EVALUATION OF DEHYDRATION TECHNIQUES FOR DIFFERENT VARIETIES OF BER FRUIT (*ZIZYPHUS MAURITIANA* LAMK.)

By

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CERTIFICATE-I

This is to certify that this thesis entitled " **Evaluation of dehydration techniques for different varieties of ber fruit (Zizyphus mauritiana Lamk.)** " submitted for the degree of M.Sc. in the subject of Horticulture of C.C.S. Haryana Agricultural University is a bonafide research work carried out by **Sh. Raj Bir Singh** under my supervision and that no part of this thesis has been submitted for any other degree.

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LIST OF ABBREVIATIONS

ml.	-	millilitre
c.c.	-	cubic centimetre
mg.	-	milligram
g.	-	gram
Kg.	-	kilogram
cm.	-	centimetre
wt.	-	weight
w/v	-	weight/volume
a_w	-	water activity
N	-	normal
C D	-	critical difference
p.p.m.	-	parts per million
TSS	-	total soluble solids
%	-	per cent
hr.	-	hour
^oC	-	degree celcius
^oF	-	degree farenhelt
TVC	-	total viable count
var.	-	variety

CHAPTER - I

INTRODUCTION

Ber (Zizyphus mauritiana Lamk.) is one of the ancient and common fruits of India. It is very nutritious and contains a good amount of carbohydrates (Bal, 1981; Sharma and Bawa, 1977), Vitamin-C (Daulta and Chauhan, 1982), minerals prominantly phosphorus, calcium and iron (Bal and Singh, 1978; Khera et al, 1976), proteins (Sharma and Bawa, 1977) and amino acids (Bal et al, 1979).

Ber is a very hardy plant and can grow well under wide range of soils and climatic conditions. The tree bears heavily and regularly. Ber is cultivated mainly in subtropical regions of north-western and central India over an area of about 22,000 hectares (Chadha, 1990). In Haryana, it covers an area of about 1432 hectares (Anon, 1990) and the total production of ber in the state is estimated to about 26,000 MT which is 5-8 % of the total fruit production i.e. 1.5 lac MT (Anon, 1991). The area under this crop is likely to increase further with the creation of a separate Directorate of Horticulture in the state. Ber bear fruits at the time when no other fresh fruits are available in the market.

The fruit is consumed as fresh and the whole produce is sold in the market in the month of March-April. Since the fruit has a short storage life, there is a glut in the market during the peak harvest period with the result the growers do not get remunerative returns of their produce.

Processing is the best means to save growers from losses and wastages. In India hardly 0.5 to 1.0 per cent of the total fruit production is used for processing and about 25-30 per cent is spoiled because of inadequate transport, storage and processing facilities.

At present, ber is not processed commercially except drying of fruits at homescale in some villages of Haryana and Rajasthan. The processing aspects of this crop has been receiving some attention in the recent past. Processing of ber for the preparation of various products at small scale can play a significant role in proper utilization of the fruit and in reducing the wastage to the minimum. Therefore, there is an urgent need to develop suitable processing techniques for its processing to solve the marketing problem and to maintain the production level and further enhancement of fruit production in the state.

The processing techniques should be such that minimum cost of processing, handling, packaging , storage and transportation are required and available natural resources may be exploited to the possible extent with minimum energy utilization. In India, fruits are processed in the form of different products-like dehydrated fruits, fruit candy, pulps, fermented and non-fermented beverages etc. Among these jam, jelly, preserve, beverages, canned fruits, candy and dehydrated fruits have wide acceptability. Possibility of canning, dehydration, candy making and pulp making from ber was suggested by Khurdiya and Singh (1975). Methods for preserve making, bottling and dehydration of ber were standardized by Dhawan (1980). Method for candy making was standardized by Gupta (1983).

Drying of ber fruit is an age old process in this area of the country, in which ripe ber fruits are dried under sun. The dried fruits have unlimited shelf life, stable and can resist microbial and enzymatic activities. It is the cheapest method of preservation. There is a considerable reduction in transportation, handling, packaging and storage costs. Studies on sun dried and dehydrated ber were conducted by Khurdiya (1980), Dhawan (1980) and Khurdiya and Roy (1986).

Most recent technique of osmo-air drying of fruits as suggested by Ponting et al,(1966) has many advantages over other methods (Hope and Vitale, 1972; Nanjundasswamy et al 1978; Ramamurthy et al. 1978; Garcia et al., 1974). The drying period is cut down to a large extent, heat damage to colour and flavour are minimised, fresh fruit flavour is protected and retained during subsequent stored period. Studies have also been carried out on osmo-air drying of pineapple (Mehta et al, 1982), Guava and Papaya (Mehta and Tomar, 1980) and Muskmelon (Tomar and Gawar, 1985). They have also advocated the use of osmo-air drying technique for fruits. Therefore, the present investigations have been undertaken for dehydration of ber with the following objectives:

1. To evaluate the various dehydration techniques.
2. To evaluate different ber varieties for their suitability to dehydration.
3. To evaluate the keeping quality of the dehydrated product.

CHAPTER - II

REVIEW OF LITERATURE

Fruits are processed by different methods of preservation. Various books (Woodroof and Luh, 1975 and 1986; Lal et al, 1986; Anon, 1985) and manuals (Salunkhe et al, 1974; Chundawat and Sharma, 1978) have been published on post harvest technology of fruits. But the information regarding the processing of ber fruit is limited. Therefore, literature relevant to post harvest technology of other fruits has also been reveiwed.

1. General

The jujube (*Zizyphus* spp.) commonly known as ber comprises two groups (Randhawa and Biswas, 1966) (i) the chinese jujube (*Z. jujube* Mill.) having a small upright growing tree with bright green leaves and is deciduous in nature (ii) the Indian jujube (*Z. mauritiana* Lamk.) is vigorous growing small spreading tree with drooping branches and is ever green. The second group is commercially cultivated in northwestern and central subtropical regions of India. More than 100 cultivars (varieties) are available in India (Yamdagni, 1984), some of them are commercially important. The ber is hardy fruit plant and can be grown even on poor and marginal soils and adverse climatic condition and gives good returns (Chadha et al, 1972).

Ber fruit has a high nutritive value especially carbohydrates (12-20 %) and Vit. C (ascorbic acid) 70-125 mg per 100 g (Sharma and Bawa, 1977), with good amount of minerals like calcium, phosphorus and iron (Bal and Singh, 1978) and a high sugar acid ratio at ripe stage. Fruits of different varieties differ in their physico-chemical characteristics. Illaichi variety (Khurdiya, 1980) has high T.S.S. (24 %) total sugar content (17 %), pulp to stone ratio (24.8 %) and very low moisture content (73.97 %). Mudia-Murhara contains 19 % T.S.S. (Yamdagni, 1984) with high pulp (95 %) and 83.13 % moisturecontent (Khurdiya, 1980). Umran contains 18.5-19.0 % TSS (Jawanda and Bal, 1978; Kumar andBabu, 1987), total sugars(14.84 %), high pulp to stone ratio (19.6 %) and a low moisture content (77.92 %) (Khurdiya, 1980). These characteristics are ideal for a variety to be used for dehydration. However, in India most of the ber fruits are consumed as fresh for table purpose. Ber fruits can be canned. candied and made into pulp (Khurdiya and Singh, 1975); it can be preserved and bottled (Dhawan, 1980) and can also be dried (Khurdiya, 1980; Dhawan 1980; Khurdiya and Roy, 1986).

2. Blanching

Blanching is the basic step in preservation of fruits by canning, freezing and dehydration,which consists of a partial cooking usually in steam or hot water. Blanching is used in preparing sliced apples for freezing and drying, and in steam or lye peeling of peaches, apricots, grapes and other fruits. 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 of moisture from inner tissues to the surface tissues because of difference in the concentration of the soluble material in the adjoining tissues.

Food have also been blanched using hot air and also infrared microwave radiations (Huxsoll et al., 1970; Ralls et al, 1973). The enzymes present in the fruit tissues are inactivated by heating during blanching . The degree of inactivation depends upon the effectiveness of blanching treatment. Blanching as well as dehydration can cause crystallinity of the cellulose in the product. This crystallinity causes change in the texture of the fruit (Holdsworth, 1971). But it has been considered necessary, the time of blanching should be as short as practicable.

2.1 Water Blanching

Immersion of fruits directly in boiling/hot water for certain period of time. Khurdiya (1980) suggested six, four and two min. time of water blanching for Umran, Bagwari and Chhuara, and Illaichi varieties respectively for complete inactivation of the enzymes. Khurdiya and Roy (1986) blanched the fruits of Katha variety of ber for five minutes in boiling water. Amla fruit is blanched in boiling water for four minutes before drying (Sethi, 1986) for maximum retention of ascorbic acid and other nutrients in the dehydrated product.

2.2 Steam Blanching

Steam blanching is used with the advantage over water blanching that the fruits are not in direct contact with boiling water and heating is attained by increasing the time of holding the fruit in the steam. Dhawan (1980) blanched ber fruits in steam at atmospheric pressure with holding time of 10 minutes before dehydration of ber fruit. A modification to steam blanching was described by Lazer et al. (1971) as the individual quick blanch process, a method that produces less effluent than conventional steam blanching. They also reported that preconditioning of carrots prior to blanching by warming and partial drying could significantly reduce effluents. Bomben et al. (1973) reported substantial reduction in the solid loss in the effluent by heat pre-conditioning and advocated heat preconditioning in individual quick blanch process.

2.3 Blanching and Nutrient losses :

Studies have been conducted on the losses of nutrients during blanching. Magoon and Culpepper (1924) reported losses of sugars and other soluble substances, when peas, snap beans and spinach upon scalding for two minutes in boiling water and chilling in cold water thereafter and Horner (1937) found that the losses were more with water blanching than steam blanching and increased with the time of blanching in water and losses were greater in small units. Retention of soluble nutrients were high in steam blanched than water blanched vegetables (Feaster, 1960). Shams and Thompson (1987) also reported dry matter losses in blanching of peas and losses were greatest for the smallest sizes in each variety.

Losses of Vitamin C have been reported by Oliver (1938) and Rostovskaya (1941) during blanching. Effect of time and type of blanching on ascorbic acid content of peas and destruction of enzyme catalase was studied by Jenkins et al. (1938) and reported 10-25 % loss of original vitamin C content in the first minute of the blanch regardless of whether the blanch was in hot water or steam. The rate of loss of Vitamin C reduced after first minute and therefore increase in blanching time affected the Vitamin C content more adversely than the increase in blanching temperature. Peas retained 75 per cent Vitamin C when blanched at 180°F for one minute as compared to 40 % when blanched at 200°F. for 12 minutes in hot water. Whereas 75 per cent retention of ascorbic acid was reported by Clifcorn (1948) in most severe conditions of steam blanching. Moyer et al. (1948) recommended short high temperature blanch for more nutritious peas. Holmquist et al. (1954) reported greater retention of ascorbic acid content in steam blanching than water blanching. Reports on retention of ascorbic acid vary widely, but it has been suggested that half of the original amount present in raw material is lost during blanching and subsequent processing (Hendel, 1971).

3. Sulphuring

Sulphurdioxide is known to have antimicrobial activities against bacteria and some molds in low concentrations and against yeasts in higher concentrations (more than 200 ppm). Among yeasts aerobic species are generally more sensitive to sulphurdioxide than the fermentative species (Joslyn and Braverman, 1954). The permitted limit of sulphurdioxide in dried products is 1500 ppm (Vijaya et al, 1979) and upto 2000 ppm for preservation of fruit concentrates.

It is also used to check the browning during drying of foods, however it cannot completely stop browning reaction, which adversely affect the colour and texture, but it can retard them sufficiently to allow the dried products to remain acceptable for about a year at 21°C (Nury et al. 1960).

3.1 Process of Sulphuring

The process of application of sulphurdioxide on or into the product is called sulphuring. Sulphurdioxide may be applied by burning sulphur in gaseous form or by addition of salts of sulphurous acid, particularly the alkali or acid salts (sodium or potassium bisulphite or metabisulphite) or alkali neutral salts (sodium or potassium sulphate) to the liquid products. Bioletti and Cruess (1912) reported that fumes of burning sulphur as a cheapest source of sulphurdioxide and the best for disinfecting purposes, but unsuitable for control of fermentation because of uncertainity in application and difficulty in regulating. Cut fruits and grapes to a limited extent are treated before drying, with the fumes of burnings sulphur, in specially constructed sulphur houses. The design factor involved in construction of a suitable sulphur house to permit rapid and uniform sulphuring with fumes of burning sulphur was investigated by Long et al. (1940).

The fruits are sulphured by placing them in adjustable vented compartment containing burning sulphur. McBean et al. (1967) suggested that sulphuring houses can be of different construction such as PVC tants, wooden frame cells or cement block tunnels. Khurdiya (1980), Dhawan (1980) and Khurdiya and Roy (1986) used a wooden chamber having space for wooden tray (made of wooden slats) for sulphuring ber fruits before drying. Khurdiya (1980) reported maximum retention of sulphurdioxide in Uman variety of ber when 18.75 g. sulphur per kg fruit was burnt in the chamber for 3 hours. But the dried fruits of variety Illaichi were not accepted organoleptically when sulphured at the rate of 18.75 g.sulphur per kg fruit because of the higher sulphurdioxide content. In addition to the initial sulphuring all cut fruits are sulphured a second time immediately after processing, just before packing. This can be done by burning sulphur, but a faster and easier method is to dip the processed fruits for 30 seconds in a 5-7 per cent potassium metabisulphite solution (Stafford and Bolin, 1972).

3.2 Sulphurdioxide absorption and retention

As far as sulphurdioxide absorption is concerned it is more rapid in fully mature fruits (Quinn, 1926). Long et al. (1940) reported that fixation of sulphurdioxide by fruits is not directly proportional to absorption. Quickly sulphured fruits of high initial sulphurdioxide content loose it at the faster rate. According to Nichols and Christie (1930a) and Chase et al. (1933) the hot water or steam blanching has no effect on sulphurdioxide absorption to retention capacity of fruits whereas Long et al. (1940) found 50 % more retention of sulphurdioxide by the fruits sulphured after blanching as compared to unblanced ones. Similarly Nichols and Christie (1930b) reported that increase in the temperature of sulphur chamber increased the penetration of sulphurdioxide into the fruit tissues and also increased the rate of combination of sulphurdioxide with other substances in the fruit. Long et al. (1940) found that sulphuring of fruits at relatively high temperature (100-120^{o}F) decreased absorption but increased retention. Fisher et al. (1942) also reported retention of more sulphurdioxide by the fruits exposed to sulphurdioxide in high temperature area than the fruits from cooler area of the sulphur chamber.

During the process of drying also the retention of sulphurdioxide seem to be affected by temperature possibly through increased formation of bisulphite addition products. According to Long *et al.* (1940) heating of fruits by solar radiation and drying of surface appear to increase the fixation of sulphurdioxide. Nichols *et al.* (1939) reported that complete shade drying of apricots reduced the retention of sulphurdioxide and exposure of fruit to sunlight for one day was sufficient to prevent the loss. Long *et al.* (1940) observed increased retention in dehydration because of rapid drying and reported that it was as great as 375 per cent than the sundried samples sometimes. Salunkhe ~~et al.~~ (1974) also reported greater losses in sundrying than in oven drying. Khurdiya and Roy (1986) reported more retention of sulphurdioxide by ber fruits dried in solar drier than the fruits dried in direct sun. McBean (1971) found that free sulphurdioxide contents diminished throughout the drying period, whereas levels of combined sulphurdioxide remained relatively unchanged and reached 80-90 per cent of total in dried fruits.

The rate of absorption of sulphurdioxide is also influenced by the characteristics of the fruit. The rate of absorption of sulphurdioxide through the fruit cuticle is 3 to 8 times slower than that through cut flesh. firm and immature tissue absorb sulphurdioxide more rapidly than softened mature tissues. The more open textured fruits like apricots absorb sulphur dioxide most rapidly followed by peaches and pears (McBean ~~et al.~~, 1964). Khurdiya (1980) found the maximum retention of sulphurdioxide by dehydrated immature ber fruits and sundried mature fruits.

4. Osmotic dehydration

Partial removal of water from the material by dipping in a saturated sugar or concentrated salt solution is carried out through the process of osmosis and is termed as osmotic dehydration. The product is reduced to about 50 per cent of its original weight by osmotic dehydration after which it is further dried in air in open sun or in cabinet or in vacuum drier. Ponting et al. (1966) described this technique for fruits by partially dehydrating them in sugar syrup, in which drying time is cut down to large extent and heat damage to colur and flavour is minimum. Farkas and Lazar (1969) studied the effect of temperature and syrup concentration on apple and other fruits and suggested a syrup concentration of 70°C Brix and working temperature of 50°C. Hope and Vitale (1972) studied osmotic dehydration of mango, banana and plantain and reported it to be the cheap and simple method for preserving tropical fruits and suggested a pilot plant scale osmotic dehydration system. Garcia et al. (1974) compared hot air drying vacuum drying and osmotic hot air drying, and found improvement in quality of osmo-air dried product. Weisberg (1976) reported the osmotic dehydration to be an excellent intermediate food technology. Nanjundaswamy et al. (1978) standardized osmo-air dehydration techniques for pineapple, papaya and apple and reported that the osmo-air dried products were 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.

5. Drying

Drying is the process of removing water from the food stuffs to such an extent so that none of the microorganisms (m.o) may perpetuate to cause spoilage. According to Dayanand (1978) , the concentration of solids as in case of fruits is increased to 70 per cent or more so that osmotic pressure within the dried fruits will check the growth of m.o. The removal of moisture from food involves mass transfer to remove water and heat transfer to replace the latent heat of vaporisation. Air movement is also required by energy involved driers or solar driers (Desrosier, 1970).

To achieve rapid drying of the products in case of traditional sun-drying regular turning is required. For sundrying on a large scale, a very large area of land is required to collect solar heat which is dependent on the weather. In factory drying conditions can be easily controlled (Caygill, 1978). But at present time of energy crisis, the natural energy source shall be utilized. Thecost of production of oven dried product is higher. Schwarz and Nury (1961) reported that dehydrated apricots differ from the sundried fruits in general appearance, colour and texture and were more porous and spongy than sundried product. Khurdiya (1980) evaluated the dehydrated and sundried ber fruit and found that sundired fruit scored more points in organoleptic rating. Dhawan (1980) investigated the drying of ber fruit and reported that the ber fruit can be dried successfully but dehydrated fruits were slightly better than sundried organleptically.

The drying of food stuffs which are partially dehydrated by osmosis further dried in oven or sun is termed as osmo-air drying.

5.1 Sundrying

Sundrying is an ancient process which is still practiced because it is cheap and requires minimum equipments etc. Its main disadvantage is the dependence upon the climate and hot sun and dry climate which is not available all over the world. But in semi-arid region of India it is in ample amount. Main hinderence seems to be the inclement weather due to which there is risk of losses and difficulty in maintaining high degree of sanitation (Salunkhe, 1974).

Fruit leathers can be prepared (Anon, 1972) by sundrying or forced air drying which retain their colour and flavour for atleast one month at room temperature, four months under refrigeration and years when frozen. Khurdiya (1980) reported slightly better organoleptic quality of sundried ber fruits over oven dried fruits. In the recent advances, achievements has been made in the use of natural energy source and to keep away the risk of losses due to natural clamities and to maintain good sanitary conditions. Bhatia (1978) suggested the use of simple solar direr, which cuts down the drying period of apricot fruits to about 1/6th as compared to open sundrying. Maximum temperature registered in the drier was 78°C as compared to 34°C in the open sun and the temperature higher than the ambient was maintained till sun set. Imre (1985) developed a chimney type country drier with natural convection and latent heat storage. Khurdiya and Roy (1986) used different solar driers for drying Katha variety of ber and potato slices and reported better retention of sulphurdioxide in both products and less changes in reducing and total sugars in ber when dried in solar drier provided with chimney. Indirect solar drier was described by Szulmayer (1971) in which the product is exposed to the heated air rather than to direct sun.

5.2 Hot air oven drying

Application of artificial heat to vaporize water and removal of vaporized water by some means is termed as dehydration. The principle which works behind the traditional method of dehydration is that the dry bulb temperature 90-100°C may be used if wet bulb can be kept low preferably below 50°C, so that no heat damage results. This induces rapid evaporation while the product temperature remains as that of wet bulb. In the last stage of drying i.e. below 15 per cent moisture content the rate of migration of water to the surface of pieces is low hence low temperature is needed. On the basis of this principle there are several types of driers used for dehydration of fruits. Tunnel drier is one of those which is most flexible and efficient system widely used for drying of fruits (Kilpatrick et al., 1975). Beaven (1944) described a cabinet drier for small scale drying. In this filtered fresh air drawn by the fan through the heated coils is blown across the material or trays to an exhaust system. The cabinet type driers are mostly used for small scale drying in laboratory. Khurdiya (1980) used cabinet drier at 60°C with air flow rate of 1.2 meter to 1.8 per second for drying of ber fruit and sun-dried ber scored more points in organoleptic rating. Dhawan (1980) dried the ber fruits in cabinet dehydrator at 50°C throughout the drying period. The use of low temperature in dehydrator might be due to the fact that the migration of moisture to the surface of the whole fruit is very low as compared to the cut pieces. Mehta and Tomar (1980) dehydrated guava slices in cabinet drier at 60°C. Mehta et al. (1982) dehydrated pineapple slices at 60°C and Tomar and Gower (1985) also used 60°C temperature for dehydration of muskmelon slices in cross flow drier.

6. Organoleptic and keeping quality of processed product

Fruits are known for their palatability and nutrition. Colour, flavour, texture and nutritional value are generally recognised as four quality factors of fruits and their products. According to Holdsworth (1971b) structure and composition of raw material, shrinkage during drying , loss of volatile components, browning reactions and rehydration are the physico-chemical aspects of dehydrated products. Nutrient loss, degradation of colour pigments and overall texture may also be added to this list (Jen, et al. 1989). These are important in determining the overall organoleptic quality of the product. Except for structure and composition of raw material these factors are directly influenced by the conditions used during the dehydration process.

