STANDARDISATION OF DRYING TECHNIQUES IN FIG (*Ficus carica* L.) FRUITS

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By

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CERTIFICATE

This is to certify that the thesis entitled "**STANDARDISATION OF DRYING TECHNIQUES IN FIG (*Ficus carica* L.) FRUITS**" submitted by **INDUDHARA S.M.** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **POST-HARVEST TECHNOLOGY** of the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this university under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

I. INTRODUCTION

Fig (*Ficus carica* L.) belongs to the family Moraceae. Morphologically fruit is called as syconium, which is a vegetative fleshy tissue with tiny true fruits enclosed inside. Fig is an important fruit crop of sub-tropical countries and is native of Southern Arabia. Its mention has been made during 2900 BC by King Urukagina for its medicinal use. The main fig growing countries are Italy, Spain, Turkey, Greece, Portugal and Algeria. It is extensively grown in the States of California (USA) and Afghanistan. The total area under fig cultivation in India is about 1000 hectares (Singhal, 1995). In India, its cultivation is mainly confined to Maharashtra, Gujarat, Uttar Pradesh (Lucknow and Saharanpur), Karnataka (Srirangapatna, Bellary and Chitradurga) and Tamil Nadu (Coimbatore). In Karnataka, the area under fig is 284 hectares with a production of 917 tonnes (Anon., 2001). The important cultivars of fig grown in different parts of India are Pune, Conadria, Mission, Kodata, Bellary, BrownTurkey, Dinakar, Daulatabad.

The fresh fig is rich in calcium, iron, copper and vitamin A. The nutritive index of fig is as high as 11 as compared to 9 of apple, 8 of raisin and 6 of dates and pears (Chadha, 2001). Fig is valued for its laxative properties and used in the treatment of skin infection. The fruit helps to maintain acid alkali balance of the human body and also used as blood purifier. Latex is used to coagulate milk (Chadha, 2001).

The area under fig crop is increasing rapidly due to its wide range of adaptability, low production cost and high economic returns. However, post-harvest losses of fruit is one of the most pressing problems of the fruit industry especially in tropical countries like India. It is estimated that the total loss of fruit in India for want of adequate post-harvest care, transportation and storage facilities was around 20 to 30 per cent of the fruit production (Madan and Ullasa, 1993). In addition to the physical losses in quantity, serious losses also occur in the essential nutrients notably of vitamins, minerals and fruit quality. It has also been observed that when there is a bumper production of fig, the fruit goes as waste for want of suitable preservation facilities. To prevent all these losses, better utilisation of the fruit can be done through value addition.

Fig can be used as fresh, dried, preserved, canned or candied fruit. In Mediterranean region, it is used for production of wine, and in other European countries, for making a substitute for coffee, which is also called as fig coffee. The spiced or pickled figs, fig bread, fig meat, fig syrup, fig burfi, toffee, jam, jelly are also prepared from it in addition to drying and dehydration (Woodroof, 1975).

Fig marketing is problematic because of its highly perishable nature. Further, during glut periods, surplus as well as scared fruits, which consists of high sugar and better edible pulp, need to be utilised for processing into value added products based on available technology such as dehydrated fruit, fig burfi, fig meat, fig paste, etc. As many of these products are new to consumers, sincere efforts need to be made to introduce them in the market and to evaluate the consumer acceptance and economic viability of commercialisation of such products.

Pre-treatments are the necessary pre-requisites for successful dehydration process. Pre-treatments check the undesirable physico-chemical and other qualitative changes that may occur during the drying process. Various pre-treatments like sulphitation, sulphuring, blanching in hot water, steeping in sugar syrup, dipping in solutions of dip oil and potassium carbonate for specific period were followed. Generally, these pre-treatments vary with the nature of fruit.

Dehydration is a method of removal of moisture under carefully controlled conditions of air flow, temperature and relative humidity. There are different means and methods of drying and dehydration that are in vogue for different kinds of fruits and vegetables. Dehydrated fruits have longer shelf life and can be used in the off-season of the particular fruit. There is great demand for dehydrated fig in the market. Eventhough some of the dehydrated fruits such as raisins, dates, banana chips are popular and available in the market.

