 57.00 | 1.68 | 77.35 | 15.03 | 34.45 |
| Water blanching | 47.50 | 1.53 | 89.72 | 15.17 | 31.79 |
| KMS blanching | 51.50 | 1.38 | 113.01 | 15.66 | 33.48 |
| KMS+Slow freezing | 51.50 | 1.35 | 123.65 | 15.43 | 32.93 |
| NaOH + citric acid treatment | 45.00 | 1.50 | 108.35 | 14.65 | 30.69 |
| Micro-wave blanching | 57.50 | 1.75 | 83.73 | 14.25 | 34.68 |

| | | | | | |
|---|---|---|---|---|---|
| **Osmo-dehydration** | 66.75 | 1.15 | 105.69 | 15.26 | 45.72 |
| **C.D. at 5%** | 1.70 | 0.23 | 17.73 | 0.44 | 0.85 |

* Calculated value (fresh fruit values corrected to dry weight basis by considering moisture content = 82 %)

followed by microwave blanched, dehydrated fruits, whereas minimum TSS was recorded in dehydrated fruits treated with NaOH + citric acid. Lower T.S.S. content of dehydrated fruits than fresh fruits was assumed to be due to leaching losses during blanching. The higher T.S.S. in osmosed fruits than fresh fruits was assumed to be due to diffusion of sugars from syrup to the tissue. Minimum T.S.S. in NaOH + citric acid pretreated fruits could be due to dissolution of peel by NaOH treatment. Similarly, Tandon *et al.* (2003) reported that T.S.S. of lye peeled, anola cultivars was lower than that of fresh and blanched fruits. This could be assumed to be due to the leaching of solids due to removal of peel by lye treatment. Kar *et al.* (2003) observed that T.S.S. of dehydrated banana fruits pretreated with microwaves was higher than T.S.S. of connective dried product indicating advantage of microwave assisted process over connective drying in retaining T.S.S. This was assumed to be due to no leaching losses in microwave pretreated, dehydrated fruits.

### 6.3.2 Acidity

The data on total titrable acidity calculated in terms of anhydrous citric acid were recorded and are presented in Table 3.

The acidity in fresh fruit was 1.58 %. It is clear from the data that all the treatments except microwave blanching, decreased acidity as compared to fresh fruits. Decrease in acidity in different pretreatment could be assumed to be due to leaching losses whereas no leaching losses were in unblanched and microwave blanched fruits. There was significant difference in acidity in all the pretreatments. Minimum acidity was recorded in dehydrated fruits pretreated with osmo dehydration (1.15 %), which was followed by the fruits pretreated with KMS + slow freezing. Amoung the various pretreated fruits, maximum acidity was found in microwave blanched fruits followed by unblanched fruits. Reduction in total acidity during osmosis had also been reported by Kumar (1969) in dates and Sagar and Mehta (1999) in mango slices. The reduction in acidity could be assumed to be due to leaching of acids during blanching and osmosis.

### 6.3.3 Ascorbic acid content

Ascorbic acid content in dehydrated product was estimated and the data are presented in Table 3.

It is evident from the data that retention of ascorbic acid content of dehydrated fruits was lower than the fresh fruits. Fresh fruits were found to contain 632.71 mg/100g ascorbic acid. Decrease in ascorbic acid on dehydration was assumed to be due to oxidation of it at high temperature of drying. There was significant difference in the retention of ascorbic acid content in the dehydrated fruits, subjected to various pretreatments. Among the various pretreatments, maximum (123.65 mg/100g) ascorbic acid content was recorded in dehydrated fruits with KMS + slow freezing pretreatments which was followed by KMS treatment. Minimum ascorbic acid content was recorded in unblanched dehydrated fruits followed by microwave blanched, dehydrated fruits.

Gadakh *et al.* (1999) also reported higher ascorbic acid content is blanched fruits as compared to unblanched, dehydrated ber fruits. Ascorbic acid content was found to be 46.44 mg/100g in dried ber (Marinuthu and Thirumaran, 2001). Pawar *et al.* (1985) observed that ascorbic acid losses were more in unblanched dehydrated fruits than blanched and KMS treated, dehydrated pumpkin fruits. Higher ascorbic acid content in KMS treated, dehydrated fruits could be due to the fact that KMS prevents oxidation of ascorbic acid.