Processing often alters the quality of fruits and vegetables but does not change the chemical basis underlining the factors (Jen, 1989). Enzymatic and non-enzymatic browning contribute to colouring of processed fruits. Non volatile compounds are responsible for special flavour of the processed fruits, in case of dried fruits in special. The texture is provided by the cellwall components and extent to which the shape of the constituting cells have changed. the nutritional value is affected due to the change in Vitamin C and mineral content which are major nutrients in fruits.

Moisture content in the finally dried product is another major factor which affects the storability of the product. Therefore, for the improvement in the quality of processed product it is necessary to understand the chemical basis of the quality factors.

6.1 Colour

Certain artifacts such as caramels, melanins etc. are the reaction products of the enzymatic and non-enzymatic reactions from the processing of the fruits and vegetables (Mackinney and Little, 1962). According to Clydesdale, et al. (1972) the organic acids released from the destruction of intact cells can cause conversion of chlorophylls to pheophytins in processed plant foods. The acidic conditions can cause the replacement of hydrogen for magnesium and make the chlorophyll into pheophytins. These peophytins are brown in colour and are undesirable in most foods.

Carotenoids are lipid soluble pigments, responsible for yellow, orange and red colour in most of the fruits. These are relatively heat stable and not suffer extensive loss during thermal processing. However most of these carotenoids are sensitive to photo-oxidation and loss their bright colour under long exposure to light and oxygen (Jen, 1989).

Other natural pigments existing in plant foods include tannin, leucoanthocynin, quinone and xanthone. According to Clydesdale and Francis (1976) leucoanthocynins, tannins, quinones and xanthones are heat stable. These are important in dehydration of ber fruits as it contains a good amount of tannins (Dhingra, 1983) and other phenolic compounds are also present.

Enzymes polyphenol oxidases (PPO) also known as phenolases cause enzymatic browning. These enzymes catalyze the conversion of monophenols and diphenols to quinones which can further undergo a series of non-enzymatic reactions to produce brown, grey and black coloured pigments, collectively known as melanins (Schwimmer, 1981). Maillard reactions, caramelizations and ascorbic acid oxidations can produce similar type of coloured compounds (Eskin et al. 1971). These browning reactions are undesirable for dehydrated fruits.

Blanching may be used to prevent enzymatic browning in some fruit products (Luh et al, 1986). Since PPO is heat labile (Vamos-Vigyazo, 1981). But the blanching results in destruction or loss of flavour components of fruits (Luh et al, 1986 and Shewfelt, 1986). According to Halpin and Lee (1987) in green peas there is decreased or constant peroxidase and PPO activity in storage at -23°C. Lipoxigenase activity is also increased over storage and these three enzymes exhibited a wide range residual activity after blanching also.

According to Reynolds (1965) the condensation of reducing sugars with amino acids which is acclerated by heat is responsible for much of the darkening of fruit tissues during storage. Sulphites are very effective browning inhibitors (Joslyn and Braverman, 1954; Vamos-Vizyazo, 1981; and Sayavendra-soto and Montgomery, 1986). Maillard reaction is also inhibited by sulphurdioxide. The mechanism of inhibition was investigated by Song and Chichester (1967) and reported that bisulphite inhibited the reaction prior to browning by combining with intermediate compound involved in overall browning reaction.

Sulphite is experiencing declined usage due to health reasons to asthmatic consumers. Sulphite can produce acute allergic reactions in some asthmatics, however, with serious if not lethal consequences (Taylor *et al.* 1986).

In recent developments ascorbic acid-2-phosphate is reported to be effective inhibitor of browning in cut apple (Seib and Liao, 1987). Other alternatives to sulphites are L-ascorbic acid and its isomer D-erythorbic acid or their sodium salts with such adjuncts as citric acid, sodium or calcium chloride, phosphates, cysteine and potassium sorbate (Langdon, 1987) . But these substitutes are considered to be less effective than sulphites because they do not penetrate as well into cellular matrix (Taylor *et al.*, 1986).

Bolin *et al.* (1964) studied the effect of prolonged illumination on dehydrated apricot, peach and apples in transparent films stored at 32.3°C and found that loss of sulphurdioxide and the rate of darkening of peaches and apricots were most affected by light.

6.2 Flavour

Various volatile aroma and nonvolatile compounds give special flavours to fruits and vegetables (Jen, 1989). The final processed product shall possess the characteristic flavour of the fresh fruit. In the recent years it has been possible to gain some knowledge on the chemical compounds that give the flavour sensation of fruits and vegetables (Heath, 1981). But a limited literature is available for the processed and dehydrated fruits with respect to flavours. The techniques involved in the prevention of off-flavour formation during processing and storage period is of the interest to the food chemists.

According to Jen (1989) enzymes peroxidases and lipoxigenases seems to be involved in off-flavour formation of fruits and vegetables.

These enzymes have ability to form highly reactive free radicals and hydroperoxides. Blanching may inactivate these enzymes but blanching to peroxidase free condition may be over blanching. Blanching also result in destruction of flavour components of fruits (Luh et al, 1986 and Shewfelt, 1986).

Loss of flavouring components during processing or dehydration of ber fruit have not been studied. In citrus Varsel (1980) reported the loss of some volatiles during the recovery and concentration of volatile aromas in citrus industry for use as essence. The final product essence does not contain all of the flavour notes of fresh juice. According to Braddock and Chen (1985) in commercial citrus juice evaporator most volatile aromas and high percentage of terpenes have been removed at 25 per cent evaporation of initial juice volume.

There is gradual decrease in volatile flavour compounds during drying and other compounds formed as a result of chemical reactions at normal drying temperature impart flavour to ths products. For the retention of the flavour during storage product may be packed in oxygen free packs. Sapers et al. (1973) reported that flavour of potato flakes was not affected for 12 months at 23^{o}C when packed with nitrogen gas.

6.3 Texture

Texture is an important quality factor of fruits, vegetbales and their products. Scientists have different definitions for food texture (Bourne, 1982) . In food chemistry, texture of the fruits and vegetables represent the biomolecules involved in the cellular structure of cell walls. The degradation during natural physiological changes or artificial processing operations may alter the textural properties of fruits. Some of most important parameters for texture are hardness, firmness and crispness (Jen, 1989).

According to Reeve (1970), texture of fresh fruits and vegetables is determined by both histological structure i.e. cell size, intercellular components, cell wall thickness, and structure and cell wall composition. The cellulosic microfibrils which comprises basic architecture of the cell wall may include some pantosans vary greatly in orientation, degree of crystallinity and cumulative thickness. The structure and composition of raw material alongwith shrinkage during dehydration influence textural properties of the product and its rehydration ratio/moisture absorption capacity.

Pectic substances are the glues to plant cells and exist predominantly in middle lamella between cell walls (Fishman and Jen, 1986). These pectic substances are in the form of protopectin, pectinic acid and pectic acid. Ber fruit contains a considerable amount of pectins ranging from 0.74 to 0.99 per cent(as calcium pectate) at ripe stage (Dhawan , 1980). The pectin is closely related with textural properties of fresh and dried ber fruits.

Other substances such as clacium and magnesium may play a role in the firmness of raw and processed fruits. According to Jen (1989), divalent ion can form a bridge between free carboxyl groups of pectic chains to give rigidity to the cell structure.

Kim and Toledo (1987) reported that high temperature fluidized bed dried osmoticially dehydrated blue berries at a water activity (a_w) of 0.5 were soft, had a raisin like texture and were suitable for consumption in dry state.

6.4 Nutritive Value

Carbohydrates, vitamins especially Vitamin C and minerals are the major nutrients of fruits and their products (Gopalan, 1977). According to U.S. Department of Agriculture (1984) the most nutritive value of fruits and vegetables are their contents of vitamin C, minerals and fiber. Various amounts of other vitamins and nutrients exist in fruits and vegetable which contribute significantly to the balance of our diet.

It is generally believed that fresh, raw fruits and vegetables contain maximum amount of vitamins and minerals but it is not always true. The nutritive values of fruits and vegetables vary due to many factors like varieties, maturities, climate and location. In case of ber fruits variation due to these factors is very much true (Kumar and Babu, 1987). Home storage time and method of preparation before consumption has significant effect on nutrient retention (Ang and Livingston, 1974).

Processing has some destructive effect on the nutritive value of fruits and vegetables (Harris and Kramas, 1975). Fruits are living organisms and undergo physiological changes when harvested. The processing techniques are to stop the physiological and enzymatic activities with minimum disruption of cellular structures. But even after total inactivation of enzyme some non-enzymatic chemical reactions may occur during processing and storage (Eskin *et al*, 1971). According to clydesdale *et al.* (1972) there is formation of acid. There are non-specific hydrolysis of macromolecules, interconversion of sugars, aggregation of monomer, dissociation of polymers and changes of ionic bonding in cell walls (Pattee, 1985 and Goodenough and Atkin, 1981).

Effect of dehydration and storage on protein and vitamin contents of foods was reveiwed by Labuza (1973). He indicated that major loss of fat soluble vitamins such as Vitamin A and E is probably due to the reaction of peroxidases and free redicals. According to Hulme (1971) there is some loss of vitamin during drying. Morgan et al. (1931) reported that 50 per cent of the original content of vitamin C is retained in the dried product by the presence of sulphurdioxide. Salem and Hegazi (1973) determined that in sundrying of apricot juice a large part of cartoenoids and vitamin C was lost during processing and drying.

Total sugars and acids seems to be less affected during drying and storage. According to Wrolstad et al. (1989) the sugars and non-volatile acids are relatively stable while the phenolic profiles show considerable change in processing and storage of fruit juice concentrates. Rao and Roy (1980) reported increase in reducing sugars and decrease in total sugar content in dehydrated mango pulp after three month storage. This increase in reducing sugar and decrease in total sugar was higher with the increase in storage temperature. Vitamin C content was also lost completely at higher temperatures even in the presence of SO_2, there was an increase in total acids with increase in storage temperature.

Mehta et al. (1982) in dehydrated pineapple rings, Tomar and Gawar (1985) in dehydrated muskmelon and Mehta and Tomar (1980 a&b) in dehydrated cut guava fruits and papaya slices reported no major change in sugar contents though there was increase in reducing and decrease in total sugars but the change was very less. There was slight decrease in acidity after six month storage. Mehta and Tomar (1980 a&b) also reported loss of Vitamin C in dehydrated cut guava fruits and papaya slices during storage. Vaghani and Chundawat (1986) reported an increase in reducing sugars with storage time and increase in total sugars during first three months of storage and decrease thereafter.

Khurdiya (1980) reported the loss of Vitamin C content after six month storage in dehydrated ber fruit. Dhawan (1980) reported reduction in sugars and Vitamin C contents in dried ber fruit with the increase in storage time.

Information regarding the retention of minerals in the dehydrated foods products is not available. But there is some effect of different processing treatments on mineral contents of fruits. Yamaguchi and Wu (1982) reviewed the mineral contents in vegetables and reported the loss of water soluble components including minerals during blanching. Calcium is generally absorbed by vegetables during blanching but the extent of increase depends upon the kind of vegetable, the hardness of blanching water and length of blanching time.

Iron is often in the water soluble form thus may be leached. Gorodnik (1969) reported that beets lost 38 per cent and carrots lost 20-50 per cent of the iron during peeling and significant loss of iron during blanching of beets. Little iron was lost when unpeeled carrots were boiled; but when peeled the loss was over 22% during blanching. The loss may be negligible in blanching of whole ber fruits and no absorption of calcium when fruits blanched in pure water.

6.5 Rehydration

Rehydration is influenced by structure, composition of raw material and shrinkage during dehydration. According to Shipman et al. (1972) there is removal of intracellular water and turgor is relieved resulting in collapse of cell walls during the process of dehydration. The collapse can be total and irrversible in case of high moisture vegetables whose cell walls are fragile such that rehydrated product only absorb a fraction of the original moisture level. The texture of the rehydrated product is mushy because of the intercellular rehydration only.

A good quality product is that which is reconstituted well upon rehydration. It may be possible only when cell wall is not totally collapsed, remain intact and intercellular spaces are maintained in the dried product. The intercellular spaces are clearly manifested in the porous structure of freeze dried foods (Jan et al, 1989).

Rate of moisture removal during dehydration has a strong influence on the shape and texture of a dehydrated product. According to Toledo (1980) in rapid initial drying the rigid outer layer is formed which resist deformation, limits total shrinkage and intercellular voids are formed. Once the cell wall dries to form rigid structure, continuous moisture removal can occur without further deformation resulting into a dried product of low bulk density.

Sullivan et al. (1980) showed that rate of dehydration of explosion puffed apples was much faster in the last stage of drying i.e. when moisture content drops below 1.0 moisture free basis as compared to conventionally dried apples. Explosion puffed or very rapid high temperature short time dehydrated products were having low bulk density and rapid rehydration.

Among the different treatments adopted for drying, Mehta and Tomar (1980) reported higher reconstitution ratio of the unsugared dehydrated guava slices and papaya segments. Ramamurthy et al. (1978) reported the rehydration ratio of osmo-air dried mango slices close to freeze dried slices.

Rehydration ratio of dehydrated ber fruits was maximum in Chhuara variety followed by Bagwari, Illaichi, Umran and Katha varieties (Khurdiya, 1980).

6.6 Moisture

For stability of the dehydrated product there is an optimum moisture level above or below which storage life is diminished (Rockland, 1969). According to Brockmann (1970) intermediate moisture foods have water activity (a_w) 0.85 and the moisture content is 20 to 30 per cent. These are semimoist, firm and more susceptible to Maillard reaction and less susceptible to fat oxidation than low moisture dry foods. Low moisture foods are hard and firm their a_w is 0.7 and below, and moisture content is below 20 per cent and these are resistant to microbial deterioration.

Hendel et al. (1955) reported the increased storage stability of dried potatoes when moisture content was reduced from seven to four per cent. According to Molaison et al. (1962) dehydrated sweet-potatoes below four per cent moisture maintained quality for longer period.

Khurdiya and Roy (1986) dehydrated the ber fruits of Katha variety to 11.26 to 15.24 per cent moisture levels in different types of solar driers.

Hsu (1982) suggested that a_w should be in equilibrium with the relative humidity (R.H.) of the atmosphere around the food and it should be 100 times as large as a_w, if the R.H. is expressed in per cent. If R.H is lower than a_w of the food, the food dries at the surface. Conversely, if the RH is higher than a_w of the food, the a_w would increase at the surface and food may be spoiled by microorganisms.

Rao and Roy (1980) found 15 per cent or a little more moisture with RH between 63 to 70 per cent ideal for storage stability. Equlibrium moisture around 17 per cent with RH 75 per cent for good texture and flavour of dehydrated ber fruit of variety Katha. Hence the dehydrated product shall be so packed that the R.H. of the microclimate within the package may be maintained.

7. Microbiological Quality of Dehydrated Product

Fruits, vegetables and their products are spoiled by growth of microorganism (m.o). Fruits are conteminated by yeasts and molds because of low pH and acidic nature. The internal tissues are almost free from contemination and the surface is conteminated by m.o (Dennis, 1987).

Kainsa _et al._ (1978) studied the surface microflora or ber fruit and reported the presence of molds like _Aspergillus niger_, _Rhizopus oryzae_, _Penicillium chrysogenum_ , _Alternaria tenuissima_ and _Phoma_ sp. predominantly and are mostly responsible for spoilage of ber fruits. May and Kelly (1965) recovered 32 per cent of the original flora conteminating a particular food item.

For dehydrated foods American Public Health Association has fixed a limit for total microbial viable count. Murphy (1973) also reported that the range of total viable count (TVC) in dried foods should not exceed (50-300) x 10^3 per g. Total bacterial count on dried vegetables tend to vary considerably although they should lie in the 10^3 to 10^4 range depending on the vegetable.

Drying destroys some m.o. but endospore formers, yeast and spores of mold survive. In sundried product the m.o. present in the environment are not destroyed and are main source of contemination. Pitt and Christian (1968) reported molds of Aspergillus glaucus and Xeromyces bisporus groups to be responsible for the spoilage of dried and high moisture prunes. Esau and Cruess (1933) found souring of prunes and dates because of yeasts. They also observed sugar like substances on dried fruits due to yeasts which give yeasty flavour to the product. Dennis (1987) reported the yeasts responsible for spoilage and yeasty flavour of dehydrated fruits.

Moisture content in the finally dehydrated product is one of the factor which affect the growth of m.o. in the products. Dehydrated foods below certain moisture level do not support the growth of m.o. under normal conditions, because insufficient moisture is present for microbial activity and bacteria in particular. Bacteria require relatively high levels of moisture for their growth and activity. Their water activity (a_w) requirement is high above 0.90, therefore these organisms play no role in spoilage of dried fruits (Jay, 1970). for dried foods Scot (1957) related a_w levels to the probability of spoilage. He suggested that at a_w of 0.65 very few organisms are known to grow and spoilage is most unlikely to occur even upto twoyears. But osmophillic yeast such as Saccharomyces rouxi can even survive at an a_w of 0.65 under certain condition. Fungus Xeromyces bisporus can grow at a_w down to 0.60 and heat or chemical treatment is necessary to prevent spoilage by this fungus (Dennis, 1987).

Khurdiya (1980) reported mold growth in dehydrated ber fruits having moisture content above 21 per cent at equilibrium relative humidity (E.R.H.) above 81per cent within few days. there was no microbial growth in dried fruits having moisture content upto 17.25 per cent and ERH below 75 per cent.

Hazards of contemination of food poisoning organisms is recognised and easily avoidable during dehydration process. Dehydration methods include some treatment like blanching, sulphuring etc. for destructing and inhibiting microbial growth (Murphy, 1973). According to Dhawan (1980) ber fruits dried after blanching and sulphuring have lowest microbial count. He also observed higher microbial counts in sundried product than in chamber dried product.

Sulphuring of fruits before drying inhibit the growth of m.o. Maintenance of certain level of sulphurdioxide content is sufficient to preserve light colour of dried fruits (Van Arsdel et al. 1973).

CHAPTER - III

MATERIAL AND METHODS

The present investigations on dehydration of ber (Zizyphus mauritiana Lamk.) were carried out in the Department of Horticulture, Haryana Agricultural University, Hisar. The experiment included the recent technique of osmo-air drying for fruits.

I. Material

Firm ripe ber fruits were procured from the experimental orchard of Haryana Agricultural University and processed in Post-harvest technology laboratory. Three Kg fruits/treatment was taken.

1.1 Varieties

Following three ber varieties were selected

i) Illaichi

ii) Mudia-Murhara

iii) Umran

1.2 Chemicals

Analar (A.R.) quality chemicals of B.D.H. Chemicals, India or E. Merck, India, Ltd. were used for analysis.

1.3 Equipments

Hot air oven of NSW make was used for dehydration of fruits and for maintaining the temperature of the syrup during osmosis.

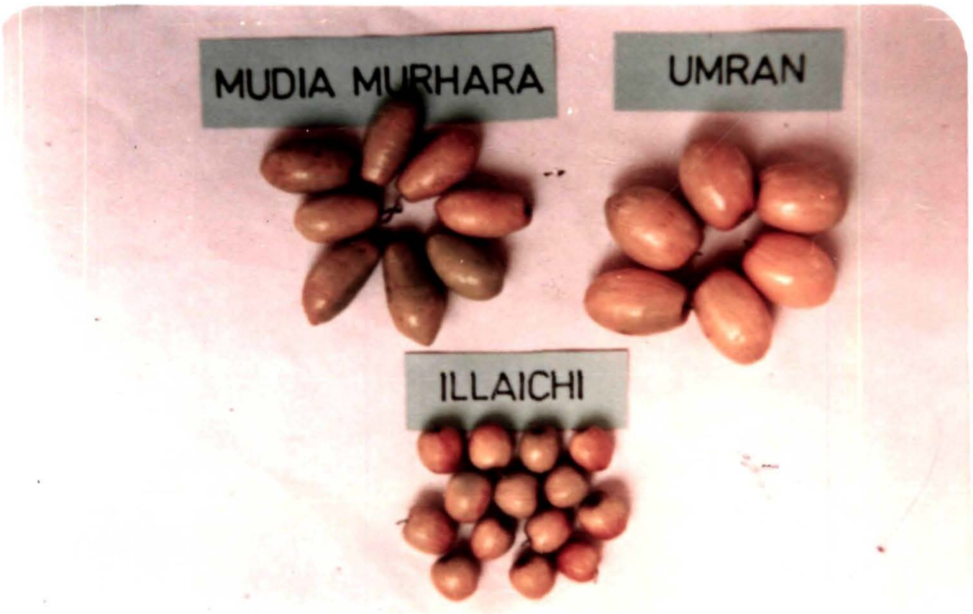

Plate 1 : Fruits of different varieties of ber at harvest.

A wooden sulphur chamber of size 5' x 3' x 2' having 10 trays (2' x 1½' size) was used for sulphur fumigation.

2. Methods

2.1 Harvesting

The fruits were harvested at fully ripe but firm stage.

2.2 Washing

Fruits were washed thoroughly under running tap water.

2.3 Blanching

The fruits were blanched by dipping in boiling water for 5 min. in case of water blanching and kept in atmospheric steam for 10 min. for steam blanching to inactivate enzymes.

2.4 Sulphuring

Blanched and untreated fruits were fumigated with sulphurdioxide gas by burning powdered sulphur in an enclosed wooden chamber. Fruits were loaded @ 1 kg per sq. ft. in single layer in the wooden trays made of slats Sulphur powder was burnt @ 2.5 g. per kg fruits inside the chamber and fruits were kept for three hours in the chamber for absorption of sulphurdioxide.

2.5 Drying

Two methods of drying i.e. sundrying and hot air oven drying were adopted. The fruits were osmotically dehydrated for partial removal of moisture followed by final drying under sun or in hot air oven.