No sincere efforts have been made to standardise the drying technique of fig in India. At present, very small quantity of fig is being preserved by sun drying using crude methods at farm level resulting in contamination, discolouration and deterioration in quality of dried final fruit (Bhatia *et al.*, 1963). Therefore there is an urgent need to standardise the techniques for production of dehydrated fig fruits.

Though the fresh ripe fruits are very delicious, it is necessary to dry the fruits for improving the keeping quality because ripe fruits have very short shelf life. Dehydration of fig not only increases the benefit, which the farmer earns, but also helps in saving the foreign exchange. Therefore the present investigation was undertaken with the following objectives:

1. To standardise the pre-treatments.
2. To standardise the drying method.
3. To assess the quality of dehydrated fig fruits.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Fig is mainly grown for consumption of fresh fruit. Very little attention has been given for the development of processed products of fig. Few products of fig have been developed but the literature on this aspect is meagre. Little research work has been done on processing of dehydrated fig fruits. Hence, literature on the research work done on the dehydration pertaining to other fruits has also been reviewed hereunder:

PRESERVATION OF FRUITS BY DRYING AND DEHYDRATION

Drying / dehydration is most widely used method for preservation. It is usually accomplished by the removal of water from the fruits and vegetables containing 70 to 95 per cent water, which provides enough moisture to permit action by their own enzymes and microorganisms. Hence by removing water content below a certain level at which enzyme activity and growth of microorganisms is affected adversely. The fruits and vegetables can be preserved for fairly long time.

2.1 EFFECT OF PRE-TREATMENTS ON QUALITY OF DEHYDRATED PRODUCT

Pre-treatments are the necessary pre-requisites for successful dehydration process. Pre-treatments check the undesirable physico-chemical and other qualitative changes that may occur during the drying process. Various pre-treatments like sulphuring blanching in hot water, steeping in sugar syrup, sulphitation, dipping in solutions of dip oil and potassium carbonate for specific period were followed. Generally, these pre-treatments vary with nature of fruit. Use of solar drying with osmotic dehydration of fruits has proved very effective for preservation of fresh produce in various forms. The solar assisted osmotic dehydration lead to considerable amount of moisture removed in the initial stage with the help of an osmotic agent, which shortens the solar drying time. The process gave a product of very high nutritional and organoleptic quality (Sudheer and Dash, 1999).

2.1.1 Fig

Gandhi (1984) suggested that in order to have quality of dried produce, the fruits having more than 17 per cent TSS are desired.

Morris (1951) reported that calimyrna figs were dipped in solutions containing 10 lb of salt and 10 lb of slaked lime per 100 gallons of water to remove some of the hairs from the surface to improve the colour and soften the skin. He also reported that steam blanching hastens drying and increases the stability of the dried product. Other treatments he suggested were sulphuring which prevents or delays discolouration during and after drying.

Norman and Franklin (1969) stated that Adriatic and Kodata figs were sulphited lightly to hold the bright colour.

Laszlo and Luh (1975) reported that the Smyrna fig, a white variety is the principle variety grown in the Mediterranean countries for drying. The best way to dry figs is to allow them to dry partially on the tree and drop naturally to the ground. They can then be gathered and dried further on drying trays. Figs left to mature completely on the tree have high sugar content and quality that can never be obtained by drying firm ripe fruits.

Cheema *et al.* (1954) reported that, in Italy figs, they are split through length, dipped in boiling water for a moment and dried in the sun for two to three days after which they are again dried finally. In California, figs are fumigated before drying in the sun and before complete drying figs are pulled flat as evenly and as neatly as possible to economise packing space and to improve their appearance. Figs are then dipped in boiling brine (4 ounce of salt/gallon of water) for few seconds, which improved the texture and taste.

Thonta and Patil (1988) reported that, ethrel treated fruits required 30 hours of sun drying, while the untreated fruits required 35 hours of sun drying for achieving the same type of dried fruits. The kilogram water / kilogram fruit dry matter was also high in control treatment, thereby showing that ethrel treatment helped in loosing water from the fruits.