### 4.3.4 Total sugars

The data pertaining to total sugars of dehydrated ber were recorded and presented in Table 3.

The data reveal that total sugars content was affected by all the pretreatments. Fresh fruits were recorded to have 35.09 % total sugars. Lower total sugars content in different pretreated fruits was assumed to be due to leaching losses in blanching medium. Higher total sugars in osmo-dehydrated fruits was assumed to be due to diffusion of sugars from sugar syrup to the tissue. There were significant differences in all the treatments with respect to total sugars. Maximum total sugars were recorded in osmo-dehydrated fruits (45.72 %) whereas minimum total sugars were recorded in dehydrated fruits treated with NaOH + citric acid.

Similarly, Devaraju *et al.* (2003) reported higher total sugars content in osmo-dehydrated ber slices. Similar results were observed by Mehta and Tomar (1980) in dehydrated guava and Sagar and Khurdiya (1999) in dehydrated mango slices. Higher total sugars in osmo-dehydrates fruits was assumed to be due to diffusion of sugars from syrup to tissue.

### 6.3.4 Reducing sugars

The data pertaining to reducing sugars of dehydrated ber were recorded and presented in Table 3.

The data reveal that reducing sugars content was affected by all the pretreatments. The fresh fruits were recorded to have 17.21 % reducing sugars. Lower reducing sugars content in different pretreated dehydrated fruits except osmo-dehydrated fruits was assumed to be due to leaching losses whereas high reducing sugar content in osmo-dehydrated fruits was assumed to be due to diffusion of solids from sugars syrup to the tissue. There was significant difference in reducing sugars content in all the treatments. Maximum reducing sugars content was recorded in osmo-dehydrated fruits followed by microwave blanched, dehydrated fruits, whereas minimum reducing sugar content was recorded in dehydrated fruits, pretreated with NaOH + citric acid.

Mehta and Tomar (1980) reported that reducing sugar content of unblanched, dehydrated guava slices was higher than that of the slices subjected to different concentrations of sugars syrup and $SO_2$. The reason for that was not reported. However, Pawar *et al.* (1987) observed that reducing sugar content increased in dehydrated banana fruits. This increase in reducing sugars was attributed to the conversion of non-reducing sugars to reducing sugars due to activity of invertase. Sagar and Khurdiya (1999) in dehydrated mango slices reported that reducing sugars were higher in sugar treated fruits than untreated fruits. This was assumed to be due to diffusion of sugars from sugar syrup to the tissue. Tondon *et al.* (2003) reported that reducing sugar content was lower in anola fruits subjected to lye treatment than unblanched and fresh fruits. This was assumed to be due to more leaching losses in case of lye treatment due to removal of peel.

## 6.4 Effect of pretreatments on moisture content during drying

The loss in weight of ber during drying with time was recorded and transformed into moisture content and presented in Table 4. The relationship between moisture content and drying time is shown for different pretreatments in Figure 1.