Daily moisture loss was calculated in terms of kg. of water lost/kg. dry matter.

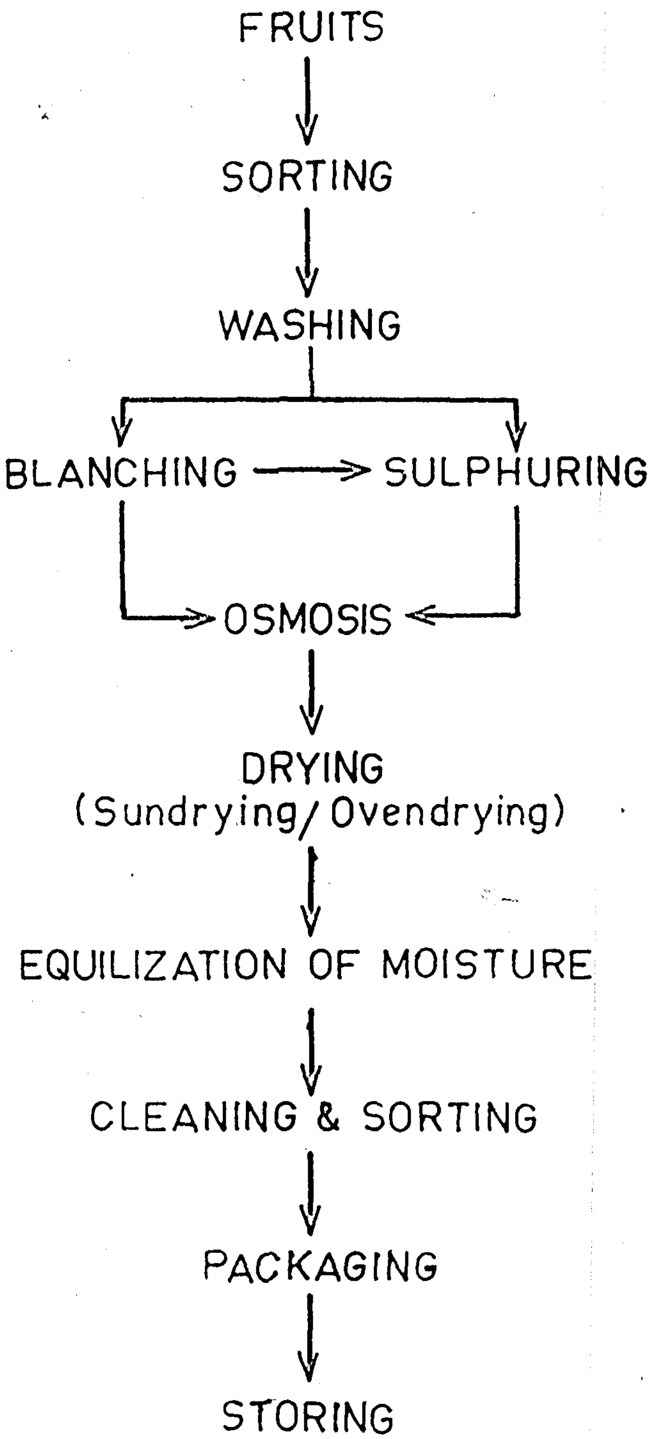

Fig. 1. FLOW SHEET FOR DEHYDRATION OF BER FRUITS

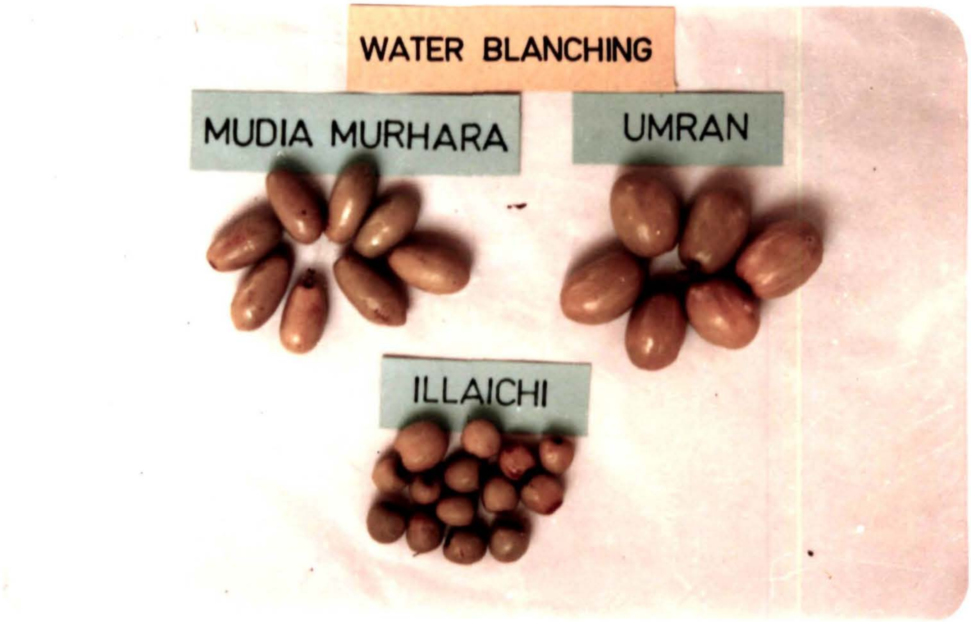

Plate 2 : Ber fruits after water blanching for five minute.

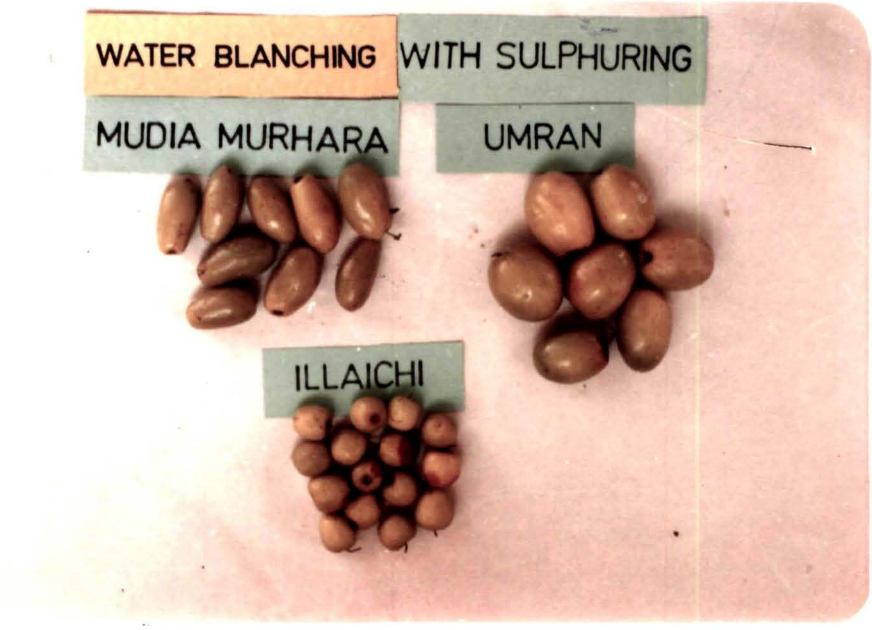

Plate 3: Ber fruits after water blanching and sulphuring.

Period (time) of drying was recorded in days.

Rate of drying was expressed in terms of per cent moisture loss per day and calculated as :

$$\text{Per cent moisture loss/day} = \frac{\text{Total moisture lost during drying period}}{\text{Total drying days}} \times \frac{100}{\text{Total moisture content in fresh fruits}}$$

2.5.1 Osmosis

The fruits were kept in 70° Brix sugar syrup in 3:2 syrup volume to fruit weight ratio for osmosis. Sulphured and unsulphured fruits were kept in separate containers for osmosis and the temperature was maintained at 50°C. Osmotic dehydration was done for 48 hours and the loss in moisture was recorded after every 24 hours. After 48 hours the osmotic dehydrated fruits were washed to remove sugar syrup, surface dried and weighed before air drying.

2.5.2 Sundrying

Wooden trays of 3' x 2 ' size made of slats were used for sundrying. The fruits were spread in trays in single layer and kept for drying under sun. Loss in moisture after 24 hours was recorded till the completion of drying process.

2.5.3 Dehydration

The fruits were dried in hot air oven fitted with air circulation fan. The fruits were loaded in perforated aluminium trays and dried at 55°C for 24 hours and finally at 50°C till the desired stage of drying was achieved.

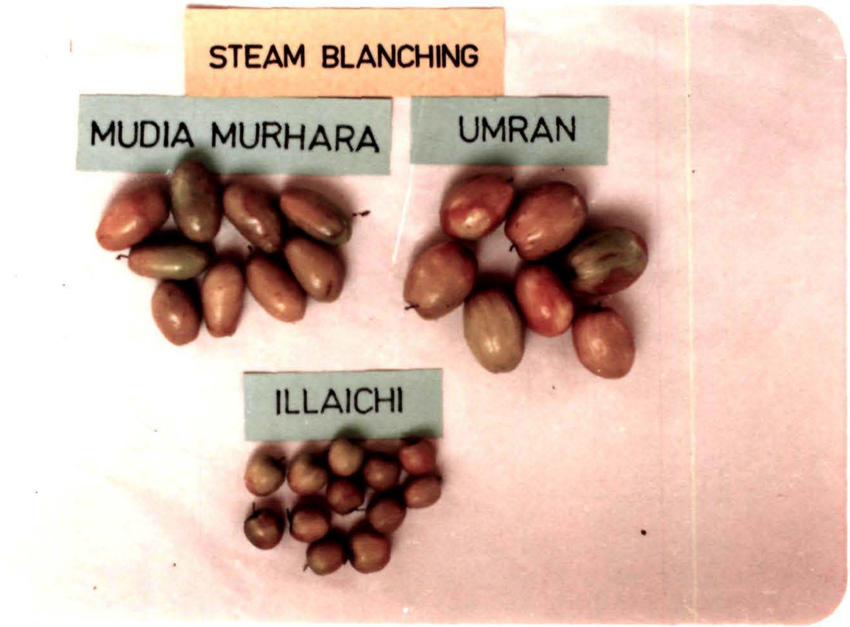

Plate 4: Ber fruits after steam blanching in atmospheric steam for 10 minute.

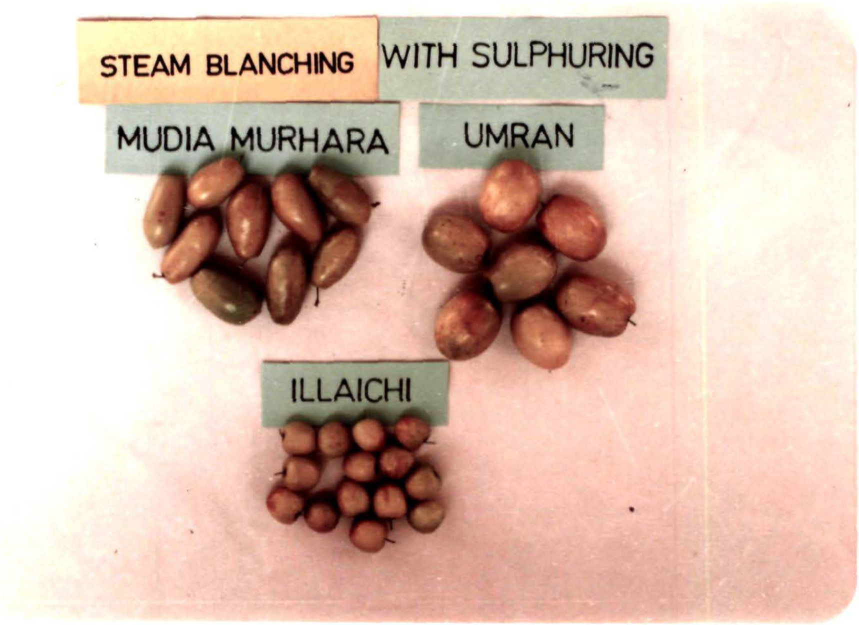

Plate 5: Ber fruits after steam blanching and sulphuring.

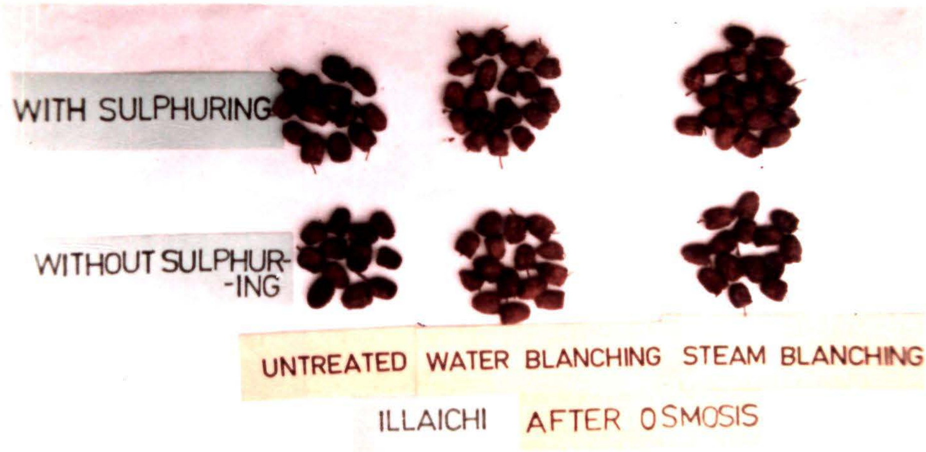

Plate 6

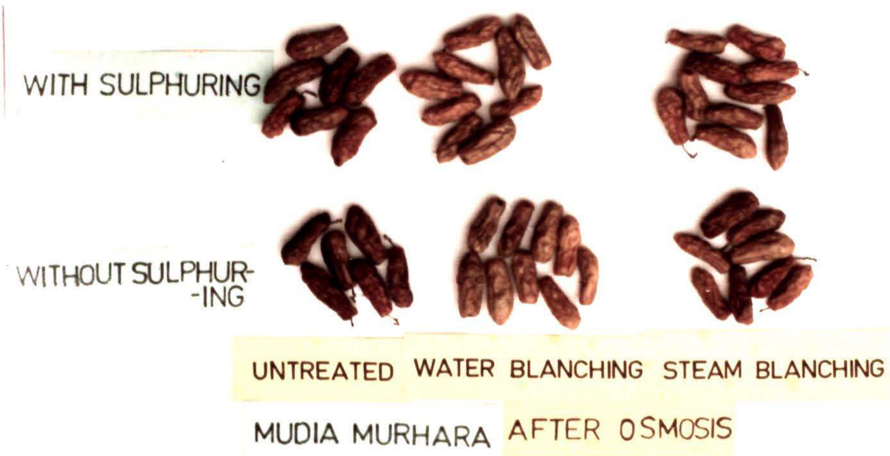

Plate 7

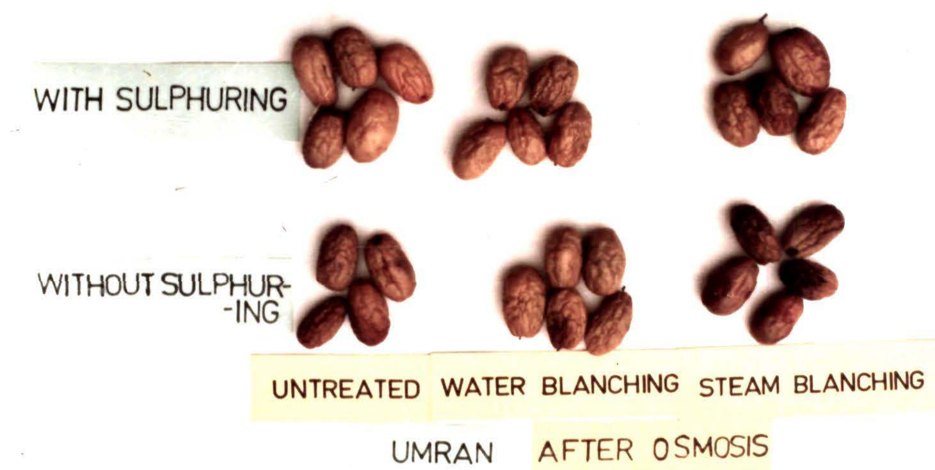

Plate 8

Plate(6-8): Fruits of different ber varieties soon after osmosis in $70^{O}B$ sugar syrup for 48 hours at $50^{O}C$.

2.6 Equilization of moisture

Sundried and ovendried fruits were kept in a container for one week for equilization of moisture. The final moisture content was kept near 15 %.

2.7 Packaging

Dried fruits were cleaned by removing stems packed in 400 guage polyethylene bags and sealed with an impulse sealer.

2.8 Analytical Methods

2.8.1 Sugars

Sugars were estimated by the method of Hanes (1929) with modification by Hulme and Narain (1931).

Reagents

i) Potassium ferricyanide solution

Potassium ferricyanide	8.25 g
Anhydrous sodium carbonate	10.6 g
Volume	1 litre

ii) Potassium iodide solution

Potassium Iodide	12.5 g
Zinc sulphate	25.0 g
Sodium chloride	125.0 g
Volume	500.0 ml

iii) Acetic acid solution

Glacial acetic acid	5 ml
Volume	100 ml

iv) Starch solution (Indicator)

Starch (soluble)	1.0 g
Sodium Chloride	20.0 g
Volume	100 ml

v) Sodium thiosulphate solution (0.01N)

A suitable portion of macerated sample was weighed and to it added five times (W/V) distilled water. Kept it on boiling water bath for half an hour. Five extractions were taken clarified it with saturated lead acetate solution and neutralized with sodium oxalate. After making an appropriate volume the extract was filtered and kept for some time. Proper dilutions were made before using for estimation.

Estimation

a) Reducing sugars : Five ml each of potassium ferricyanide and sugar solutions were pipetted out in a glass test tube (1 x 7 inch). Covered tubes were kept in boiling water bath for 15 minutes the tubes were cooled for 3 minutes in running cold water. Then 5 ml of potassium iodide-zinc solution followed by 3 ml of acetic acid solution were added. The iodine soliberated was titrated with soium thiosulphate (0.01N) using starch as indicator, the end point was the disappearance of blue colour and appearance of milky colour. A water blank was also run with 5 ml distilled water simultaneously. The results were calculated by the following formula:

(ml. of 0.1N thiosulphate used in blank - (ml. of 0.1N thiosulphate used in unknown + 0.05] X 0.338

= mg of sugars per 5 ml. unknown solution

b) Total Sugars : Took 10 ml of extract and 2.5 ml conc. HCl in a flask kept it in a water bath at $70^{O}C$ for 15 minutes for hydrolysis. Excess HCl was neutralized by adding anhydrous sodium carbonate(pinch by pinch) till effervescence stopped. Made the proper volume and dilutions. The method described under reducing sugars was followed for further estimation.

2.8.2 Total Acids

Total acids were extracted in distilled water and estimated by titration against sodium hydroxide (A.O.A.C. 1985). A suitable portion of mecerated sample was weighed and after adding distilled water in 1:5 (W/V) ratio kept in boiling water bath for one hour. It was cooled, filtered and made to appropriate volume. Suitable aliquote was titrated against (0. 1N) sodium hydroxide, from the volume of alkali used. The acidity was calculated and results were expressed as gram anhydrous citric acid per 100 g sample.

2 .8.3 Ascorbic acid

Ascorbic acid was estimated by the method described by Ranganna (1977).

Reagents

i) <u>Metaphosphoric acid (MPA)</u> 3 %

Metaphosphoric acid	=	15	g
Glacial acetic acid	=	40	ml
Volume	=	500	ml

ii) 2,6- dichlorophenol indophenol dye solution

2, 6 dichlorophenol indophenol	50 mg
Sodium carbonate	42 mg
Volume	200 ml

iii) Standard Ascorbic acid solution

L- Ascorbic acid	50 mg
Volume (with MPA solution)	50 ml

Extraction : ascorbic acid was extracted by mashing a weighed portion of sample in 3 per cent MPA solution, filtered and appropriate volume was made.

Estimation :

Suitable volume of extract was titrated against 2,6-dichlorophenol indophenol dye till the light pink colour appeared. Similarly one ml of standard ascorbic acid solution was also titrated against dye. the results were expressed as mg ascorbic acid per 10 g sample.

$$\text{mg. of ascorbic acid per 100 g sample} = \frac{\text{100 X total volume of extract made}}{\text{g. of sample extracted} \times \text{Volume of extract used for titration}} \times \frac{\text{ml. of dyeused for unknown sample}}{\text{ml. of dye used for 1 ml standard solution}}$$

2.8.4 Total Phenols

Phenols were estimated by the method of A.O.A.C. (1980).

Reagents

i) Follin's Ciocalteau reagent

ii) Sodium carbonate solution (20 %)

Sodium carbonate	= 20 g
Volume	= 100 ml

iii) Acetone 80 %

Acetone	=	800 ml
Volume	=	1 lite

Extraction

Hundred mg mecerated portion of the sample was weighed and after adding 5 ml of 80 % acetone in the centrifuge tube kept for 15 min. It was centrifuged at 4000 rpm for 10 minutes and the supernatant was separated. To the pallets added 5 ml of 80 % acetone and again centrifuged for 10 min. Supernatant was mixed to the first and made the final volume to 100 ml,

Estimation

To 0.2 ml of above extract added 5 ml distilled water and 0.5 ml of follin's reagent and kept for 14 minutes. Then 0.5 ml sodium carbonate solution was added and made the volume to 10 ml. Absorbance was recorded at 760 nm and calculated the quantity of phenols in mg per 100 gm. by comparing with the standard.

2.8.5 Minerals

Minerals, calcium and iron were estimated by wet digestion of ground, dried and homogenised sample of fruits. Five hundred mg. dried sample was digested in diacid (4:1 ; Nitric acid : perchloric acid), made appropriate volume and used for estimating the calcium and iron contents.

a) Calcium : Calcium was estimated by the method of Chang and Pray (1951).