They also studied on improving the TSS of fruits by various means. They indicated that maximum TSS was in the fruits treated with pre-treatment of dry sugar (oven) followed by pricked as well as non-pricked fruits dipped in sugar solution subjected to oven-treatment (58±2°C) for two days. Minimum drying period was required in pricked and non-pricked fruits placed in sugar solution and kept in oven.

Pawar *et al.* (1992) tried different treatments, viz., sulphitation, blanching, blanching plus sulphitation, lye treatment and control on quality of solar dried figs. The total and reducing sugars were found higher in sulphited samples. Sulphitation helps in preventing fungal attack and to maintain the colour of the dried product. The drying rate studies showed almost similar pattern in all the treatments at initial stages of drying. However, control and blanched plus sulphited sample showed rapid rate of drying at final stages.

Giridharlal *et al.* (1998) reported that treating fig fruits in lime and salt (1 kg of each in 1000 litres of water) remove the hairs on the skin and soften the fruits.

Different pre-treatments were tried to improve the quality of dried Poona fig. Pre-treatments consisting of dipping fruit in solution (1.0%

salt + 1.0% calcium oxide), lye (0.6% NaOH) boiling for three minutes, SO_2 fumigation resulted in good quality product (Anon., 2002).

Gawade and Waskar (2002) reported that among varieties tried for dehydration, an attractive and firm dried figs could be prepared from the Deanna variety followed by Conadria. Moreover, the Deanna has maximum weight, high TSS and low acidity. They also reported that fig fruits pretreated with blanching plus sulphitation before drying had a beneficial effect on maintaining colour, flavour, texture for long period of storage.

2.1.2 Other fruits

Dixon and Jen (1977) studied the dehydration of apple by subjecting freshly sliced apple to osmotic dehydration and vacuum drying. The slices immersed in 70 per cent sucrose syrup at 50°C for one hour and subsequent vacuum drying at 92°C for four hours to a moisture content of 2.2 per cent produced a product with little browning. Slight reduction in total organic acid level had contributing to a three fold increase in the sugar to acid ratio.

Bongiwar and Sreenivasan (1977) described the method of partial dehydration of banana fruits by osmosis in sugar syrup of 70 per cent concentration. The fruit was reduced to about 50 per cent of its original weight by the process of osmosis, after which it was drained, washed and dried in a vacuum oven at 70 to 75°C under pressure of 29 in Hg for eight hours, which produced a superior quality product with good flavour, colour, appearance and texture attributes.

Khurdiya (1980) reported that ber having golden yellow to reddish brown colour were superior for drying. The optimum blanching time required varied with the varieties. Sulphuring at the rate of 150 g per eight kg of fruits, exposing three hours was considered optimum, but the rate of browning increased during storage for six months at room temperature.

Mehta and Tomar (1980) studied the dehydration of guava fruits and reported that slices dried by steeping in 70°B sugar syrup containing 1000 ppm SO_2 for eighteen hours and dried in an electric cabinet cross flow drier at 60°C for 6 to 10 hours gave the best product, which contained 65 per cent sugar, about 8.5 per cent moisture, the reconstitution ratio of 1 : 1.70 and the retention of ascorbic acid was only six per cent.

Kulkarni (1984) observed that sulphitation with one per cent potassium metabisulphite (KMS) for 20 minutes gave a better colour to raisins.

Vaghani and Chundawat (1986) studied the sun drying of sapota and reported that slices dried by steeping in 40 per cent sugar syrup containing one per cent potassium metabisulphite for 20 minutes gave most stable and quality product, which contained 48 to 52 per cent sugar and about 16 per cent moisture. The recovery of dried product was 30 to 40 per cent when dried for 33 hours. The organoleptic quality of these slices could be retained upto 11 months at ambient temperature.

Thimmareddy *et al.* (1988) conducted an experiment on effect of pre-treatments on grapes with different chemicals and concluded that the raisins obtained from berries pretreated with two per cent dip oil with 2.5 per cent K_2CO_3 were good with golden yellow colour and less sticky.