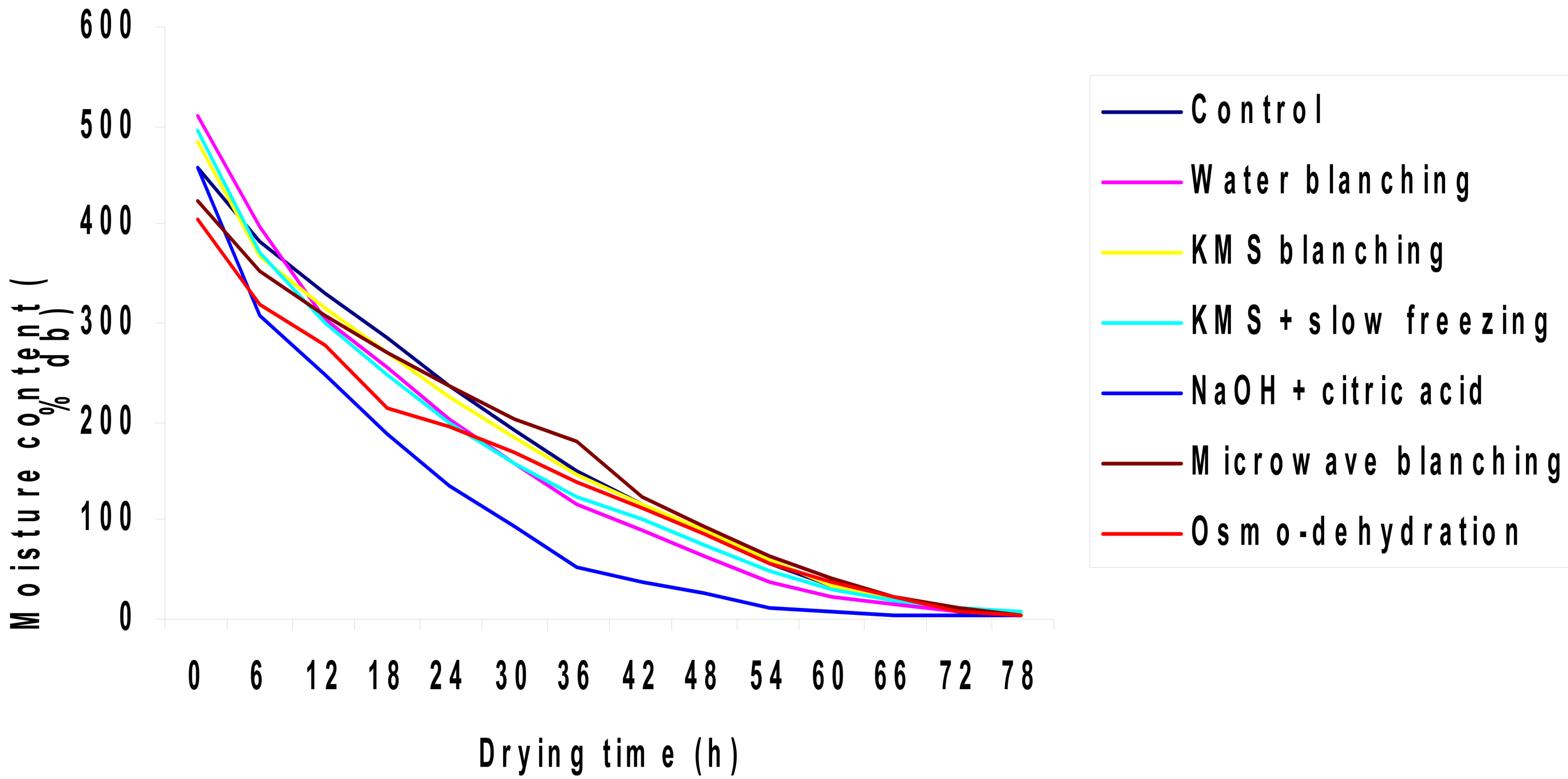
The blanched fruits except microwave blanched and osmosed fruits, had a higher moisture content to start with. However, after first observation itself (6h), the moisture content of blanched fruits was lower than that of unblanched fruits at any particular time interval during the process of dehydration. Higher moisture content in blanched fruits initially could be assumed to be due to absorption of water during blanching. There was significant difference in moisture content between pretreatment. Moisture content decreased steadily in all the pretreatments. At any time internal NaOH + citric acid treatment was found to be most effective in reducing moisture content. Minimum reduction was observed in unblanched fruits which was followed by microwave blanched fruits. NaOH + citric acid treatment took only 66h as compared to other treatments (78 h) to reach final moisture content (~5 %).