Reagents :

i) 4N sodium hydroxide solution

Sodium hydroxide	60 g
Volume	1 litre

ii) Ammonium purpuriate (indicator)

Ammonium purpuriate powder	0.5 g
Potassium sulphate	100 g

iii) Ethylene diamine tetracetate solution (EDTA) 0.01N

EDTA	2.0 g
Magnesium chloride	0.05 g
Volume	1 litre

Estimation

Took 5 ml aliquote in a China disk with an equal quantity of distilled water and a pinch of ammonium purpuriate (indicator) titrated it against 0.01N EDTA solution. The end point was change of orange red colour to purple. Calculated the quantity of calcium by using the formula and expressed as mg per 100 mg-

$$\text{Percent calcium} = \frac{\text{ml. of 0.01N EDTA used} \times 1000 \times \text{Normality of EDTA} \times \text{Eq. wt of calcium} \times \text{Dilution factor}}{\text{ml. of aliquote taken} \times 10^4}$$

b) Iron : Iron content was estimated by subjecting the aliquote directly to atomic absorption spectrophotometer, the results were calculated and expressed as mg. per 100 mg edible portion.

2.8.6 Total sulphurdioxide

Sulphurdioxide was estimated by the Monier-Williams (1927) method and modified by Shipton (1954).

Reagents

i) Concentrated Hydrochloric acid

ii) Bromophenol blue (Indicator)

Bromophenol blue	0.4 g
0.1N sodium hydroxide	6.0 ml
Volume	100 ml

iii) Sodium hydroxide (0.05N)

Sodium hydroxide	0.75 g
Volume	1.0 litre

iv) Hydrogen peroxide (3 %)

Estimation

Fifty g. edible portion of dried fruits was taken in a round bottom flask. Added 350 ml distilled water and 20 ml of conc. HCl. The content boiled quickly on electric heater and simultaneously nitrogen gas was passed through the contents in the flask at the rate of 6-12 bubbles per min. cold water was circulated into the vertical condenser. The distillate was allowed to pass through the condenser and collected in a flask containing 15 ml of 3% hydrogen peroxide and left over (if any) in a U-tube containing 5 ml of 3% hydrogen peroxide ; continued the heating for one hour. Transferred the solution of U-tube into the flask, washing it with little distilled. Added 3 drops of bromophenol indicator and titrated against 0.05 N sodium hydroxide to a pale sky blue end point. Titrated free acid in 20 ml hydrogen peroxide solution separately.

Results were calculated by following formula.

$$\text{Total sulphur-dioxide (ppm)} = \frac{\text{Volume of sodium hydroxide} \times \text{Normality of Sod. hydroxide} \times 32 \times 1000}{\text{Weight of the sample}}$$

2.8.7 Non enzymatic browning

Non-enzymatic browning was measured by the method of Hendel et al. (1950). One g. of ground and homogenised edible portion of the dried fruit was soaked in 25 ml of distilled water for 24 hours, filtered and absorbance was measured at 420 nm. using spectronic-20. O.D. was calculated in terms of original material by multiplying with dilution factor.

2.8.8 Rehydration ratio

Rehydration ratio of the product was measured by method described by Khurdiya and Roy (1986) for dried ber. Weighed portion of dried flesh was soaked in distilled water for 2 hours before boiling in distilled water for six minutes. Water was drained and the flesh was air dried on the filter paper. The results were expressed as the ratio of the weight of the rehydrated product to the weight of dried product i.e. rehydrated weight per unit dehydrated weight.

Per cent regain in weight was calculated by multiplying the per cent recovery with rehydration ratio of the dehydrated fruits.

2.8.9 Organoleptic Rating

Organoleptic quality was assessed by a panel of seven judges using Hedonic scale (Amerine et al. 1965) for appearance of colour, flavour, texture and taste as described by Ranganna (1977). The results were expressed as scores scored in each treatment for each variety after storing the product for three months. Hedonic rating scale given in Appendix-IV was used for the assessment of over all organoleptic quality of dehydrated ber.

2.8.10 Moisture

Per cent moisture in fresh ber fruit and the dehydrated product was estimated by drying the sample to a constant weight (AOAC, 1985). Fresh fruits were cut into small pieces and dried fruits were ground. A weighed (25 g) sample was kept in oven for drying at 60°C for drying to a constant weight.

2.8.11 Recovery of the product

Recovery of the product was expressed as weight of the product per 100 kg. fresh fruit at 15 % moisture level.

2.8.12 Total soluble solids

Total soluble solids in the fresh fruits were estimated at ambient temperature by using Abbe-Refractometer and the reading were corrected to 20°C.

2.9 Microbiological Examination

The microbiological examination for total viable count of organisms per g. product was done by the method as suggested by Sharf (1966) and recommended by American Health Association. Plate count agar media was used. Constitution of the medium is given below.

Tryptone	5.0	g
Yeast extract	2.5	g

Dextorse	1.0	g
Agar-Agar	15	g
Distilled water	1.0	litre

The media was autoclaved at 15 lbs pressure for 20 minutes to attain sterilization at 121°C.

Procedure

A weighed sample of dried fruit was suspended in a sterilized water blank to prepare primary suspension, which was diluted to suitable dilutions. One ml. of different serial dilutions were plated with the medium. The plates were incubated for 48 hours at 30°C. The plates with counts between 20 to 100 were considered. Total viable count per gram of product was calculated. Similarly the counts were taken for the product after thoroughly washing the product under free flowing tap water and after 3 months of storage in 400 gauge polypacks. The results has been expressed as total viable count per g product for each treatment in all the three varieties.

2.10 Statistical Design: Split Plot.

CHAPTER - IV

RESULTS AND DISCUSSION

Research work on the Evaluation of dehydration techniques for different varieties of ber fruits was carried out. During the course of investigations, the effect of different processing treatments and methods of dehydration for the ber were studied. The presentation of results and discussion has been arranged under the following heads.

1. Physico-chemical characteristics (Proximate composition) of different ber varieties.
2. Effect of different treatments on the nutritional quality of ber after processing and storage.
3. Effect of drying techniques on the time, rate of dehydration and product recovery.
4. Organoleptic and keeping quality.
5. Microbiological quality.

1. Physico-chemical characteristics (Proximate composition) of ber fruits :

The data with respect to colour, size (length and breadth), average fruit weight (wt), specific gravity, total soluble solids (TSS) and moisture content were recorded and are presented in Table 1.

The data revealed that var. Umran had the largest size fruit

Table 1: Physico-chemical characteristics of different varieties of ber fruit.

S.No.	Fruit character	Varieties		
		Illaichi	Mudia-Murhàra	Umran
1.	Colour	Golden yellow turning to cho-clate brown	Greenish-yellow	Golden-yellow
2.	Average fruit length (cm)	2.14	4.33	4.50
3.	Average fruit breadth (cm)	2.08	2.47	3.39
4.	Average fruit weight (g)	3.90	14.00	26.60
5.	Specific gravity at 20°C	1.015	0.973	0.981
6.	Moisture (%)	75.60	82.20	81.40
7.	Total soluble solids (%)	22.1	15.80	16.50
8.	Total sugars (%)	19.25	13.18	14.87
9.	Reducing sugar (%)	7.44	6.42	6.76
10.	Acidity (%) (as anhydrous citric acid)	0.28	0.24	0.23
11.	Ascorbic acid (mg/100 g.)	93.37	105.24	129.52
12.	Total phenols (mg/100 g)	214	173	153
13.	Minerals (mg/100 g.)			
	i) Calcium	25	23	23
	ii) Iron	1.060	1.960	1.035

with a highest average wt. (26.60 g) than var. Mudia-Murhara (14.0 g) and Illaichi (3.90 g). Var. Illaichi had the highest total soluble solids (22.1%), gravity (1.015) and lowest moisture content (75.60 %), whereas var. Mudia Murhara showed the minimum T.S.S. (15.80 %), specific gravity (0.973) and maximum moisture content (82.2 %). Khurdiya (1980) also reported highest T.S.S. and lowest average fruit weight and moisture content in var. Illaichi, and lowest TSS and highest moisture content in var. Mudia Murhara.

The chemical composition of ber fruits as presented in Table 1 showed that total and reducing sugars were higher (19.25 and 7.44 %) in var. Illaichi followed by var. Umran (14.87 and 6.76 %) and Mudia Murhara (13.18 and 6.42 %). Khurdiya (1980) also observed higher total sugars in var. Illaichi and lower in var. Mudia Murhara. The trend in reducing sugar content in different varieties of ber was also similar to the varieties under study.

Total acidity was found maximum in var. Illaichi (0.28 %) followed by var. Mudia-Murhara (0.24 %) and Umran (0.23 %) whereas Khurdiya (1980) observed highest acidity in var. Umran, however, Yamdagni (1984) reported higher acidity in var. Illaichi than in var. Mudia Murhara and Umran. Variation in acidity levels in different varieties might be due to the locations where these were planted. Var. Umran had the maximum (129.52 mg) ascorbic acid content whereas minimum content was observed in var. Illaichi (93.37 mg) . Var. Mudia-Murhara had 105.24 mg of ascorbic acid per 100 g. pulp. Khurdiya (1980) also recorded highest ascorbic acid content in var. Mudia Murhara. According to Bal and

Singh (1978) var. Umran had 117.13 mg ascorbic acid at ripe stage. Kumar and Babu (1987) recorded 97.46 mg of ascorbic acids in var. Mudia Murhara.

Total phenols were found highest in var. Illaichi (214 mg) followed by var. Mudia Murhara (173 mg) and Umran (153 mg). Similar trend in tannin content was observed by Dhingra (1983) in var. Illaichi and Umran. Not much differences were noticed in mineral constituents in different ber varieties. Calcium content ranged from 23 mg in var. Mudia Murhara and Umran to 25 mg in var. Illaichi. The iron content was found maximum in variety Illaichi (1.06 mg) followed by Umran (1.035 mg) and Mudia-Murhara (0.96 mg). Bal and Singh (1978) reported 0.26 mg of calcium and 1.05 mg of iron at ripe stage.

2. Effect of different treatments on the nutritional quality of ber fruit after processing and storage :

The changes in chemical composition of ber fruit were studied after the application of pre-drying treatments. The results thus obtained are presented below.

2.1 Total sugars :

The data pertaining to total sugar content of dehydrated ber were recorded and presented in Tables 2 a and b.

The data revealed that total sugar content was affected in all the treatments. A significant increase in total sugar content was observed where the fruits were osmo-air dried. Among various treatments, water blanched fruits dried after osmosis had the highest total sugars in all the varieties than other treatments. Umran had the maximum total sugars (68.63 %) followed by var. Illaichi (67.09 %) and Mudia

Table 2a: Effect of different treatments and drying methods on the total sugar content in dehydrated ber.

(g/100g)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	65.22	59.05	65.61	63.29	65.58	59.23	65.13	63.31	65.40	59.14	65.37	63.30
T_2 (OS)	65.58	60.78	66.25	64.20	66.17	60.00	66.57	64.25	65.88	60.39	66.41	64.22
T_3 (SUL+OS)	66.19	62.11	67.13	65.14	65.82	61.14	67.98	64.98	66.01	61.62	67.55	65.06
T_4 (WB)	63.66	57.80	64.22	61.89	63.84	58.85	64.85	62.52	63.75	58.33	64.54	62.20
T_5 (WB +OS)	67.15	65.95	68.84	67.31	67.03	65.50	68.43	66.99	67.09	65.73	68.63	67.15
T_6 (WB+SUL+OS)	65.08	64.55	67.03	65.55	65.81	63.84	67.13	65.59	64.44	64.19	67.08	65.57
T_7 (SB)	63.88	58.62	64.97	62.49	64.43	59.08	65.17	62.90	64.16	58.85	65.07	62.69
T_8 (SB + OS)	65.56	61.93	67.52	65.00	65.32	62.85	67.11	65.09	65.44	62.39	67.31	65.04
T_9 (SB+SUL+OS)	65.65	60.61	67.24	64.50	65.62	61.60	66.93	64.72	65.63	61.10	67.09	64.60
Mean	65.33	61.27	66.53	64.37	65.51	61.34	66.59	64.48	65.42	61.30	66.56	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5 %

i)	Variety	0.58	iv)	Variety x Method	0.82
ii)	Method	N.S.	v)	Variety x Treatment	0.85
iii)	Treatment	0.49	vi)	Method x treatment	N.S.

Table 2b : Effect of different treatments and drying methods on the total sugar content. in stored (3 months) dehydrated ber.

(g./100g)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	63.62	58.39	64.30	62.10	65.09	57.88	63.36	62.11	64.36	58.13	63.83	62.10
T_2 (OS)	64.47	60.06	65.34	63.29	65.93	58.98	65.45	63.45	65.20	59.52	65.40	63.37
T_3 (SUL+OS)	64.31	61.24	65.90	63.82	65.55	60.44	67.22	64.40	64.93	60.84	66.56	64.11
T_4 (WB)	62.93	57.10	62.87	60.97	63.51	57.91	63.10	61.51	63.22	57.50	62.98	61.23
T_5 (WB +OS)	66.95	65.28	68.50	66.91	65.96	64.43	67.97	66.12	66.46	64.85	68.23	66.51
T_6 (WB+SUL+OS)	64.40	63.26	66.38	64.68	65.34	62.60	65.87	64.60	64.87	62.93	66.12	66.64
T_7 (SB)	63.12	57.93	63.80	61.62	63.66	58.11	63.64	61.80	63.39	58.02	63.72	61.71
T_8 (SB+OS)	65.36	60.39	66.20	63.98	64.56	61.38	65.73	63.89	64.96	60.88	65.96	63.93
T_9 (SB+SUL+OS)	64.95	59.17	66.60	63.57	64.80	60.65	66.24	63.90	64.87	59.91	66.42	63.73
Mean	64.46	60.31	65.54	63.44	64.93	60.26	65.40	63.53	64.69	60.29	65.47	

UT= Untreated; OS= Osmosis, SUL= Sulphuring, WB= Water blanching; SB = Steam blanching

C.D. at 5%

i) Variety	0.46	iv) Variety x Method	0.65
ii) Method	N.S.	v) Variety x treatment	0.86
iii) Treatments	0.50	vi) Method x treatment	0.70

Murhara (65.73 %) when water blanced and osmo-air dried. Kim and Toledo (1987) also observed higher total sugars in osmo-air dried blue berries. A significant decrease in total sugar content was recorded under water blanching in all varieties whereas under steam blanching it was non significant in Mudia Murhara and Umran except Illaichi where a significant decrease had been observed. these losses were due to the leaching out of various soluble substances in the blanching medium. Losses in total sugars had also been reported during blanching by Kumar (1989) in dates.

Among different varieties, irrespective of the treatments, maximum total sugars were observed in var. Umran (66.56%) followed by var. Illaichi (65.42 %) and Mudia Murhara (61.3%). Higher total sugar content in var. Umran might be due to the low dry matter to moisture ratio in fresh fruits than var. Illaichi where this ratio was high. The reason for low total sugars in Mudia-Murhara could be low initial sugars in fresh fruits, though Umran and Mudia-Murhara had almost same moisture content. No significant effect was noticed in total sugar content with different methods of drying. Wrolstad et al. (1989) had also reported that sugars are relatively stable during processing.

Trend in total sugar content as a result of different processing treatments and drying methods remained almost the same even after 3 months of storage in all the varieties (Table 2b). However a decrease in total sugars was noticed in all the treatments. Similar results had also been reported by Dhawan (1980) in dehydrated ber and Rao and Roy (1980) in dehydrated mango pulp. The decrease in sugars might be due to the non specific hydrolysis of macromolecules, inter-conversion of sugars and aggregation of monomers during storage as reported by Pattee(1985) and Goodenough and Atkin (1981).

2.2 Reducing Sugars :

Reducing sugar content in dehydrated fruits was estimated and the data are presented in Tables 3a and b.

The results indicate that reducing sugar content decreased significantly in all the treatments over untreated fruits (39.61 %). Among different treatments maximum reducing sugars were observed in fruits dried after steam blanching (39.18 %) and the minimum sugars (33.65 %) in fruits which were water blanched , osmosed and dried. A significant decrease in reducing sugars was also observed after osmosis. Mehta and Tomar (1980) also reported a decrease in reducing sugar in osmo-air dried guava slices. The diffusion of sugars (sucrose) during osmotic dehydration in to the fruits resulted in higher per cent recovery of the product consequently increase in per cent total sugar and decrease in per cent reducing sugar content.

Among different varieties, dehydrated fruits of var.Umran had the maximum reducing sugars (39.6 %) followed by var. Mudia Murhara (37.19 %) and Illaichi (35.19 %). The high reducing sugar content in var. Umran was due to the low dry matter to moisture ratio and higher initial reducing sugar in fresh fruits. Various drying methods had no significant effect on reducing sugars of the dehydrated fruits.

The data in Table 3b showed similar trend in all the treatments, varieties and methods of drying with respect to reducing sugar content when stored upto 3 months. However, an increase in reducing sugar content upto 1.25 % was noticed under all the treatments when compared

Table 3a : Effect of different treatments and drying methods on the reducing sugar content in dehydrated ber.

(g./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	37.42	40.35	41.60	39.79	37.14	39.94	41.25	39.44	37.28	40.14	41.43	39.61
T_2 (OS)	37.18	38.35	40.56	38.70	37.35	39.40	39.80	38.85	37.26	38.87	40.18	38.77
T_3 (SUL + OS)	34.27	38.09	39.36	37.24	36.46	38.21	40.37	38.35	35.36	38.15	39.86	37.79
T_4 (WB)	35.53	38.30	41.57	38.47	34.52	38.84	41.47	38.28	35.03	38.57	41.52	38.37
T_5 (WB + OS)	32.11	30.99	36.99	33.36	31.43	33.14	37.26	33.94	31.77	32.07	37.12	33.65
T_6 (WB+SUL+OS)	34.58	32.70	38.11	35.23	33.92	34.13	38.20	35.42	34.25	33.41	38.15	35.27
T_7 (SB)	37.37	39.30	41.66	39.44	34.29	39.95	42.55	38.93	35.83	39.62	42.10	39.18
T_8 (SB + OS)	35.15	37.30	37.82	36.76	34.56	36.05	38.18	36.26	34.85	36.67	38.00	36.50
T_9 (SB+SUL+OS)	35.55	37.34	38.62	37.17	34.62	37.10	39.15	36.96	35.08	37.22	38.88	37.06
Mean	35.46	36.97	39.59	37.34	34.92	37.42	39.80	37.78	35.19	37.19	39.69	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5 %

i) Variety	0.75		iv) Variety x Method	1.07
ii) Method	N.S.		v) Variety x treatment	0.50
iii) Treatments	0.50		vi) Method x treatment	0.71

Table 3b : Effect of different treatments and drying methods on the reducing sugar content in stored (3 months) dehydrated ber.

(g./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	38.18	41.00	42.55	40.58	37.64	41.29	41.99	40.31	37.91	41.15	42.27	40.44
T_2 (OS)	38.53	39.07	41.91	39.84	38.71	40.17	40.87	39.92	38.62	39.62	41.39	39.87
T_3 (SUL+OS)	35.24	39.53	39.97	38.25	37.18	39.60	41.45	39.41	36.21	39.57	40.71	38.82
T_4 (WB)	36.27	39.00	41.91	39.06	35.06	39.78	42.39	39.08	35.67	39.39	42.15	39.07
T_5 (WB + OS)	33.47	31.65	37.67	34.26	32.79	33.80	38.31	34.97	33.13	32.72	37.99	34.61
T_6 (WB+SUL+OS)	35.62	33.16	38.77	35.85	35.03	35.40	38.89	36.44	35.33	34.28	38.83	36.14
T_7 (SB)	38.11	40.38	42.73	40.41	35.22	40.92	43.70	39.95	36.67	40.65	43.21	40.17
T_8 (SB + OS)	36.50	38.30	38.48	37.76	36.07	37.27	39.11	37.49	36.29	37.78	38.80	37.62
T_9 (SB+SUL+OS)	36.24	38.04	39.26	37.85	35.33	38.06	39.60	37.66	35.78	38.05	39.43	37.75
Mean	36.46	37.79	40.36	38.20	35.89	38.48	40.70	38.35	36.17	38.13	40.53	

UT= Untreated; OS= Osmosis, SUL= Sulphuring, WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.35	iv) Variety x Method	0.50
ii) Method	N.S.	v) Variety x treatment	0.56
iii) Treatment	0.56	vi) Method x treatment	0.80

with the dried fruits immediately after drying. Increase in reducing sugars had also been reported during storage by Rao and Roy (1980) in dehydrated mango pulp , Mehta et al. (1982) in pineapple rings, Vaghani and Chundawat (1986) in Sapota and Kumar (1989) in dates. This increase in reducing sugar content might be due to the hydrolysis of non reducing sugars, dissociation of polymers and interconversions of sugars during storage as reported earlier (loc. cit.2.1).

2.3 Total acids :

The data on total titrable acidity calculated in terms of citric acid were recorded and are presented in Tables 4 a and b.

It is clear from the results that all the processing treatments significantly reduce the total acidity of the fruits. The reduction in acidity was highest where the fruits were water blanched and osmosed (0.678 %). All the treatments where blanching was performed a significant reduction in total acids was observed and the osmotic treatment further reduced the acidity. Reduction in total acidity during osmosis had also been reported by many workers. Mehta and Tomar (1980) in guava slices and papaya pulp; Tomar and Gawar (1985) in muskmelon and Kumar (1989) in dates. This reduction in acidity might be due to leaching of acids during blanching and osmosis.

Among different varieties, irrespective of treatments, maximum acidity was observed in var. Umran (0.93 %) followed by var. Mudia Murhara (0.85 %) and Illaichi (0.68 %). The reason for maximum leaching of acids in var. Illaichi might be due to the small sized fruits which resulted into the contact of more surface area with the blanching

Table 4a: Effect of different treatments and drying methods on total acidity in dehydrated ber.

(g: citric acid/100 g.)