They also concluded that the number of days required for drying were only 19 in case of grapes treated with a mixture of dip oil and K_2CO_3 solution, while 26 days in case of boiling NaOH or K_2CO_3. Untreated grapes required 32 days to attain constant weight. The SO_2 absorption was more when the grapes were dipped in NaOH and dip oil with K_2CO_3. This was due to greater dissolution of wax by the chemicals. The greater amount of SO_2 absorption ensures greater keeping quality and development of attractive colour of raisins.

Chavan *et al.* (1992) observed that hot water blanching followed by sulphitation prior to drying, yielded acceptable ber powder which contained more total sugars (22.40%), reducing sugar (14.00%), non-reducing sugar (8.41%) and acidity (0.61%) than the original ber fruits (10.00, 4.60, 5.40 and 0.24%, respectively).

The effect of pre-treatments, viz., heat application, chemical dipping and sulphur fumigation during drying of apricots to prevent discolouration was investigated by Sharma *et al.* (1993). Maximum yield of dried apricots was recorded in control followed by steam blanching of fruits. Lye peeled apricots retained lower moisture than steam blanched fruits. Maximum and minimum brownings were observed in untreated samples and fruits subjected to sulphur fumigation, respectively.

Sagar and Khurdiya (1999) reported that mango slices heated for two minutes in an equal amount of 70°B sugar syrup in the pressure of 0.1 per cent KMS at 90°C further dried in an electric cabinet drier at 58±2°C gave the best dehydrated product, which had improved solid contents and chewing characteristics.

Fully matured banana slices of variety Basarai were treated with 0.25 per cent KMS, 0.5 to 1.0 per cent $CaCl_2$, 2 per cent NaCl, 0.1 per cent turmeric for 10 minutes and sugar syrup (50°B, 60°B, 70°B) for one hour before drying in a tray drier at 60°C. The quality of dehydrated banana slices treated with 0.25 per cent KMS + 0.5 per cent $CaCl_2$, 0.25 per cent KMS + 1 per cent $CaCl_2$ @ 60°B + 0.5 per cent $CaCl_2$ were found to be very good (Unde *et al.*, 2001).

The dehydration per cent of the ber slices was maximum (31.75%) in slices treated with blanching + slicing + steeping in 60°Brix syrup for 24 hours. The maximum levels of reducing and total sugars (9.50 and

17.02%, respectively) were recorded in the above treated fruits (Devaraju, 2001).

Patil (2001) reported that the maximum recovery of dehydrated slices (30.16%) and lowest dehydration ratio (3.28) were recorded in sapota slices exposed to sulphuring at 4 g per kg of slices for two hours, whereas minimum recovery was observed in steeping of sapota slices in 0.25 per cent KMS solution for 30 minutes (24.46%).

Lakkond (2002) observed that steeping of sapota slices in 50°Brix sugar syrup with 0.1 per cent KMS and 0.5 per cent citric acid for 12 hours before drying gave maximum recovery of sapota slices (32.02%), minimum dehydration ratio (3.18), lowest moisture content (13.66%) and highest total sugars (60.38%) as compared to other treatments.

The recovery of ber slices was maximum (27.60%) in slices steeped in 70°Brix sugar syrup with 0.5 per cent citric acid and 0.2 per cent KMS for 15 hours and with maximum level of reducing, non-reducing and total sugars (8.31%, 8.20% and 16.93%, respectively) (Nagaraju, 2002).

Kustagi (2002) reported that maximum recovery of dehydrated fruits (36.48%) and lowest dehydration ratio (2.75) were recorded in aonla fruits blanched for two minutes and steeping in 70°Brix sugar syrup containing 0.2 per cent KMS for 24 hours, whereas minimum (14.32%) recovery was observed in aonla fruits blanched for two minutes (control).

2.2 EFFECT OF DRYING METHODS ON QUALITY OF DEHYDRATED PRODUCT

There are several methods of dehydration employed for different kinds of fruits and vegetables such as sun drying, solar drying, air convection drying, drum drying and osmotic drying. In recent days, osmotic dehydration is becoming increasingly popular with various fruits. In this method, sugar acts as an osmotic agent to remove the moisture from the fruit tissues.