The results are in accordance with that observed by Banga and Bawa (2002) in grated carrots and Pradeshi *et al.* (2001) in peas. Gadakh *et al.* (1999) in ber reported that moisture content decreased rapidly during initial stage of drying. However, there was slow decreases in moisture content towards the end of drying. More reduction in moisture content during early stages of drying was assumed to be due to the fact that in the early stage of drying food material behave as though the surface is saturated with water. Fast

**Table 4. Effect of pre treatments on moisture content during drying**

| Treatments | Dehydration time (h) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 | 78 |
| Control (unblanched) | 82.0 | 79.2 | 76.8 | 74.0 | 70.3 | 67.7 | 59.8 | 53.9 | 46.6 | 36.3 | 25.1 | 16.0 | 9.5 | 6.3 |
| Water blanching | 83.6 | 79.9 | 75.4 | 71.8 | 67.1 | 61.1 | 53.6 | 47.1 | 38.6 | 27.6 | 18.8 | 12.3 | 7.4 | 5.2 |
| KMS blanching | 82.9 | 78.6 | 75.9 | 72.8 | 69.2 | 64.7 | 59.3 | 54.0 | 47.5 | 37.3 | 25.2 | 17.5 | 10.8 | 6.7 |
| KMS + slow freezing | 83.2 | 78.7 | 74.9 | 71.3 | 66.5 | 61.4 | 55.6 | 50.0 | 42.9 | 33.6 | 22.6 | 15.5 | 9.6 | 6.3 |
| NaOH + citric acid treatment | 82.1 | 75.6 | 71.2 | 65.2 | 57.5 | 48.2 | 37.1 | 27.6 | 17.9 | 10.8 | 7.2 | 5.3 | 4.1 | 3.3 |
| Microwave blanching | 80.9 | 77.9 | 75.4 | 72.9 | 70.3 | 67.1 | 62.2 | 55.6 | 48.6 | 39.2 | 29.2 | 17.9 | 9.7 | 5.2 |
| Osmo dehydration | 80.2 | 76.1 | 73.4 | 68.3 | 67.3 | 62.9 | 57.8 | 53.3 | 45.9 | 36.6 | 26.3 | 17.7 | 8.2 | 4.8 |
| C.D. at 5 % | N.S. | 1.5 | 1.7 | 1.6 | 2.1 | 2.8 | 1.8 | 2.7 | 2.5 | 1.8 | 1.3 | 1.5 | 1.7 | 1.5 |

Figure 1. Effect of pre-treatments on moisture content during drying



removal of moisture content in NaOH + citric acid treatment was assumed to be due to removal of peel and wax layer on lye treatment.

## 6.5 Effect of pre-treatments on drying rate of ber

The rate of drying was affected by different pretreatments. The results obtained are presented in Table 5 and Figure 2. The rate of drying was expressed as g/h/100 g dry matter.

The results reveal that there was significant difference in drying rates among all pretreatments. It was observed that all treated fruits dried at a faster rate than the untreated fruits at higher moisture level. But at lower moisture level, the drying appeared to be slightly easier in case of untreated fruits than treated ones except microwave treated fruits. Rate of moisture removal was highest in NaOH + citric acid pretreatment during first six hours and minimum in microwave blanched fruits. In any treatment, initially the rate of drying was high and then it gradually decreased. In all the treatments the rate of drying was very low at the end of drying. This was assumed to be due to case hardening.