Treatments	Sun drying				Hot air oven drying				Overall mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	0.99	1.14	1.02	1.05	0.92	1.08	1.00	1.00	0.95	1.11	1.01	1.025
T_2 (OS)	0.58	0.87	0.94	0.80	0.62	0.89	0.94	0.82	0.60	0.88	0.94	0.807
T_3 (SUL+OS)	0.55	0.91	0.95	0.80	0.69	0.88	0.95	0.84	0.62	0.89	0.95	0.822
T_4 (WB)	0.69	0.80	0.94	0.81	0.67	0.79	0.93	0.80	0.68	0.79	0.93	0.803
T_5 (WB+OS)	0.51	0.71	0.85	0.69	0.48	0.67	0.85	0.67	0.49	0.69	0.85	0.678
T_6 (WB+SUL+OS)	0.54	0.76	0.88	0.73	0.56	0.73	0.86	0.72	0.55	0.75	0.87	0.722
T_7 (SB)	0.84	0.99	0.99	0.94	0.81	0.96	1.00	0.92	0.82	0.98	0.99	0.932
T_8 (SB + OS)	0.61	0.75	0.88	0.75	0.70	0.73	0.89	0.77	0.65	0.74	0.88	0.760
T_9 (SB+SUL+OS)	0.71	0.81	0.92	0.81	0.73	0.79	0.93	0.82	0.72	0.80	0.93	0.815
Mean	0.67	0.86	0.93	0.820	0.69	0.84	0.928	0.817	0.68	0.85	0.93	

UT= Untreated; OS = Osmosis; SUL= Sulphuring; WB = Water blanching; SB = Steam blanching

C.D. at 5%

i) Variety	0.01		iv) Variety x Method	0.01
ii) Method	N.S.		v) Variety x treatment	0.02
iii) Treatments	0.01		vi) Method x treatment	0.01

Table 4b : Effect of different treatments and drying methods on total acidity in stored (3 month) dehydrated ber.

(g. citric acid/100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	1.03	1.16	1.03	1.07	0.94	1.09	1.02	1.02	0.98	1.12	1.02	1.05
T_2 (OS)	0.59	0.89	0.97	0.82	0.62	0.92	0.96	0.83	0.60	0.90	0.96	0.83
T_3 (SUL+OS)	0.57	0.96	0.98	0.84	0.71	0.93	0.99	0.88	0.64	0.94	0.98	0.86
T_4 (WB)	0.70	0.82	0.96	0.83	0.68	0.80	0.94	0.81	0.69	0.81	0.95	0.82
T_5 (WB+OS)	0.53	0.72	0.87	0.71	0.50	0.70	0.86	0.69	0.51	0.71	0.86	0.70
T_6 (WB+SUL+OS)	0.57	0.81	0.93	0.77	0.59	0.77	0.89	0.75	0.58	0.79	0.91	0.76
T_7 (SB)	0.84	1.00	1.01	0.95	0.83	0.98	1.00	0.94	0.83	0.99	1.01	0.94
T_8 (SB + OS)	0.61	0.77	0.90	0.76	0.72	0.75	0.91	0.79	0.66	0.76	0.90	0.78
T_9 (SB+SUL+OS)	0.74	0.86	0.95	0.85	0.76	0.86	0.96	0.86	0.75	0.86	0.95	0.86
Mean	0.69	0.89	0.96	0.843	0.71	0.87	0.95	0.84	0.70	0.88	0.95	

UT= Untreated; OS= Osmosis; SUL= Sulphuring, WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.01	iv) Variety x Method	0.01
ii) Method	N.S.	v) Variety x treatment	0.02
iii) Treatments	0.01	vi) Method x treatment	0.01

medium and sugar syrup during osmosis. Methods of drying had no significant effect on total titrable acidity of the dehydrated fruits.

The data with respect to total titrable acidity after 3 month of storage, presented in Table 4b indicate an increase in total acidity in all treatments, varieties and in both the methods of drying. This increase in acidity might be due to the formation of acids in the product due to interconversion of sugars and other chemical reactions taking place in the product as reported by Clydesdale et al. (1972) and accelerated at high ambient temperature during storage (Rao and Roy, 1980). Increase in acidity in the dehydrated product had also been reported by Rao and Roy (1980) and Kumar (1989) in mango pulp and dates respectively.

2.4 Ascorbic acid (Vitamin C) :

Ascorbic acid content in dehydrated product was estimated after processing and after 3 months of storage and the data are presented in Table 5a and b.

It is evident from the data that the retention of ascorbic acid was higher in all the treatment as compared to the untreated fruits. The maximum (56.93 mg) retention was observed, where the fruits were dried after steam blanching + sulphuring + osmosis followed by water blancing + sulphuring + osmosis (55.49 mg). Higher retention of ascorbic acid was also noticed where the fruits were only blanched and osmosed. Mehta and Tomar (1980) also observed similar results in dehydrated guava slices when steeped in sugar syrup with and without sulphurdioxide. Dhawan (1980) also reported higher retention of ascorbic acid content due to the inactivation of enzymes and minimization of

Table 5a: Effect of different treatments and drying methods on the ascorbic acid content in dehydrated ber.

(mg/100 g.)

Treatments	Sun drying				Hot air oven drying				Overall mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	40.23	33.15	58.16	43.85	41.26	37.67	59.62	46.18	40.74	35.41	58.89	45.02
T_2 (OS)	46.26	35.45	55.39	45.70	47.20	43.13	65.99	52.11	46.72	39.29	60.69	48.90
T_3 (SUL+OS)	47.53	38.14	56.96	47.54	45.15	48.87	74.10	56.04	46.34	43.50	65.53	51.79
T_4 (WB)	38.33	47.82	56.85	47.66	53.60	41.83	75.72	57.05	45.96	44.82	66.28	52.36
T_5 (WB + OS)	39.16	54.35	63.31	52.27	54.32	44.51	74.75	57.86	46.74	49.43	69.03	55.07
T_6 (WB+SUL+OS)	43.49	58.50	50.88	50.96	54.65	50.84	74.56	60.01	49.07	54.67	62.72	55.49
T_7 (S.B.)	40.35	49.38	47.67	45.80	53.22	40.90	66.01	53.38	46.78	45.14	56.84	49.59
T_8 (SB+OS)	43.13	53.35	59.58	52.02	53.69	37.93	75.09	55.57	48.41	45.64	67.33	53.79
T_9 (SB+SUL+OS)	43.03	53.89	61.44	52.79	60.50	46.83	75.87	61.07	51.76	50.36	68.65	56.93
Mean	42.39	47.11	56.69	48.73	51.51	43.61	78.30	55.47	46.95	45.36	64.00	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; SB=Steam blanching

C.D. at 5%

i) Variety	0.86	iv) Variety x Method	1.21
ii) Method	0.70	v) Variety x treatment	2.10
iii) Treatments	1.21	vi) Method x treatment	1.71

Table 5b. Effect of different treatments and drying methods on the ascorbic acid in stored (3 month) dehydrated ber.

(mg./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	13.00	11.70	19.32	14.67	13.81	12.35	16.06	14.07	1341	12.02	17.69	14.37
T_2 (OS)	15.39	11.60	19.05	15.35	15.77	13.76	22.92	17.48	15.58	12.68	20.98	16.42
T_3 (SUL.+OS)	16.28	12.54	19.33	16.05	15.23	16.10	25.17	18.83	15.76	14.32	22.25	17.44
T_4 (WB)	12.61	16.11	20.23	16.32	17.22	12.10	25.24	18.19	14.91	14.10	22.73	17.25
T_5 (WB + OS)	13.33	18.92	21.70	17.98	18.18	14.50	24.75	19.14	15.76	16.71	23.22	18.56
T_6 (WB+SUL+OS)	14.77	19.92	17.35	17.35	18.19	16.88	25.67	20.25	16.48	18.40	21.51	18.80
T_7 (SB)	13.28	16.62	13.73	14.54	17.25	12.95	20.25	16.82	15.26	14.78	16.99	15.68
T_8 (SB + OS)	14.07	17.62	18.56	16.75	17.28	13.06	25.66	18.67	15.67	15.34	22.11	17.71
T_9 (SB+SUL+OS)	14.27	17.70	19.12	17.03	20.10	15.25	25.96	20.44	17.18	16.47	22.54	18.73
Mean	14.11	15.86	18.71	16.23	17.00	14.10	23.52	18.21	15.56	14.98	21.11	17.22

UT= Untreated; OS; Osmosis; SUL= Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.13	iv) Variety x Method	0.18
ii) Method	0.11	v) Variety x treatment	0.84
iii) Treatments	0.49	vi) Method x treatment	0.69

oxidative reactions in dehydrated ber when dried after sulphuring. A significant loss in ascorbic acid content was observed in all the treatments and under both the methods of drying as compared to the fresh fruits. Dhawan (1980) also observed the reduction in ascorbic acid content with the predrying treatments during processing.

Significant varietal difference were also observed with respect to ascorbic acid content, the maximum (64 mg) was observed in var. Umran and the minimum in var. Mudia Murhara (45.36 mg). Higher retention of ascorbic acid by var. Umran might be due to the high initial content of ascorbic acid. Stevens (1933) also reported loss of ascorbic acid under aerobic conditions.

Method of drying had also affected the ascorbic acid content of the dehydrated product. Oven dried ber retained significantly higher ascorbic acid content (55.47 mg) than thesundried (48.73 mg) ones. Higher ascorbic acid retention was also observed by Khurdiya (1980) in oven dried ber fruits.

The data presented in Table 5b revealed that the ascorbic acid content of dehydrated ber reduced further considerably when stored upto three months. The reduction was significantly higher in oven dried fruits than sundried, however higher retention of ascorbic acid was observed in oven dried fruits (18.21 mg) which was significantly higher than the sundried fruits (16.23 mg). The trend in reduction or retention of ascorbic acid content remained the same in all the treatments and varieties. The reduction in ascorbic acid might be due to the oxidation during storage at high ambient temperature. Rao and Roy (1980) had also observed complete loss of ascorbic acid content in dehydrated mango slices when stored for 3 months at 30 and 40°C.

2.5 Total Phenols :

Total phenols in the dehydrated fruits were estimated and the results are presented in Table 6a and b.

The data indicate that fruits which were subjected to the various treatments had less phenol content than untreated fruits. Among different treatments, fruits dehydrated after sulphuring and osmosis had the highest (758.61 mg) phenol content whereas water blanched, osmosed had the lowest (614.66 mg). In general, the blanched fruits resulted in lower phenols. These results are in accordance with the results obtained by Kumar (1989) in dates where he observed lower tannins in fruits which were either water blanced or steam blanched. He also recorded the minimum tannins in blanched osmosed dates. Highest phenol content in sulphured fruits may be the result of protective effect of sulphurdioxide on cinnamic acid and flavonols; and procynidins were also detected with addition of sulphurdioxide as reported by Wrolstad et al. (1989) in pear juice concentrates.

Among different varieties, maximum phenols (732.44 mg) were observed in var. Mudia-Murhara followed by var. Umran (688.63 mg) and Illaichi (643.85 mg). Higher phenol content in Mudia Murahara might be due to low dry matter to moisture ratio than var. Illaichi and because of high initial phenol content than var. Umran. Methods of drying had no significant effect on the total phenols of the dehydrated product.

Table 6a: Effect of different treatments and drying methods on the total phenol content in dehydrated ber.

(mg./100g.)

Treatments	Sun drying				Hor air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	840.67	864.67	744.00	816.44	734.33	778.67	724.67	745.89	787.50	821.67	734.33	781.16
T_2 (OS)	785.00	788.33	622.00	731.78	650.00	565.00	677.67	630.89	717.50	676.67	649.83	681.33
T_3 (SUL+OS)	802.67	831.67	753.67	796.00	607.67	863.33	692.67	721.22	705.17	847.50	723.17	758.61
T_4 (WB)	708.00	758.00	654.33	706.78	581.67	807.67	674.67	688.00	644.83	782.83	664.50	697.38
T_5 (WB+OS)	624.33	581.33	627.67	611.11	608.67	614.00	632.00	618.22	616.50	597.67	629.83	614.66
T_6 (WB+SUL+OS)	598.33	664.00	688.33	650.22	660.00	671.33	699.00	676.78	629.17	667.67	693.67	663.50
T_7 (SB)	555.67	767.67	742.00	688.44	567.33	796.00	746.67	703.33	561.50	781.83	744.33	695.88
T_8 (SB+ OS)	524.33	668.00	666.67	619.67	588.00	677.33	633.33	646.22	556.17	672.67	670.00	632.94
T_9 (SB+SUL+OS)	531.33	734.67	682.67	649.56	621.33	752.33	693.33	689.00	576.33	743.50	688.00	669.27
Mean	663.37	739.81	686.81	696.66	624.33	725.07	690.44	679.95	643.85	732.44	688.63	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; WB= Steam blanching

C.D. at 5%

i) Variety	65.02	iv) Variety x Method	91.96
ii) Method	N.S.	v) Variety x treatment	57.58
iii) Treatments	33.24	vi) Method x treatment	47.08

Table 6b: **Effect of different treatments and drying methods on the total phenol content in stored(3 month) dehydrated ber.**

(mg./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	933.67	953.00	823.67	903.44	883.00	843.67	868.00	864.89	908.33	898.33	845.83	884.16
T_2 (OS)	863.33	892.33	710.33	822.00	737.33	693.67	758.67	729.89	800.33	793.00	734.50	775.94
T_3 (SUL + OS)	969.33	971.00	975.67	972.00	761.33	981.00	964.67	902.33	865.33	976.00	970.17	937.16
T_4 (WB)	814.67	858.67	971.00	881.44	751.33	890.67	1010.67	884.22	783.00	874.67	990.83	882.83
T_5 (WB + OS)	781.33	746.33	848.67	792.11	687.67	735.33	862.00	761.67	634.50	740.83	855.33	776.88
T_6 (WB+SUL+OS)	715.67	841.67	921.00	826.11	787.67	861.33	949.00	866.00	751.67	851.50	935.00	846.05
T_7 (SB)	678.67	875.00	973.00	842.22	678.67	871.00	907.00	818.89	678.67	873.00	940.00	830.55
T_8 (SB + OS)	613.33	738.00	862.67	738.00	625.67	744.00	944.67	771.44	619.50	741.00	903.67	754.72
T_9 (SB+SUL+OS)	626.00	822.33	918.67	789.00	695.00	872.00	923.67	830.22	660.50	847.17	921.17	809.61
Mean	777.33	855.37	889.41	840.70	734.19	832.52	909.81	825.50	755.75	843.94	899.61	

UT= Untreated; OS= Osmosis; SUL= Sulphuring;WB = Water blanching; SB= Steam blanching

C.D. at 5 %

i) Variety	46.55	iv) Variety x Method	65.83
ii) Method	N.S.	v) Variety x treatment	53.56
iii)Treatments	30.93	vi) Method x treatment	43.73

The data presented in Table 6b indicate that druing storage an increase in total phenols in all treatments, varieties and in both the methods was observed. High ambient temperature prevailing during summer months might be responsible for increased phenol content. Srisuma et al. (1989) reported the increase in hydroxycinnamic acid (a phenol) content in navy beans when stored at 35°C. Wrolstad et al (1989) had also reported a considerable change in the phenolic profile of fruits juice concentrates during processing and storage. The trend with respect to total phenol content remained the same as it was after processing in all the treatments. However, during storage var. Umran showed higher phenol content (899.61 mg) than other varieties. Inadequate blanching as discussed under browning (Loc. cit. 4.3) might be the reason for increased enzyme activity during storage resulting into more conversion into phenols.

2.6 Minerals :

2.61 Calcium :

Calcium content in dehydrated fruits was estimated and the results are presented in Table 7a and b.

The data indicate that calcium content in different treatments differ significantly with untreated fruits. Water blanched, dried fruits had maximum calcium content (104.67 mg), whereas water blanched + osmosed had the minimum (89.67 mg) in all varieties and in both the methods of drying. Different varieties also showed significant differences in their calcium content. The maximum calcium content

Table 7a: Effect of different treatments and drying methods on the calcium content in dehydrated ber.

(mg./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	91.00	107.00	101.67	99.89	91.00	107.00	101.67	99.89	91.00	107.00	101.67	99.89
T_2 (OS)	89.33	101.67	100.00	97.00	89.33	101.67	100.00	97.00	89.33	101.67	100.00	97.00
T_3 (SUL+OS)	87.67	100.00	98.00	95.22	87.67	103.33	96.33	95.78	87.67	101.67	97.17	95.50
T_4 (WB)	98.33	108.67	105.33	104.11	101.67	107.00	107.00	105.22	100.00	107.83	106.17	104.67
T_5 (WB+OS)	84.33	96.33	92.67	91.11	82.67	89.33	92.67	88.22	83.50	92.83	92.67	89.67
T_6 (WB+SUL+OS)	87.67	101.67	98.00	95.78	87.67	101.67	88.00	95.78	87.67	101.67	98.00	95.78
T_7 (SB)	98.33	107.00	103.67	103.00	100.00	105.33	103.67	103.00	99.17	106.17	103.67	103.00
T_8 (SB + OS)	89.33	101.67	100.00	97.00	91.00	101.67	100.00	97.56	90.17	101.67	100.00	97.28
T_9 (SB+SUL+OS)	92.67	103.67	100.00	98.78	92.67	103.67	100.00	98.78	92.67	103.67	100.00	98.78
Mean	90.96	103.07	99.93	97.99	91.52	102.30	99.93	97.91	91.24	102.69	99.93	

UT= Untreated; OS= Osmosis; SUL= Sulphuring ; WB = Water blanching; SB=Steam blanching

C.D at 5%

i) Variety	1.15	iv) Variety x Method	1.63
ii) Method	N.S.	v) Variety x treatment	5.21
iii) Treatments	3.01	vi) Method x treatment	4.26

Table 7b : Effect of different treatments and drying methods on the calcium content in stored (3 month) dehydrated ber.

(mg./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	91.00	107.00	101.33	99.78	90.33	105.67	101.33	99.11	90.67	106.33	101.33	99.44
T_2 (OS)	87.00	101.33	99.33	95.89	88.67	101.33	99.33	96.44	87.83	101.33	99.33	96.17
T_3 (SUL+OS)	88.00	99.33	98.67	95.33	88.00	103.67	96.33	96.00	88.00	101.50	97.50	95.67
T_4 (WB)	98.67	110.33	104.67	104.56	101.33	107.33	107.00	105.22	100.00	108.83	105.88	104.89
T_5 (WB+OS)	83.67	96.33	93.00	91.00	83.00	89.67	93.00	88.56	83.33	93.00	93.00	89.78
T_6 (WB+SUL+OS)	88.00	101.33	98.67	96.00	88.00	101.33	98.67	96.00	88.00	101.33	98.67	96.00
T_7 (SB)	98.00	107.00	104.00	103.00	99.33	106.33	104.00	103.22	98.67	106.67	104.00	103.11
T_8 (SB+OS)	88.67	101.33	99.33	96.44	91.00	101.33	99.33	97.22	89.83	101.33	99.33	96.83
T_9 (SB+SUL+OS)	93.00	104.00	99.33	98.77	93.00	104.00	99.33	98.78	93.00	104.00	99.33	98.77
Mean	90.67	103.11	99.81	97.86	91.41	102.30	99.81	97.84	91.04	102.70	99.81	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB = Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	1.96	iv) Variety x Method	2.78
ii) Method	N.S.	v) Variety x treatment	4.49
iii) Treatments	2.59	vi? Method x treatment	3.67

was recorded in var. Mudia Murhara (102.69 mg) followed by var. Umran (99.93 mg) and Illaichi (91.24 mg). Method of drying did not show any significant effect on calcium content in the dehydrated product. The maximum calcium content was obtained in water blanched, dried fruits which indicated no loss of calcium during blanching. These results are in accordance with the results reported by Yamaguchi and Wu (1982) who observed that the water soluble components including minerals were lost during blanching of vegetables. Since calcium is in insoluble form under acidic pH range, therefore there was no loss of calcium. Minimum calcium content had been recorded in water blanced osmo-air dried fruits as a result of maximum product recovery due to the diffusion of sugars into the fruits during osmosis. Higher calcium content in var. Mudia Murhara might be due to low dry matter to moisture ratio than var. Illaichi and Umran.

The data regarding the calcium content during storage presented in Table 7b, revealed that storage had no significant effect on the calcium content of dehydrated product.

2.6.2 Iron :

Iron content in dehydrated fruits was estimated and the results are presented in Table 8 a and b.

The data showed significant differences in iron content among different treatments. Maximum iron content (4.44 mg) was noticed in steam blanched fruits, whereas it was minimum (3.87 mg) in water blanched + osmosed treatment. Var. Umran had significantly higher (4.52 mg) iron content followed by var. Mudia Murhara (4.28 mg)

Table 8a : Effect of different treatments and drying methods on the iron content in dehydrated ber.

(mg./100 g.)

Treatments	Sun drying				Hot air oven drying				Overall mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	3.85	4.60	4.68	4.38	3.86	4.60	4.76	4.41	3.85	4.60	4.72	4.39
T_2 (OS)	3.79	4.32	4.56	4.23	3.78	4.34	4.50	4.21	3.79	4.33	4.53	4.22
T_3 (SUL+ OS)	3.74	4.25	4.44	4.14	3.75	4.25	4.59	4.20	3.74	4.25	4.52	4.17
T_4 (WB)	3.99	4.44	4.76	4.40	3.96	4.56	4.78	4.43	3.97	4.50	4.77	4.42
T5 (WB+OS)	3.58	3.75	4.25	3.86	3.62	3.81	4.21	3.88	3.60	3.78	4.23	3.87
T_6 (WB+SUL+OS)	3.90	3.94	4.44	4.09	3.87	3.91	4.33	4.04	3.88	3.92	4.38	4.06
T_7 (SB)	3.95	4.61	4.80	4.46	3.97	4.54	4.77	4.43	3.96	4.58	4.78	4.44
T_8 (SB + OS)	3.75	4.21	4.32	4.09	3.72	4.23	4.41	4.12	3.73	4.22	4.36	4.11
T_9 (SB+SUL+OS)	3.82	4.37	4.43	4.21	3.83	4.33	4.43	4.20	3.83	4.35	4.43	4.20
Mean	3.82	4.28	4.52	4.21	3.82	4.29	4.53	4.21	3.82	4.28	4.52	

UT= Untreated; OS= Osmosis; SUL= Sulphuring, WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.01	iv) Variety x Method	0.02
ii) Method	N.S.	v) Variety x treatment	0.09
iii) Treatments	0.05	vi) Method x treatment	0.07

Table 8b: Effect of different treatments and drying methods on the iron content in stored (3 month) dehydrated ber.