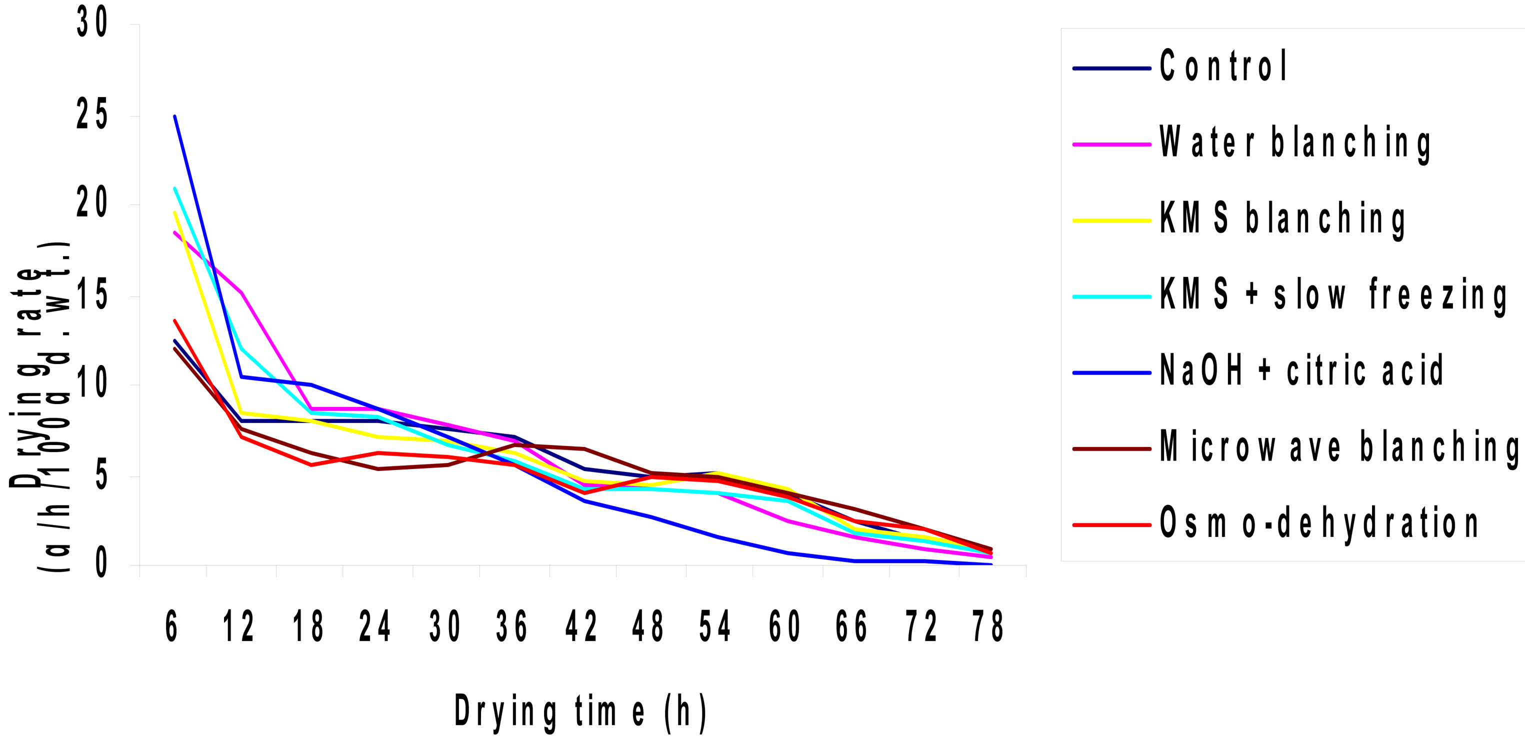
Banga and Bawa (2002) reported that rate of drying was faster in blanched fruits as compared to unblanched ones in carrots. Baig and Chakraverty (2002) also reported similar results in carrot slices. Higher drying rate in NaOH + citric acid treated sample could be assumed to be due to easy removal of water due to removal of peel.

The lower drying rates in sucrose treated fruits could be attributed to two reasons. (1) sucrose that crystallizes during the air drying process lowers the diffusivity of water vapour and impairs heat transfer within the product and (2) the vapor pressure of water in the product is depressed due to dissolved sugars.

Table 5. Effect of pre- treatments on drying rate (g/h/100 g dry weight)