(mg./100 g.)

Treatments	Sun dryinng				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	3.85	4.61	4.69	4.38	3.86	4.60	4.76	4.41	3.85	4.61	4.73	4.40
T_2 (OS)	3.79	4.34	4.56	4.23	3.78	4.34	4.50	4.21	3.79	4.34	4.53	4.22
T_3 (SUL+OS)	3.74	4.25	4.44	4.14	3.75	4.25	4.59	4.20	3.74	4.25	4.52	4.17
T_4 (WB)	3.99	4.45	4.75	4.40	3.96	4.56	4.78	4.44	3.98	4.51	4.77	4.42
T_5 (WB+OS)	3.58	3.75	4.26	3.87	3.62	3.82	4.21	3.88	3.60	3.79	4.24	3.88
t_6 (WB+SUL+OS)	3.90	3.95	4.38	4.08	3.87	3.91	4.34	4.04	3.83	3.93	4.37	4.07
T_7 (SB)	3.95	4.60	4.80	4.46	3.97	4.56	4.77	4.43	3.96	4.58	4.79	4.45
T_8 (SB + OS)	3.75	4.22	4.32	4.10	3.72	4.21	4.41	4.11	3.74	4.21	4.37	4.11
T_9 (SB+SUL+OS)	3.82	4.37	4.44	4.21	3.84	4.33	4.43	4.20	3.83	4.35	4.44	4.21
Mean	3.82	4.29	4.52	4.21	3.82	4.29	4.53	4.21	3.82	4.29	4.53	

UT= Untreated ; OS= Momosis; SUL= Sulphuring; WB= Water blanching; SB=Steam blanching

C.D. at 5%

i) Variety	0.05	iv) Variety x Method	0.07
ii) Method	N.S.	v) Variety x treatment	0.08
iii) Treatments	0.04	vi) Method x treatment	0.06

and Illaichi (3.82 mg). Different methods of drying did not show any significant differences. A significant difference in iron content of sulphured and unsulphured treatments was also observed. The iron content in blanched + sulphured + osmosed was more than blanched osmosed while lower iron content (4.17 mg) was noticed in untreated sulphured + osmosed fruit than untreated osmosed (4.22 mg).

Higher iron content obtained in steam blanched fruits than water blanched inspite of low recovery of the product indicated the loss of iron during water blanching. Minimum content was observed in water blanched osmosed treatment due to the leaching losses during blanching and osmosis. The maximum iron content in var. Umran might be due to the high initial iron content in fresh fruits and low dry matter to moisture ratio. These results are similar with the findings of Gorodnik (1969) who reported the loss of iron during water blanching of carrots.

Higher iron content in blanched + sulphured + osmosed treatments than blanched + osmosed indicated the protective effect of sulphuring on leaching losses of iron during osmosis. This protective effect of sulphuring might be due to the stiffening tissues which were disintegrated during blanching. Whereas in untreated sulphured + osmosed fruits lower iron content might be due to the disturbance in the peel and adjoining surface tissues during sulphuring treatments which may have resulted into enhanced leaching losses as compared to untreated osmosed fruits.

No significant changes in iron content were recorded during 3 months storage as shown in Table 8b.

3. Effect of drying techniques on time, rate of drying and product recovery :

Time, rate of drying and per cent recovery of the product, were affected by the osmotic treatments. The results obtained are presented and discussed as under.

3.1 Time and rate of drying :

The data regarding daily moisture loss for each variety were calculated in terms of Kg. of water lost per kg. dry matter are shown in bar diagrams (Fig. 2-4) and the data are given in Appendix I to III.

It is evident from the bar diagram (Fig. 2-4) that the loss in moisture, was faster in all the treatment than untreated fruits in each variety. Various varieties had shown different trend in moisture loss during osmosis treatment. The maximum loss in moisture (1.67 kg./kg. dry matter) was observed in steam blanched + sulphured + osmosed fruits during 24 hours in var. Illaichi, whereas in water blanched + osmosis treatment loss in moisture was found highest in var. Umran (1.54 kg) followed by Illaichi (1.48 kg) and Mudia-Murhara (1.18 kg.). Among osmosis treatments, the maximum per cent loss in moisture during first 24 hrs was observed in var. Illaichi ranging from 41.3 to 54.7 in sulphured +osmosis and steam blanched + sulphured + osmosis, respectively whereas the water blanched alone lost 48.5 % moisture. Variety Mudia Murhara lost the maximum 47.4 per cent and Umran 49.3 per cent moisture in 48 hours (2 days) osmotic treatment after water blanching. Sulphuring treatment had no additive effect on the loss in moisture. From the various treatments it was observed that unblanched sulphured fruits lost comparatively less moisture than blanched + sulphured fruits during osmosis.

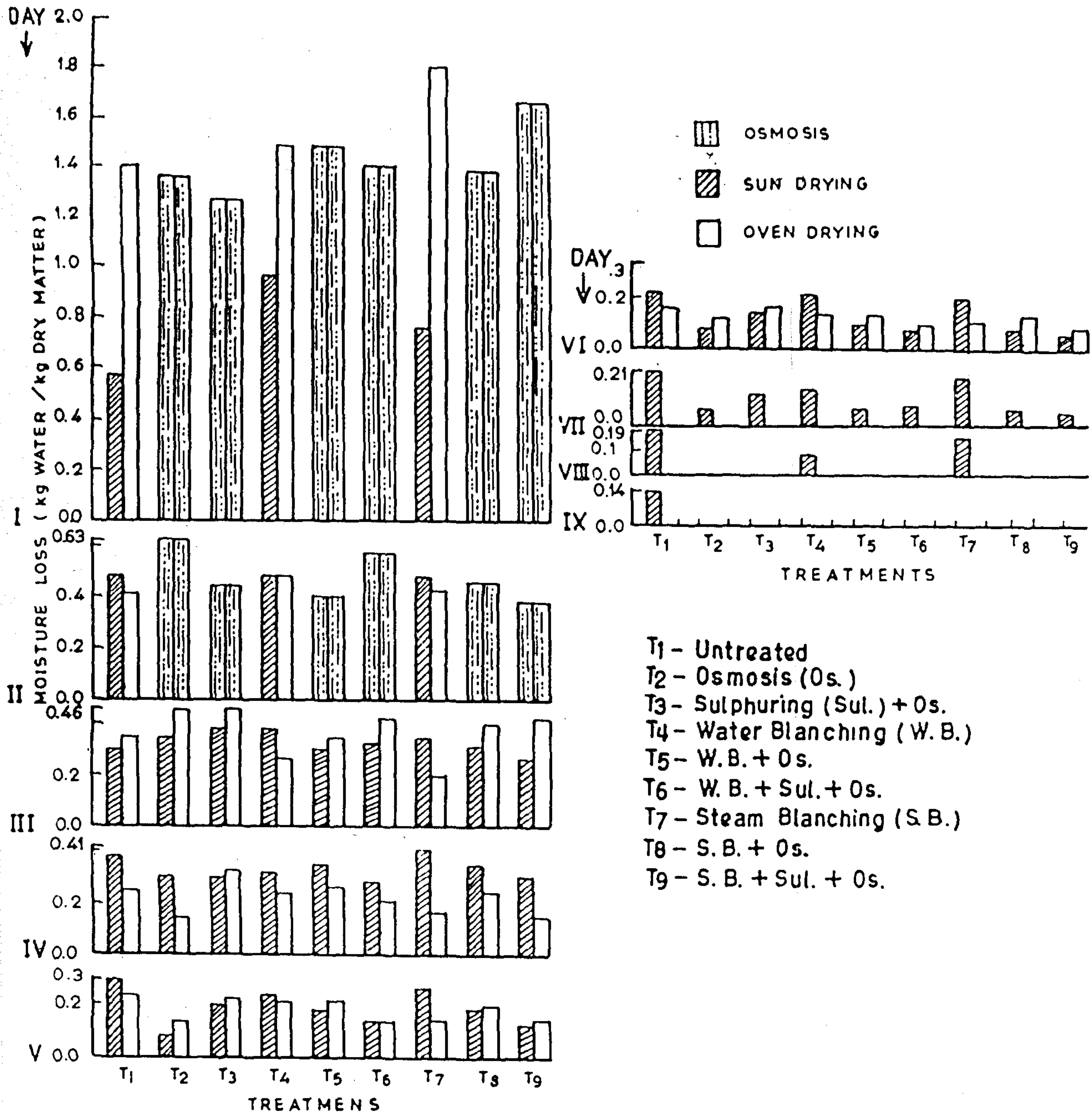

Fig. 2. DAILY MOISTURE LOSS (kg Water/ kg Dry matter) VARIETY ILLAICHI

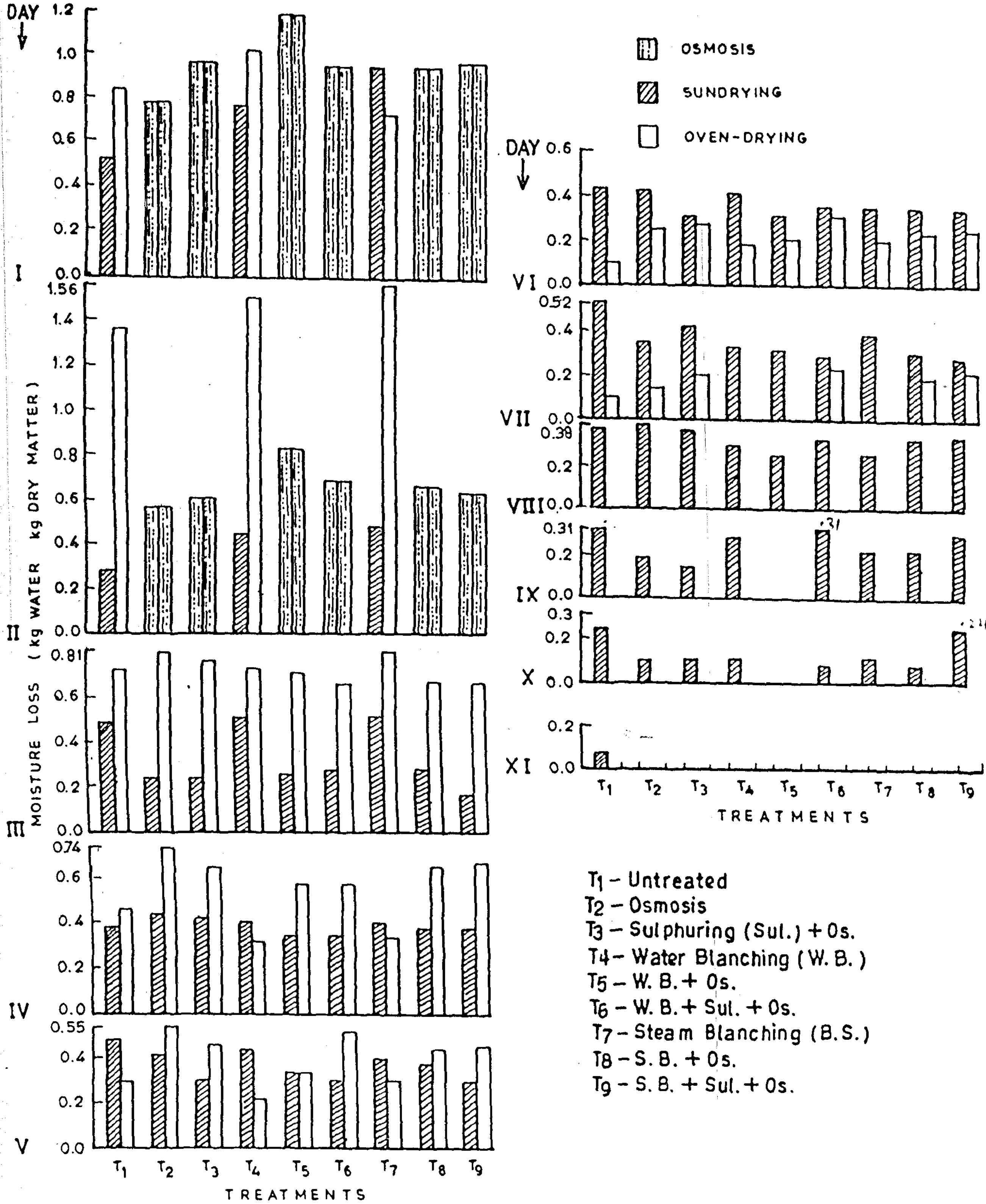

Fig. 3. DAILY MOISTURE LOSS (kg Water/ kg Dry matter)
VARIETY - MUDIA MURHARA

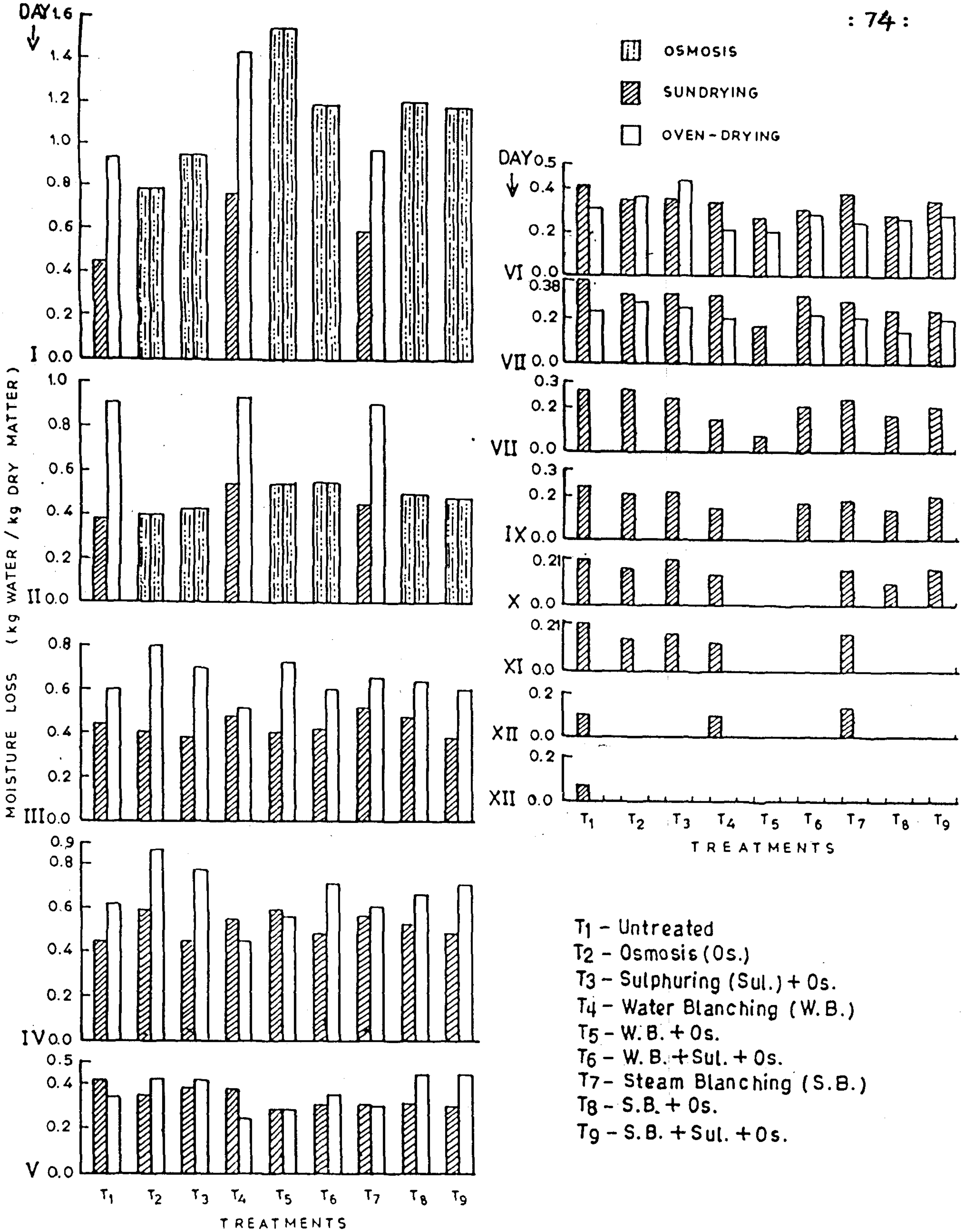

Fig. 4. DAILY MOISTURE LOSS (kg Water/kg Dry matter)
VARIETY-UMRAN

The data with respect to time (in days) taken for drying and average per cent moisture lost per day are presented in Table 9.

The data reveal that minimum time ranged from 6-8 days with highest rate of drying ranging from 11.30 to 15.70 per cent loss in moisture in the treatment where the fruits were water blanched and osmosed in both the methods of drying. Whereas, untreated fruits had taken maximum time ranging from 9-13 days with lowest drying rate from 7.4 to 15.4, per cent.

Among different varieties, var. Illaichi had taken minimum days for drying. It took 6 days in oven drying and 9 days in sundrying method followed by var. Mudia Murhara, six and 11 days and Umran, six and 13 days in oven and sundrying respectively.

From the results it was clearly indicated that osmo air drying took lesser drying time than without osmosis. These results are similar to the findings of Ponting _et al._ (1966) who reported that partial dehydration of fruits in sugar syrup took less period for drying. For partial dehydration of ber fruits, osmosis in 70° Brix sugar syrup for 24 hours at 50°C for var. Illaichi and 48 hrs osmosis for var. Mudia Murhara and Umran was found suitable to reduce the moisture content to about 50 per cent of the original.

The loss of moisture during oven drying followed by osmosis in var. Illaichi in treatments steam blanched alone and steam blanched sulphured respectively, was higher than the water blanched osmosed treatment. This might be due to over blanching effect, as the fruits were water blanched for five minute in boiling water. The over blanching might have caused the collapse of cellular structure of surface tissues,

Table 9: Effect of different treatments and drying methods on the time taken for drying and average moisture loss.

S.No.	Variety		Sundrying									Oven drying								
			T1	T2	T3	T4	T5	T6	T7	T8	T9	T1	T2	T3	T4	T5	T6	T7	T8	T9
1.	Illaichi	Time(days)	9	7	7	8	7	7	8	7	7	6	6	6	6	6	6	6	6	6
		Moisture loss/day (per cent)	10.1	13.4	13.3	11.6	13.6	13.4	11.6	13.4	13.4	15.4	15.7	15.7	15.6	15.7	15.6	15.6	15.6	15.6
2.	Mudia-Murhara	Time(days)	11	10	10	10	8	10	10	10	10	7	7	7	6	6	7	6	7	7
		Moisture loss/day (per cent)	8.8	9.2	9.2	9.5	11.3	9.2	9.6	9.2	9.3	13.2	12.9	13.3	15.7	15.2	13.4	15.6	12.9	13.2
3.	Umran	Time(days)	13	11	11	12	8	9	12	10	10	7	7	7	7	6	7	7	7	7
		Moisture-loss/day (per cent)	7.4	8.6	8.8	8.0	11.5	10.4	7.9	9.4	9.6	13.4	13.2	13.3	13.5	15.3	13.3	13.2	13.2	13.3

T1- Untreated
T2- Osmosis
T3- Sulphuring + Osmosis
T4- Water blanching (W.B.)
T5- W.B. + Osmosis
T6- W.B. +Sulphuring +Osmosis
T7- Steam blanching (SB)
T8- S.B. + Osmosis
T9- S.B.+ Sulphuring + Osmosis

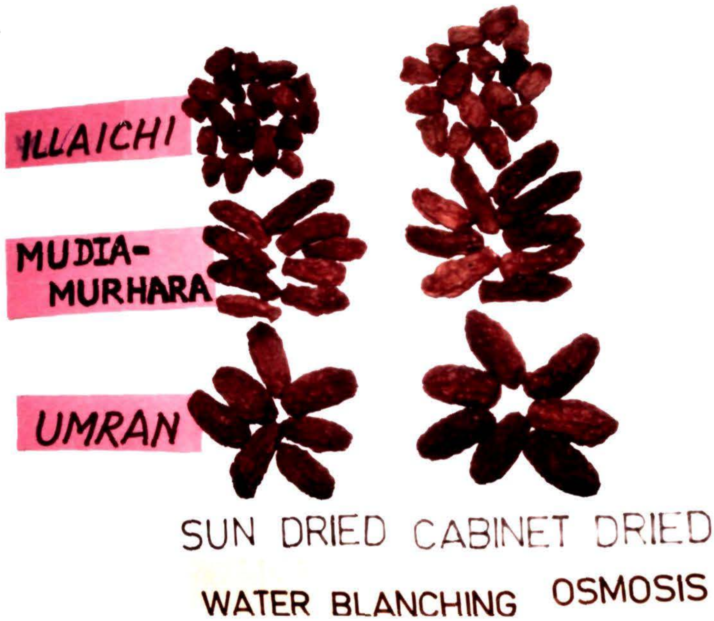

Plate 9 : Ber fruits dehydrated after water blanching and osmosis under sun and in cabinet dryer (Hot air oven).