| Treatments | Dehydration time(h) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 | 78 |
| Control (unblanched) | 12.5 | 8.1 | 8.0 | 7.9 | 7.5 | 7.2 | 5.3 | 4.9 | 5.1 | 3.9 | 2.4 | 1.4 | 0.6 |
| Water blanching | 18.4 | 15.2 | 8.7 | 8.6 | 7.7 | 6.9 | 4.4 | 4.3 | 4.1 | 2.5 | 1.5 | 0.9 | 0.5 |
| KMS blanching | 19.5 | 8.6 | 8.0 | 7.2 | 6.9 | 6.2 | 4.7 | 4.5 | 5.2 | 4.3 | 2.1 | 1.5 | 0.8 |
| KMS + slow freezing | 20.9 | 11.9 | 8.4 | 8.2 | 6.6 | 5.7 | 4.2 | 4.2 | 4.1 | 3.6 | 1.8 | 1.3 | 0.7 |
| NaOH + citric acid treatment | 24.9 | 10.5 | 9.9 | 8.6 | 7.1 | 5.6 | 3.5 | 2.7 | 1.6 | 0.7 | 0.3 | 0.3 | 0.1 |
| Microwave blanching | 11.9 | 7.6 | 6.3 | 5.3 | 5.5 | 6.6 | 6.5 | 5.1 | 5.0 | 3.9 | 3.2 | 1.9 | 0.9 |
| Osmo dehydration | 13.6 | 7.1 | 5.5 | 6.3 | 5.9 | 5.5 | 3.9 | 4.9 | 4.6 | 3.7 | 2.4 | 2.1 | 0.6 |
| C.D. at 5 % | 1.7 | 1.8 | 1.8 | 1.6 | N.S. | N.S. | 1.8 | N.S. | 1.6 | 1.5 | 1.2 | 0.14 | 0.04 |

Figure 2. Effect of pre-treatments on drying rate



## 6.6 Effect of pretreatments and moisture content on the organoleptic rating of dehydrated ber

The organoleptic evaluation was done by a panel of semi-trained judges following 9 point hedonic scale and the data as overall acceptability are presented in Table 2 and Table 6.

It is reveal from the data that various pretreatments improved the organoleptic score. There was significant difference in all the treatments with respect to organoleptic score. Organoleptic score indicated that although all the pretreatments were acceptable, the treatment osmo-dehydration was found to be the best showing maximum score (7.36), followed by KMS + slow freezing treatment getting score (7.00). Unblanched fruits were found to have least sensory score. The results are similar to that observed by Mehta and Tomar (1980) in guava and Devaraju *et. al.* (2003) in dehydrated ber slices. Higher score in osmosed and KMS + slow freezed fruits could be assumed to be due to the reason that sugar syrup and KMS are reported to have protective effect on retention of fresh fruit flavour and texture during drying.

In the present investigation, dehydrated fruits at 20 % moisture level showed maximum organoleptic score (7.27) and at 5 % level get minimum score (5.15), (Table-6). Although maximum score was at 20 % moisture level but it is expected that at 15 % moisture level which has a little lower organoleptic score (6.25) would have better shelf life as compared to fruits at 20 % moisture level and thus could be regarded as the best pretreatment to dehydrate ber fruits.

**Table 6. Effect of moisture content on organoleptic score of dehydrated ber**

| Moisture content (%) | Organoleptic score ( 9 point basis) |
|---|---|
| 25 | 6.50 |
| 20 | 7.27 |
| 15 | 6.25 |
| 10 | 5.97 |
| 5 | 5.15 |
| C.D. at 5 % | 0.68 |

# CHAPTER–V

## *SUMMARY AND CONCLUSION*

The demand for fruits in India is increasing rapidly due to growth in population, change in demographic pattern, socio-economic status, income distribution, taste and preference of peoples. Ber is a common fruit, suited well for cultivation in arid and semi-arid regions of India where most of other fruits cannot be grown. It is a rich source of nutrients. The shelf-life of fresh fruits is limited (2-4 days). Dehydration can increase the shelf life of ber fruit to largest extent. The review of literature revealed that not much work has been carried out to standardize the dehydration techniques and popularize dried ber till now.