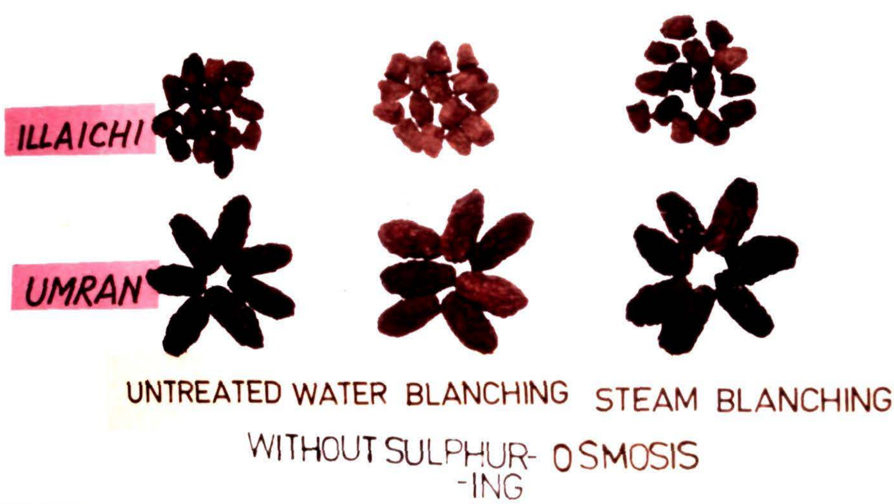

Plate 10: Ber fruits dehydrated as such and after water blanching and steam blanching(osmosed without sulphuring).

which affected the transfer of moisture from the internal tissues of the fruits to the surface tissues resulting in reduced moisture losses. This fact had been supported by the recommendation of two min. blanching time in boiling water for var. Illaichi by Khurdiya (1980).

The minimum time and maximum rate of drying had been recorded in var. Illaichi followed by var. Mudia Murhara and Umran. Less time and higher rate of drying were observed in oven drying than sundrying, however the differences were not too much in osmo air drying under sun and in oven when ber fruits were dried after water blanching and osmosis. Thus ber could be osmo-air dried in sun after water blanching and osmosis, in significantly lesser time than conventional sun drying and reasonably more time as compared to oven drying at the cost of energy which could be saved in sun drying. Khurdiya (1980) also reported minimum time of dehydration in var. Illaichi and maximum in var. Umran and further noticed that more time was required for sundrying of ber fruits.

3.2 Recovery of the product :

Per cent recovery of the dehydrated ber fruits was calculated and presented in Table 10.

From the data it was observed that water blanched, osmosed fruits had the highest per cent recovery (27.70 %) . The lowest recovery was recorded in fruits which were dehydrated after water blanching alone (24.08 %) followed by steam blanching alone (24.31 %) and were significantly less than untreated fruits in both the methods of drying.

Among different varieties, maximum recovery was obtained in var. Illaichi in water blanched osmosed fruits (31.02 %) which was

Table 10: Effect of different treatments and drying methods on the recovery of the dehydrated ber.

(per cent)

Treatments	Sun drying				Hot air oven drying				Over all Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	29.00	22.52	22.89	24.80	29.07	22.39	22.92	24.79	29.03	22.45	22.90	24.79
T_2 (OS)	29.22	23.62	23.34	25.39	29.34	23.31	23.62	25.42	29.28	23.46	23.48	25.40
T_3 (SUL+OS)	29.66	24.10	24.00	25.92	29.64	24.00	23.51	25.72	29.65	24.05	23.75	25.81
T_4 (WB)	28.00	21.87	22.24	24.04	28.07	22.04	22.30	24.14	28.03	21.96	22.27	24.08
T_5 (WB+OS)	31.00	27.34	25.00	27.78	31.05	27.00	24.83	27.63	31.02	27.17	24.92	27.70
T_6 (WB+SUL+OS)	28.65	25.97	24.00	26.21	29.03	25.69	24.28	26.33	28.84	25.83	24.14	26.26
T_7 (SB)	28.21	22.08	22.38	24.22	28.31	22.44	22.44	24.44	28.26	22.26	22.41	24.31
T_8 (SB + OS)	29.34	24.31	24.62	26.09	29.72	24.62	24.62	26.32	29.53	24.46	24.62	26.20
T_9 (SB+SUL+OS)	29.00	23.62	23.93	25.52	29.28	24.00	23.93	25.74	29.14	23.81	23.93	25.62
Mean	29.12	23.94	23.60	25.55	29.28	23.94	23.61	25.60	29.19	23.94	23.60	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB+ Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.16	iv) Variety x Method	0.23
ii) Method	N.S.	v) Variety x treatment	0.49
iii) Treatments	0.28	vi) Method x treatment	0.40

significantly higher than var. Mudia Murhara (27.17 %) and Umran (24.72 %). Different methods of drying had no significant effect on per cent recovery of the product.

Among different treatments, the highest per cent recovery in water blanched osmosed fruits was due to the diffusion of sugar in the fruits. Kim and Toledo (1989) also reported the diffusion of sugars in blue berries during osmotic dehydration. The minimum per cent recovery in blanched fruits indicated losses of dry matter during blanching. It is evident from the per cent recovery of the product that the dry matter lost in water blanching was more than in steam blanching. Feaster (1960) noticed similar results during blanching of vegetables. Shams and thompson (1987) also observed the loss of dry matter during blanching of peas.

The maximum recovery in var. Illaichi was due to the highest total soluble solids and minimum moisture content (Table 1), resulting in higher dry matter to moisture ratio in fresh fruits. Majority of the soluble solids were sugars and organic acids which might be least affected during dehydration process. Wrolstad et al. (1989) had also observed that the sugars and acids were relatively less affected during processing of fruit juice concentrates.

4. Organoleptic and keeping quality :

Organoleptic and keeping quality of dehydrated product was evaluated by judging the quality through organoleptic rating by a panel of judges rehydration ratio, browning and total sulphurdioxide content. The results obtained are discussed as under:

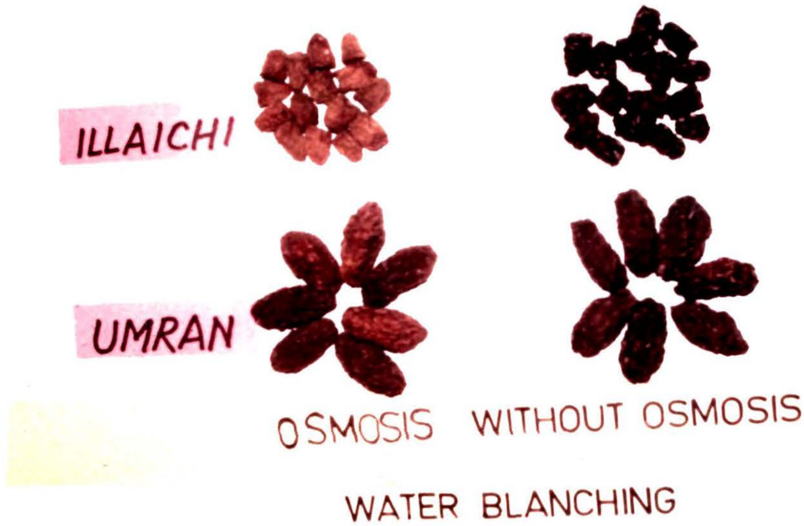

Plate 11: Water blanched fruits dehydrated with and without osmosis.

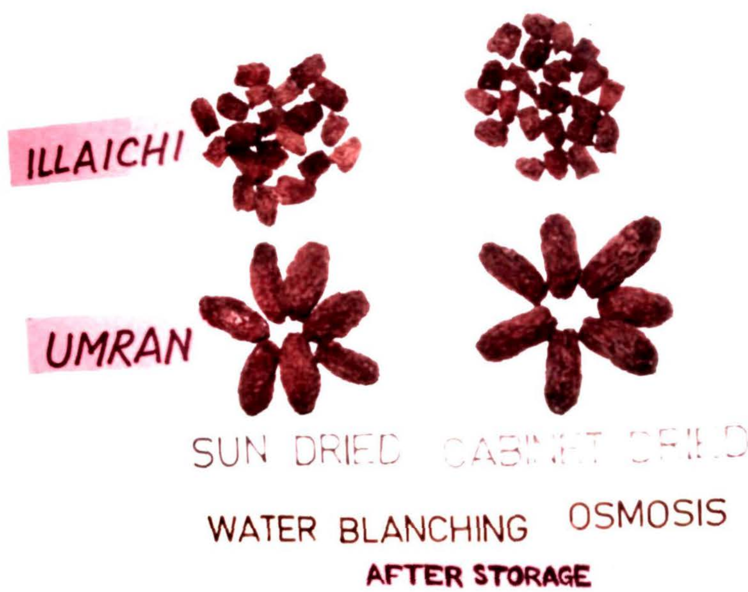

Plate 12 : Ber fruits dehydrated after water blanching and osmosis after 3 months of storage at ambient temperature.

4.1 Organoleptic Rating :

Organoleptic rating was done by a panel of judges following Hadonic rating scale (Appendix V) and the data thus obtained are presented in Table 11a and b.

The data indicate that highest scoring was obtained under water blanched + osmosed (8.08) treatment and the minimum (6.13) in untreated fruits. Var. Umran had maximum (7.95) scores followed by var. Illaichi (7.80) & Mudia-Murhara (6.02). Maximum scores (7.47) were recorded in oven dried than sun dried fruits (7.10). Among different treatments the maximum scores were obtained in water blanched+ osmosed and dried ber fruits as indicated by the excellent quality of the dehydrated product. Mehta and Tomar (1980) also reported that guava and papaya segments steeped (partially dehydrated) in 70^{o}B sugar syrup were alloted highest points. Among different varieties, var. Illaichi and Umran were found best and classified under the category liked moderately. Var. Mudia-Murhara had failed to achieve the requisite level of acceptance in any of the treatment. Failure of var. Mudia-Murhara in organoleptic rating test might be due to hard texture and breakage of stone in the mouth while eating the dehydrated fruit. Water blanched + osmosed and dried products of var. Illaichi and Umran scored 8.70 points each and were classified under the category liked very much. Although the oven dried product scored higher points yet both sun and oven dried fruits were placed under the same category i.e. liked moderately.

The data regarding organoleptic rating (Table 11b) after storage indicate a reduction in quality of the dehydrated fruits. The trend was

Table 11a: Effect of different treatments and drying methods on the organoleptic quality of dehydrated ber.

(Hedonic scale)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	6.80	4.20	6.90	5.96	7.20	4.40	7.30	6.30	7.00	4.30	7.10	6.13
T_2 (OS)	7.20	5.40	7.30	6.63	7.50	5.60	7.50	6.86	7.35	5.50	7.40	6.75
T_3 (SUL)	7.00	5.50	7.10	6.53	7.80	5.80	7.70	7.10	7.40	5.65	7.40	6.81
T_4 (WB)	7.20	6.30	7.10	6.86	7.60	6.40	7.90	7.30	7.40	6.35	7.50	7.08
T_5 (WB + OS)	8.60	6.80	8.60	8.00	8.80	6.90	8.80	8.16	8.70	6.85	8.70	8.08
T_6 (WB+SUL+OS)	7.80	6.40	8.10	7.43	8.30	6.80	8.50	7.86	8.05	6.60	8.30	7.64
T_7 (SB)	7.00	6.10	8.00	7.03	7.90	6.40	8.40	7.56	7.45	6.25	8.20	7.29
T_8 (SB + OS)	8.00	6.70	8.20	7.63	8.40	7.00	8.60	8.00	8.20	6.85	8.40	7.81
T_9 (SB+SUL+OS)	8.40	6.80	8.50	7.73	8.80	6.90	8.70	8.13	8.60	6.85	8.60	7.93
Mean	7.53	6.03	7.74	7.10	8.03	6.23	8.15	7.47	7.80	6.02	7.95	

UT= Untreated; OS= Osmosis, SUL= Sulphuring; WB= Water blanching; SB=Steam blanching

Table 11b: Effect of different treatments and drying methods on the organoleptic quality of stored (3 month) dehydrated ber .

(Hedonic scale)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	4.60	3.14	4.21	3.98	4.68	3.50	5.14	4.44	4.64	3.32	4.67	4.21
T_2 (OS)	6.07	4.60	5.96	5.54	6.21	4.93	6.18	5.77	6.14	4.76	6.07	5.65
T_3 (SUL+OS)	5.89	4.28	6.00	5.39	5.86	4.78	5.89	5.51	5.87	4.53	5.94	5.45
T_4 (WB)	6.78	5.07	6.57	6.14	6.75	5.28	6.60	6.21	6.76	5.17	6.58	6.17
T_5 (WB + OS)	8.10	6.21	8.07	7.46	8.18	6.07	8.11	7.45	8.14	6.14	8.09	7.45
T_6 (WB+SUL+OS)	7.18	5.68	6.75	6.53	7.43	5.82	7.10	6.78	7.50	5.75	6.92	6.65
T_7 (SB)	6.43	5.18	6.43	6.01	6.28	5.10	6.21	5.86	6.35	5.14	6.32	5.93
T_8 (SB+OS)	6.82	5.93	6.96	6.57	7.32	6.07	6.53	6.64	7.07	6.00	6.74	6.69
T_9 (SB+SUL+OS)	6.50	5.71	6.82	6.34	6.50	5.75	6.43	6.22	6.50	5.73	6.62	6.28
Mean	6.50	5.10	6.42	6.00	6.57	5.25	6.46	6.19	6.53	5.17	6.44	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; SB= Steam blanching almost similar in all the treatment and varieties under both the methods of drying. The fruits of var. Illaichi and Umran dehydrated after water blanching + osmosis still scored more than 8.00 scores and were placed under the category liked very much. Thus, the product remained excellent even after three month of storage. Dhawan (1980) also reported reduced organoleptic rating of dehydrated ber fruits. He also reported higher scoring by cabinet dried fruits.

4.2 Rehydration Ratio :

Rehydration ratio was calculated by taking weight of rehydrated product per unit weight of dehydrated fruits and the results are presented in table 12.

A persual of the data indicated significant differences in rehydration ratio under different treatments. Maximum (3.23) rehydration ratio was observed in water blanched + osmosed and dried fruits, whereas minimum (2.90) in sulphured + osmosed and dried fruits. Highest ratio was noticed in var. Umran (3.39) followed by var. Mudia Murhara (2.98) and Illaichi (2.91) . Rehydration ratio of sundried fruits was significantly higher than the oven dried fruits. Per cent regain in weight was calculated as 84.9, 80.0 and 71.3 % in var. Illaichi, Umran and Mudia Murhara respectively.

Jen (1989) had reported rehydration ratio as a measure to know the textural quality of dehydrated product. The dehydrated product having higher rehydration ratio will be having good texture also. Water blanched + osmosed and dried fruits showed maximum rehydration ratio. Mehta and Tomar (1980) in guava slices and Tomar and Gawar (1985) in muskmelon pieces, reported that the product dehydrated after steeping in sugar syrup

Table 12 : Effect of different treatments and drying methods on the rehydration ratio of the dehydrated ber.

Treatments	sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	2.90	3.10	3.40	3.13	3.00	3.10	3.40	3.17	2.95	3.10	3.40	3.15
T_2 (OS)	2.90	3.10	3.20	3.07	2.80	3.10	3.20	3.03	2.85	3.10	3.20	3.05
T_3 (SUL+OS)	2.60	3.00	3.10	2.90	2.60	3.00	3.10	2.90	2.60	3.00	3.10	2.90
T_4 (WB)	3.00	3.00	3.60	3.20	3.10	3.00	3.50	3.20	3.05	3.00	3.55	3.20
T_5 (WB+OS)	3.00	3.20	3.80	3.33	2.90	3.00	3.50	3.13	2.95	3.10	3.65	3.23
T_6 (WB+SUL+OS)	3.00	2.90	3.60	3.17	2.80	2.80	3.20	2.93	2.90	2.85	3.40	3.05
T_7 (SB)	3.00	2.90	3.40	3.10	2.90	2.90	3.30	3.03	2.95	2.90	3.35	3.07
T_8 (SB + OS)	2.90	3.00	3.60	3.17	3.00	2.90	3.40	3.10	2.95	2.95	3.50	3.13
T_9 (SB+SUL+OS)	3.00	2.80	3.50	3.10	2.90	2.80	3.20	2.97	2.95	2.80	3.35	3.03
Mean	2.92	3.00	3.47	3.13	2.89	2.96	3.31	3.05	2.91	2.98	3.39	

UT=Untreated; OS= Osmosis; SUL= Sulphuring ; WB= Water blanching; SB=Steam blanching

C.D. at 5%

i) Variety	0.06	iv) Variety x Method	0.08
ii) Method	0.05	v) Variety x treatment	0.19
iii) Treatments	0.11	vi) Method x treatment	0.16

showed less rehydration ratio. But Kim and Toledo (1987) observed soft and raisin like texture or osmo air dried blue berries at very low moisture content also.

Among different varieties, var. Umran had highest rehydration ratio due to the low dry matter to moisture ratio whereas var. Illaichi had the minimum rehydration ratio because of highest dry matter to moisture ratio and recovery of the product. These varieties also exhibited higher per cent regain in weight upon reconstitution. Thus, var. Illaichi and Umran might have good texture after dehydration whereas Mudia-Murhara exhibited lowest per cent regain in weight and showed poor texture after dehydration as evidenced by the results obtained in overall organoleptic rating (Table 11a and b) of the dehydrated fruits.Comparatively higher rehydration ratio had been obtained under sundried fruits. Khurdiya (1980) also reported similar results in sun dried ber fruits when dried at the ripe stage. He further reported higher reabsorption by var. Illaichi than Umran.

4.3 Browning :

Browning was judged by measuring as optical density (O.D.) at 420 nm expressed in terms of original material and the results are presented in Table 13a and b.

The data indicate that maximum O.D. was recorded in untreated fruits. Extent of browning was affected significantly under different treatments. the minimum browning (4.71) was observed in the treatments which were osmosed after blanching. Among different varieties the maximum browning (6.08) was noticed in var. Umran which was significantly higher than var. Mudia-Murhara (5.21) and Illaichi (5.03).

Table 13a: Effect of different treatments and drying methods on browning of dehydrated ber.

(O.D. at 420nmxdilution factor)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	8.50	4.50	8.00	7.00	7.50	3.75	7.50	6.25	8.00	4.13	7.75	6.63
T_2 (OS)	3.00	6.25	6.50	5.25	2.75	5.25	5.50	4.50	2.88	5.75	6.00	4.88
T_3 (SUL+OS)	3.50	6.75	7.25	5.83	2.75	6.00	7.50	5.42	3.13	6.38	7.38	5.63
T_4 (WB)	5.25	5.75	5.25	5.42	5.00	5.75	6.75	5.83	5.13	5.75	6.00	5.63
T_5 (WB+OS)	5.00	4.00	5.00	4.67	4.75	5.25	4.25	4.75	4.87	4.63	4.63	4.71
T_6 (WB+SUL+OS)	6.50	5.50	6.00	6.00	4.50	5.25	5.75	5.17	5.50	5.38	5.88	5.58
T_7 (SB)	4.75	5.75	6.25	5.58	4.25	5.00	6.00	5.08	4.50	5.38	6.13	5.33
T_8 (SB+OS)	4.50	3.75	5.50	4.58	5.25	4.50	4.75	4.83	4.88	4.13	5.13	4.71
T_9 (SB+SUL+OS)	6.50	4.50	6.00	5.67	6.25	6.25	5.75	6.08	6.38	5.38	5.88	5.88
Mean	5.28	5.19	6.19	5.56	4.78	5.22	5.97	5.32	5.03	5.21	6.08	

UT= Untreated; OS= Osmosis; SUL=Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	0.18	iv) Variety x Method	0.25
ii) Method	0.15	v) Variety x treatment	0.40
iii) treatments	0.23	vi) Method x treatment	0.32

Table 13b: Effect of different treatments and drying methods on browning of stored (3 month) dehydrated ber.

(O.D. at 420nm x dilution factor)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_1 (UT)	14.50	5.25	16.25	12.00	16.00	5.25	16.75	12.67	15.25	5.25	16.50	12.33
T_2 (OS)	6.50	11.50	12.75	10.25	7.00	12.00	9.75	9.58	6.75	11.75	11.25	9.92
T_3 (SUL+OS)	7.50	13.25	14.25	11.67	8.50	13.25	12.75	11.50	8.00	13.25	13.50	11.58
T_4 (WB)	8.75	14.50	11.50	11.58	13.50	14.00	12.25	13.25	11.13	14.25	11.88	12.42
T_5 (WB+OS)	10.50	10.00	10.25	10.25	11.50	9.50	10.75	10.58	11.00	9.75	10.50	10.42
T_6 (WB+SUL+OS)	12.50	14.50	12.50	13.17	9.25	10.75	13.75	11.08	10.87	12.62	12.88	12.13
T_7 (SB)	10.00	15.75	13.50	13.08	11.75	6.00	14.00	10.58	10.87	10.87	13.75	11.83
T_8 (SB+ OS)	10.50	7.00	11.25	9.58	10.50	11.25	11.50	11.08	10.50	9.13	11.37	10.33
T_9 (SB+SUL+OS)	13.25	9.50	13.00	11.92	12.75	13.50	12.25	12.83	13.00	11.50	12.62	12.38
Mean	10.44	11.25	12.81	11.50	11.19	10.61	12.58	11.46	10.82	10.93	12.69	

UT= Untreated; OS= Osmosis, SUL= Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5 %

i) Variety	0.34	iv) Variety x Method	0.49
ii) Method	N.S.	v) Variety x treatemt	1.29
iii) Treatments	0.74	vi) Method x treatment	1.05

Oven dried product shown significantly less browning than sundried product.

Untreated ber fruits dried either by sundrying or oven drying had the maximum browning. Dhawan (1980) also noticed more browning in untreated dehydrated ber fruits. Minimum browning recorded in osmo-air dried fruits might be due to the diffusion of sugar and replacement of reducing sugars with sucrose in the fruits especially in the surface tissues, which might have inhibited the Maillard reactions i.e. condensation of reducing sugars with amino acids. Maillard reactions are responsible for much of the darkening of fruit tissues as reported by Raynold (1965). Sulphured treatments also showed less browning than unsulphured ones and the results are similar to the findings of Vamos-Vigyazo (1981) and Sayavendra-soto and Montgomery (1986) who reported sulphurdioxide as a browning inhibitor.

The maximum browning in var. Umran might be due to the inadequate blanching of fruits because of the large sized fruit. Khurdiya (1980) suggested that in var. Umran water blanching should be done for 6 minutes. Sundried fruits recorded more browning than ovendried as shown in Plate 9 Dhawan (1980) also observed better colour of ber fruits dehydrated in hot air oven (cabinet dryer). The loss of bright colour in sundried fruits may be possible due to the photooxidation of carotenoids because of long exposure to light and oxygen as reported by Jen and Thomas (1978).

The data presented in Table 13b indicated an increase in browning in all the treatments and varieties under both methods of drying during storage. The increased browning might be due to the corresponding increase in phenol content during storage as discussed under phenols (loc. cit. 2.5). Besides this exhibition of wide range of residual activities by peroxidases, polyphenol oxidases and lipooxigenases even after blanching as reported by Halpain and Lee (1987) in green peas might be the reason for increased browning.

Different varieties showed similar trend in browning as exhibited after drying. No significant differences were observed in browning in the product dehydrated either by sundrying or oven drying after storage.

4.4 Total sulphurdioxide :

Total sulphurdioxide content was estimated in sulphured dehydrated fruits and the results are presented in Table 14a and b.

The results indicate significant differences in the retention of total sulphurdioxide in different treatments and varieties under both methods of drying. Among different treatments, water blanched + sulphured osmosed fruit retained maximum (238.20 ppm) sulphurdioxide followed by steam blanched + sulphured + osmosed (185.70 ppm) and sulphured + osmosed fruits (125.00 ppm). The highest (289.00 ppm) retention was noticed in var. Illaichi followed by var. Mudia Murhara (157.30 ppm) and Umran (102.60ppm) Oven dried fruits retained comparatively higher sulphurdioxide content (216.1 ppm) than sundried fruits (149.8 ppm).

Higher retention in blanched fruits might be due to the more absorption of sulphurdioxide by the fruits because of the softening of surface tissues during blanching. Var. Illaichi had also absorbed maximum sulphurdioxide due to the more surface area (being small sized fruit) available for absorption during sulphuring. Sundried fruits might have lost more sulphurdioxide because of the longer exposure to light and outer environment as reported by Bolin et al. (1964) in peaches.

Table 14a: Effect of different treatments and drying methods on the sulphurdioxide content in dehydrated ber.

(parts per million)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_3 (SUL+OS)	157.5	97.1	52.0	102.2	220.9	134.6	87.6	147.7	189.2	115.9	69.8	125.0
T_6 (WB+SUL+OS)	317.0	162.2	108.9	196.0	448.9	224.4	167.5	280.3	383.0	193.3	138.2	238.2
T_9 (SB+SUL+OS)	244.9	130.0	78.5	151.1	344.6	195.2	121.2	220.3	294.8	162.6	99.9	185.7
Mean	239.8	129.8	79.8	149.8	338.1	184.7	125.4	216.1	289.0	157.3	102.6	

UT= Untreated; OS=Osmosis; SUL= Sulphuring, WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	4.07	iv) Variety x Method	5.76
ii) Method	3.33	v) Variety x treatment	6.56
iii) Treatments	3.79	vi) Method x treatment	5.36

Table 14b: Effect of different treatments and drying methods on the total sulphur-dioxide content in stored (3 month) dehydrated ber.

(Parts per million)

Treatments	Sun drying				Hot air oven drying				Overall Mean			
	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean	Illaichi	Mudia-Murhara	Umran	Mean
T_3 (SUL+OS)	44.1	28.2	9.2	27.2	64.9	53.1	13.3	43.8	54.5	40.7	11.3	35.5
T_6(WB+SUL+OS)	94.7	64.5	36.0	65.1	125.7	79.3	53.7	86.2	110.2	71.9	44.9	75.6
T_9 (SB+SUL+OS)	64.7	51.9	28.9	48.5	102.7	64.6	32.8	66.7	83.7	58.9	30.9	57.6
Mean	67.9	48.2	24.7	46.9	97.8	65.7	33.3	65.6	82.8	57.0	29.0	

UT= Untreated; OS= Osmosis; SUL= Sulphuring; WB= Water blanching; SB= Steam blanching

C.D. at 5%

i) Variety	1.31	iv) Variety x Method	1.86
ii) Method	1.07	v) Variety x treatment	2.99
iii) Treatments	1.73	vi) Method x treatment	2.44

The data in Table 14b reveal that there was a considerable loss of sulphurdioxide when fruits were stored for three months. The trend in sulphurdioxide retention remained the same in all the treatments and varieties under both methods of drying. Khurdiya (1980) and Dhawan (1980) also reported similar results for different varieties and methods of drying. They had further reported the loss of sulphurdioxide during storage. But Dhawan (1980) did not find any effect of pretreatments on sulphurdioxide retention of ber fruits.

5. Microbiological Quality :

Microbiological examination of the dehydrated fruits was conducted after dehydration, after washing thedehydrated fruits under free flowing tap water and after three month storage in 400 gauge polythene bags at ambient temperature. The results are presented as total viable count per g. product in Table 15.

The data with respect to total viable count (TVC) reveal that total count were affected by the different treatments. Highest count (23×10^4) were observed in osmosed sundried Illaichi fruits. Higher total viable count was also observed in unsulphured fruits as compared to sulphured ones in each variety under both methods of drying. No definite trend was noticed in TVC in different varieties however var. Umran showed slightly lower counts than other varieties. It was also noticed that sundried fruits had high microbial count than oven dried fruits.

Presence of high counts in osmosed fruits of variety Illaichi might be due to the more surface area in var. Illaichi, easy availability of sugar

Table 15: Effect of different treatments and drying methods on the total viable counts in dehydrated ber.

(No. of colonies/g.)

	After Dehydration (unwashed)						After Dehydration(washed)						After three month storage(unwashed)					
	Sundried			Oven dried			Sundried			Oven dried			Sundried			Oven dried		
Variety	I	M	U	I	M	U	I	M	U	I	M	U	I	M	U	I	M	U
Treatments		$X10^3$			$X10^2$			$X10^2$			$X10^2$			$X10^3$			$X10^2$	
T_1 (UT)	38	44	33	2.3	2.1	2.3	30	17	8,8	1.8	1.7	1.9	$62x10^5$	81	33	$28x10^4$	$36x10^3$	$19x10^3$
T_2 (OS)	230	49	37	3.4	2.2	2.4	7.4	4.7	3.0	2.2	1.9	1.6	120	92	28	4.2	$11x10^3$	410
T_3 (SUL+OS)	28	26	28	2.0	1.7	1.7	5.5	3.7	2.7	1.8	2.0	2.0	110	97	8.1	34	20	48
T_4 (WB)	42	7.8	5.9	2.6	2.3	1.8	19	9.2	5.1	1.8	1.4	2.1	$45x10^3$	82	6.0	$44x10^2$	350	31
T_5 (WB+OS)	60	22	7.6	3.1	2.8	2.4	2.6	3.5	1.9	1.3	1.9	1.8	120	18	8.7	3.4	2.5	4.3
T_6 (WB+SUL+ OS)	6.9	5.8	4.0	1.8	1.4	1.2	3.1	2.8	1.5	0.8	1.6	1.7	7.2	5.2	3.0	37	1.7	42
T_7(S.B)	33	40	24	1.7	1.6	2.0	8.6	6.6	3.3	2.2	2.1	2.2	$34x10^2$	36	100	260	$11x10^2$	540
T_8(S.B.+OS)	21	43	29	2.6	2.5	2.5	3.4	3.1	2.3	2.0	2.1	2.1	19	240	21	52	28	330
T_9SB+SUL+	6.3	28	19	1.9	1.5	1.5	2.2	1.8	1.9	1.7	1.8	1.5	8.8	39	10	35	230	470

I- Illaichi; M- Mudia-Murhara; U- Umran ; UT- Untreated; OS- Osmosis;
SUL.- Sulphuring; W.B= Water blanching; S.B. - Steam blanching

(substrate) in surface tissues and its sticking effect and exposure to outer environment when fruits were dried in sun. Sulphured dehydrated fruits showed low T.V.C. possibly due to the antimicrobial activity of sulphurdioxide. Dhawan (1980) also reported low count in ber fruits which were dehydrated after sulphuring. He further noticed that sundried product had higher count than cabinet dried fruits.

The minimum counts in var. Umran might be because of the big fruit size , as less surface area was exposed to outer environment. Higher total viable count in sundried fruits were found due to the drying of fruits in open atmosphere, the fruits were contaminated by the dust, dirt and micro-organisms present in the atmosphere. But the total count was found to be within permissible limits (50-300)x 10^3 per g which has been fixed by American Public Health Association (Murphy, 1973).

A considerable reduction in total viable count was noticed in sundried fruits when examined after rinsing with water after drying. The reduction in count might be because of the removal of dust and dirt, and some of microorganisms present on the surface of the fruits. Thus thorough washing of sundried fruits after drying them to the desired moisture level and surface drying before its final packaging had been suggested.

Higher moisture content also affected the total viable count in dried product. Increased total viable count were observed in the dehydrated fruits with moisture content above 16 per cent (Appendix IV) during storage. It indicated that storability of the dehydrated product depends upon the moisture content in the product at the time of packaging. Total viable count in the products which were having moisture content above 17 per cent crossed the safe limits but no visible growth was observed upto 19.2 per cent moisture. These results were similar to the findings of Khurdiya (1980) for dehydrated ber fruits of var. Umran, he observed that the dehydrated fruits with 21.55 per cent equilibrium moisture had free surface water and became mouldy after 35 days of storage. It could be concluded from the results that the ber fruits should be dried below 16 per cent moisture for microbiologically safe storage of the product. Sundried or ovendried, product of all varieties dried after any of the treatments can be stored safely at moisture content around 15 per cent (i.e. ± 1 per cent).

Microscopic examination of the product indicated the presence of Yeasts and Molds. Among the molds Aspergillus and Penicillium spp. were predominant. Dhawan (1980) also reported the yeasts and molds as the contaminating organisms of dried ber. Kainsa (1978) reported Aspergillus Penicillium and some other molds as the surface microflora of fresh ber fruits. Aspergillus and Penicillium spp. were detected in dried ber fruits in this experiment. These results are similar to the findings of May and Kelly (1965) who recovered about 32 per cent of original flora in dried product. The organisms detected in dried ber fruits were same in all varieties and treatments dried by both method of drying irrespective of their number.

CHAPTER - V

SUMMARY AND CONCLUSION

The present investigations on dehydration of ber fruits were undertaken to standardize the dehydration techniques and to evaluate the nutritional, organoleptic and keeping quality during storage. The work was conducted during the year, 1991 in the Fruit Technology Laboratory of the Department of Horticulture, Haryana Agricultural University, Hisar. The results of the investigations are summarised below.

1. Fruits dried by osmo-air drying technique after water blanching took less time for drying with a maximum drying rate under both the drying methods.
2. Osmo-air drying under sun took comparatively more time than in oven drying, but sun drying is much economical because of the utilization of natural energy with minimum investment.
3. Variety Illaichi took minimum time for drying followed by var. Mudia Murhara and Umran.
4. Blanching facilitate transfer of moisture from the internal tissues of fruit to surface tissues and the fruit loose moisture at a faster rate in sugar syrup during osmosis and subsequently during sun drying and oven drying. Water blanching showed better results than steam

blanching though there were leaching losses of some soluble solids from the fruits.

6. The maximum recovery of the dehydrated product was obtained in var. Illaichi when the fruits were dried after water blanching and osmosis.

7. No significant changes in sugars, total acids, total phenols and minerals of the dehydrated fruits were noticed except in osmosis treated fruits, where the sugar was found to be diffused into the fruits resulting in an increase in sugar content and recovery of the product.

8. Losses of acids, phenols and iron due to leaching had been observed during osmotic dehydration of fruits.

9. A significant loss in ascorbic acid was observed during processing and storage. Higher retention of ascorbic acid was noticed in blanched+sulphured and osmosis treated fruits.

10. During storage for three months at ambient temperature a reduction in total sugars, ascorbic acid and sulphurdioxide and an increase in reducing sugars, acids and total phenols were observed. Browning was also found to be increased. However mineral contents remained unaffected.

11. Dehydrated product from var. Illaichi and Umran were liked very much during organoleptic rating whereas Mudia-Murhara had failed to achieve the minimum level of acceptability. Water blanched and osmo-air dried fruits of var. Illaichi and Umran scored maximum point and were excellent in quality.

12. Microbiological examination of the product revealed that yeasts and molds were predominant contaminating organisms of dried ber fruits.

Sundried product had comparatively higher total viable count but these were within permissible limits. After washing the sundried product there was a considerable decrease in total viable count, hence it is suggested to wash and surface dry the sundried product before final packaging. The product having moisture content more than 16 per cent was not found microbiologically safe.

Microscopic examination of molds confirmed the presence of Aspergillus and Penicillium spp.

CONCLUSION

From the studies on the evaluation of dehydration techniques for ber fruits it is concluded that var. Illaichi and Umran were found suitable for drying purpose. The fruits dried after water blanching and osmosis in 70^{o} Brix sugar syrup at $50^{o}C$ produced the excellent dehydrated product. Sundried and oven dried product has not much difference in their nutritional and organoleptic quality after storing for three months at ambient temperature. The fruits partially dehydrated by osmosis after water blanching took lesser time during sundrying and the product was comparable with the osmo-air drying in oven with the benefit of minimum energy utilization.

Dehydrated product should have moisture around 15 % for microbiologically safe storage. The sundried product should be washed and surface dried before packaging and storage.

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APPENDIX-I

Daily moisture loss during drying in var. Illaichi

(kg. water/kg. dry matter)

Day/ Treatment	Sun drying T1	T2	T3	T4	T5	T6	T7	T8	T9	Hot oven drying T1	T2	T3	T4	T5	T6	T7	T8	T9
1-	0.57	1.36	1.26	0.97	1.48	1.40	0.76	1.39	1.67	1.40	1.36	1.26	1.48	1.48	1.40	1.81	1.39	1.67
2-	0.48	0.63	0.44	0.49	0.41	0.57	0.48	0.47	0.38	0.41	0.63	0.44	0.49	0.41	0.57	0.43	0.47	0.38
3-	0.30	0.35	0.38	0.38	0.30	0.32	0.35	0.32	0.27	0.35	0.46	0.46	0.27	0.35	0.43	0.20	0.41	0.43
4-	0.38	0.30	0.30	0.32	0.35	0.27	0.41	0.35	0.30	0.25	0.16	0.32	0.24	0.27	0.21	0.16	0.25	0.14
5-	0.30	0.09	0.21	0.24	0.19	0.14	0.27	0.19	0.13	0.24	0.14	0.22	0.22	0.22	0.14	0.14	0.20	0.14
6-	0.23	0.08	0.14	0.22	0.10	0.08	0.21	0.08	0.06	0.17	0.12	0.17	0.14	0.14	0.10	0.11	0.14	0.10
7-	0.21	0.06	0.11	0.14	0.07	0.08	0.19	0.07	0.05	-	-	-	-	-	-	-	-	-
8-	0.19	-	-	0.08	-	-	0.16	-	-	-	-	-	-	-	-	-	-	-
9-	0.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

T1- Untreated
T4- Water blanching (W.B.)
T7= Steam blanching (S.B.)
T2- Osmosis
T5- W.B.+ Osmosis (OS)
T8- S.B. + Osmosis (OS)
T3- Sulphuring+Osmosis
T6- W.B.+Sulphuring + OS
T9- W.B.+Sulphuring +OS

APPENDIX-II

Table 3: Daily moisture loss during drying in var. Mudia-Murhara (kg. water/kg. Dry matter)

Day	Sun drying									Hot air oven drying								
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T1	T2	T3	T4	T5	T6	T7	T8	T9
1-	0.52	0.78	0.96	0,76	1.18	0.94	0.94	0.94	0.97	0.84	0.78	0.96	1.01	1.18	0.94	0.73	0.94	0.97
2-	0.28	0.57	0.61	0.45	0.82	0.69	0.48	0.66	0.63	1.36	0.57	0.61	1.50	0.82	0.69	1.56	0.66	0.63
3-	0.49	0.24	0.24	0.52	0.26	0.28	0.52	0.28	0.17	0.73	0.80	0.77	0.74	0.72	0.68	0.81	0.68	0.69
4-	0.38	0.45	0.42	0.41	0.35	0.35	0.41	0.38	0.38	0.46	0.74	0.65	0.32	0.59	0.58	0.34	0.66	0.68
5-	0.49	0.42	0.31	0.45	0.35	0.31	0.41	0.38	0.31	0.30	0.55	0.47	0.22	0.35	0.53	0.31	0.45	0.46
6-	0.42	0.42	0.31	0.41	0.31	0.35	0.35	0.35	0.35	0.10	0.24	0.27	0.18	0.20	0.31	0.20	0.24	0.25
7-	0.52	0.35	0.42	0.35	0.31	0.28	0.38	0.35	0.38	0.10	0.14	0.20	-	-	0.23	-	0.19	0.22
8-	0.35	0.38	0.35	0.28	0.24	0.31	0.24	0.31	0.32	-	-	-	-	-	-	-	-	-
9-	0.31	0.18	0.14	0.27	-	0.31	0.21	0.21	0.28	-	-	-	-	-	-	-	-	-
10-	0.24	0.10	0.10	0.10	-	0.07	0.10	0.07	0.24	-	-	-	-	-	-	-	-	-
11-	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

T1 - Untreated
T2- Osmosis (OS)
T3- Sulphuring (Sul.)+OS
T4- Water blanching (W.B.)
T5- W.B.+ OS
T6- W.B. +Sul. OS
T7- Steam blanching (S.B.)
T8- S.B.+OS
T9- S.B. + Sul. + OS

APPENDIX-III

Table 11: Daily Moisture loss during drying in var. Umran (kg water / kg. dry matter)

	Sun drying									Hot air oven drying								
Day	T1	T2	T3	T4	T5	T6	T7	T8	T9	T1	T2	T3	T4	T5	T6	T7	T8	T9
1-	0.45	0.78	0.95	0.76	1.54	1.18	0.59	1.20	1.18	0.93	0.78	0.95	1.42	1.54	1.18	0.97	1.20	1.18
2-	0.38	0.40	0.43	0.55	0.54	0.55	0.45	0.50	0.48	0.90	0.40	0.43	0.93	0.54	0.55	0.90	0.50	0.48
3-	0.45	0.41	0.38	0.48	0.41	0.42	0.52	0.48	0.38	0.61	0.80	0.70	0.52	0.73	0.61	0.66	0.65	0.61
4-	0.45	0.59	0.45	0.55	0.59	0.48	0.56	0.52	0.49	0.62	0.87	0.77	0.45	0.56	0.71	0.60	0.66	0.71
5-	0.42	0.35	0.38	0.38	0.28	0.31	0.31	0.31	0.31	0.35	0.42	0.41	0.24	0.28	0.35	0.30	0.45	0.45
6-	0.41	0.35	0.35	0.34	0.27	0.31	0.38	0.28	0.35	0.31	0.36	0.44	0.21	0.20	0.28	0.24	0.27	0.28
7-	0.38	0.31	0.31	0.31	0.17	0.31	0.28	0.24	0.24	0.23	0.27	0.25	0.20	-	0.22	0.21	0.15	0.20
8-	0.28	0.28	0.24	0.14	0.07	0.21	0.24	0.17	0.21	-	-	-	-	-	-	-	-	-
9-	0.24	0.21	0.21	0.14	-	0.17	0.18	0.14	0.20	-	-	-	-	-	-	-	-	-
10-	0.21	0.17	0.21	0.14	-	-	0.17	0.10	0.17	-	-	-	-	-	-	-	-	
11-	0.21	0.14	0.16	0.13	-	-	0.17	-	-	-	-	-	-	-	-	-	-	-
12-	0.10	-	-	0.10	-	-	0.14	-	-	-	-	-	-	-	-	-	-	-
13-	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

T1- Untreated
T2- Osmosis (OS)
T3 - Sulphuring +Osmosis (Sul.)
T4- Water blanching (W.B.)
T5- W.B.+OS
T6 - W.B.+Sul.+OS
T7- Steam blanching (S.B.)
T8- S.B. +OS
T9 -S.B.+Sul.+OS

APPENDIX- IV

Actual moisture available in different varieties of ber after drying (per cent)

Treatments / Varieties	Sundried			Hot air oven dried		
	Illaichi	Mudia-Murhara	Umran	Illaichi	Mudia-Murhara	Umran
T1 -(UT)	19.2	16.5	15.0	18.7	18.7	18.2
T2 -(UT + OS)	15.2	15.6	15.0	15.2	18.0	17.0
T3 -(UT + Sul + OS	17.2	15.9	15.5	15.4	16.2	16.4
T4 -(W.B.)	17.5	16.0	15.9	17.3	17.0	15.8
T5 -(W.B. + OS)	16.0	12.8	14.1	15.2	14.6	15.2
T6 -(W.B. +Sul.+ OS)	16.0	12.8	14.9	16.5	14.9	16.2
T7 -(S.B.)	17.3	13.7	15.6	16.8	16.7	16.8
T8 -(S.B. + OS)	15.2	15.7	14.6	15.9	15.8	16.2
T9 -(S.B. +Sul.+ OS)	15.6	15.8	15.2	16.0	16.0	16.4

UT= Untreated, OS- Osmosis, Sul- Sulphuring , W.B.- Water blanching, SB- Steam blanching

APPENDIX- V

Hedonic Rating Test

Name ____________________ Date ______________

Product ____________________

Taste these samples and check how much you like or dislike each one. Use the appropriate scale to show your attitude by assigning points that best describes your feeling about the sample. Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help us

Sr.No.	Colour	Flavour	Texture/Feel	Taste	Total	Remarks
1						
2						
3						
:						
:						
:						

Rating	Organoleptic score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1