A study was therefore conducted to standardize various pretreatment for dehydration of ber. Fresh ripe fruit at yellow green stage were subjected to various pretreatments like blanching in boiling water (7 min), blanching in 0.5 % KMS solution (5 min), blanching in 0.5 % KMS solution + slow freezing, blanching in 0.5% NaOH and then washing with 0.5 % citric acid solution, microwave blanching and osmo dehydration by dipping in $50^0$ Brix sugar solution containing 0.1 % KMS and 0.2 % citric acid for 4h. Blanching time was standardized by checking peroxidase activity. The pretreated fruits were then dried in tray drier at $65^0$C and dehydrated fruits were evaluated for various physico-chemical and sensory characteristics. The silent findings of the present study can be concluded as –

The various pretreatments given to fruit before cabinet drying at $60^0$C improved the quality of dehydrated ber. Minimum browning was observed in fruits given KMS + slow freezing treatment, which was followed by osmo-dehydrated fruits. Rehydration ratio was not significantly affected by various pretreatments. Higher ascorbic acid was retained in dehydrated fruits given various pretreatments as compared to control. Maximum ascorbic acid content was observed in fruits given KMS + slow freezing and osmo-dehydration pretreatments. The dehydration rate was maximum in fruits given NaOH + citric acid pretreatment, followed by osmo-dehydrated and water blanched fruits. The maximum organoleptic scores were observed for dehydrated fruits having 20 % moisture content. A little lower scores were observed for 15 % moisture fruits, however these fruits may show better shelf-life as compared to 20 % moisture fruits. Thus, it can be said that various pretreatments improved the organoleptic score of dehydrated fruits. Maximum scores were observed for osmo-dehydrated and KMS + slow freezed dehydrated fruits.

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* Original not seen.

**Appendix –I**

**HEDONIC RATES SCALE**

Name____________ Date______________

Product _____________ Time______________

**INSTRUCTIONS:** Taste the given samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by assigning points that best described your feelings about the sample. An honest expression of yours will help us. Evaluate on the basis of the following scale.

| **Score Preference** | **Code** |
|---|---|
| Liked Extremely | 9 |
| Liked very much | 8 |
| Liked moderately | 7 |
| Liked slightly | 6 |
| Neither liked or disliked | 5 |
| Disliked slightly | 4 |
| Disliked moderately | 3 |
| Disliked very much | 2 |
| Disliked extremely | 1 |

| **Sample code** | **Colour and appearance** | **Taste** | **Aroma** | **Texture** | **Overall acceptability** | **Remarks** |
|---|---|---|---|---|---|---|
| | | | | | | |

Signature

**ABSTRACT**

| | | |
|---|---|---|
| **Title of Research Project** | : | Study on dehydration of ber (*Zizyphus mauritiana* Lamk.) |
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| **Major subject** | : | Food Science & Technology |
| **Total number of pages in thesis** | : | 49 + vi |
| **Number of words in abstract** | : | 209 Approx. |
| **Key words** | : | Ber, dehydration, standardization, pretreatments, blanching, cabinet dryer. |

The present investigation was undertaken to standardize various pretreatments for dehydration of ber fruits. Fresh ripe fruits at yellow green stage were subjected to different pretreatments viz., water blanching (7 min), blanching in 0.5 % KMS solution (5 min), blanching in KMS solution (5 min) + slow freezing, NaOH blanching (5 min) and then washing with 0.5 % citric acid solution, microwave blanching and osmo-dehydration. Pretreated samples were dehydrated at 65°C in a cabinet dryer. Dehydrated fruits were evaluated for sensory score and physico-chemical characteristics. Pretreatment KMS + slow freezing recorded better retention of ascorbic acid followed by osmo-dehydration. Nonenzymatic browning was minimum in fruits given KMS + slow freezing followed by osmo-dehydrated fruits. Rehydration ratio was not significantly affected by various pretreatments. Drying rate was faster in first six hours and then slowed down. It was maximum in fruits given NaOH + citric acid pretreatment followed by osmo-dehydrated and water blanched fruits. Dehydrated fruits having 20 % moisture content received maximum organoleptic scores. However 15 % moisture fruits, though showing a little lower organoleptic score, may show better shelf life as compared to 20 % moisture fruits. Organoleptic score was improved by all the pretreatments. Maximum scores were observed for osmo-dehydrated and KMS + slow freezed fruits.

**Major Advisor**

**Signature of the Degree Holder**

**Director**

## KEY WORDS

1. **Ber**
2. **Dehydration**
3. **Standardization**
4. **Pretreatments**
5. **Osmo-dehydration**
6. **Blanching**
7. **Slow freezing**
8. **Cabinet dryer**