2.2.1 Sun drying

Bhatia *et al.* (1963) reported that at present, very small quantity of fig is being preserved by the sun drying using crude methods at farm level, resulting in contamination, discolouration and deterioration in quality dried final product.

Thonta and Patil (1988) reported that fig fruits required 35 hours of sun drying for achieving optimum moisture content, maximum drying ratio, reducing and total sugar content.

Very conspicuous differences were noticed in number of days needed for preparing raisins under different types of drying. A maximum number of 23 days were needed under sun drying to obtain better raisins (Thimmareddy *et al.*, 1988).

Pawar (1989) observed that fig varieties Daulatabad and Poona, which subjected to sun drying took 60 hours to reach a moisture content of 16 to 20 per cent, while the drying ratio was 4.25.

Bhardwaj and Lalkaushal (1990) studied the drying behaviour of apple rings. Sun drying retained moisture content, titrable acidity, reducing sugar and total sugar (16.10%, 2.70%, 53.90% and 69.90%, respectively) and it took 23 to 24 hours to sun dry the apple as compared to dehydration of apple rings took eight hours to reach a moisture content of 16.8 per cent when dried in a cabinet drier at a temperature of 60±2°C.

Sharma *et al.* (1993) studied the sun drying of apricot and reported that the recovery of dried product was 32.2 per cent when dried for 96 to 108 hours to achieve moisture content of 21.9 per cent. They also observed that the sun dried samples retained less sulphur dioxide than other drying methods but the rate of browning was maximum.

Monagheddu and Chessa (2002) reported that traditional drying of fig in open sun leads to mycotoxin contamination and should be replaced by the use of closed PVC tunnels in which the temperature should not exceed 60°C and the openings for ventilation must be protected with mesh to exclude insects.

2.2.2 Solar drying

Pawar (1989) reported that solar drying of fig was found superior among drying methods because of the temperature difference during day and night hours resulting into stage drying as well as dust proof condition.

Raghupathy *et al.* (1997) developed a solar drier for drying figs (Bellary variety) wherein the temperature inside the drier ranged between 42 to 75°C during different hours of the day. They reported that the solar drier took 42 hours for drying figs from an initial moisture content of 78 per cent to a final moisture content of 16 per cent, when compared to 60 hours in sun drying. The quality of solar dried figs were found superior to the sun dried samples.

El-Razik *et al.* (1997) reported that solar dried fig samples were dried 2.5 to 3.0 times faster than traditional sun dried samples with retention of maximum SO_2 (600 ppm). Solar dried samples had higher sugars than traditionally dried fruit with a drying ratio of 4.1:1 to 4.8:1.

Khurdiya and Roy (1986) developed a solar drier with chimney effect for solar drying of fruits and vegetables and found that the product dried in solar drier with chimney effect had better retension of sulphur dioxide and less changes in reducing and total sugars than other design and sun drying. Further, they reported that the drying rate of whole ber was faster in solar driers with plain glass. The moisture content of solar dried ber varied between 11.26 and 15.24 per cent with minimum retention of sulphur dioxide, higher reconstitution ratio (3.6) but non-enzymatic browning was maximum.

Chander *et al.* (1991) reported that *Punica granatum* seeds (Anardana) dried in solar cabinet drier at a shorter period than by open sun drying. Solar cabinet dried anardana scored highest score for colour, flavour and texture.

The quality of dried pomegranate seeds was superior when dried in solar drier as compared to conventional sun drying or hot air drying (Mahajan *et al.*, 1997).

The treated sapota fruits subjected for candy preparation were uniformly dried in solar cabinet drier for 11 to 14 hours to get moisture content of 2 to 3 per cent. The treated raw sapota fruits for preparation of sapota powder were also uniformly dried for 20 to 23 hours to get moisture content of 2 to 3 per cent. The temperature in the solar cabinet drier was maintained between 50°C and 60°C (Unde, 1998).

Unde *et al.* (1998) conducted a study on effect of method of drying on organoleptic properties and chemical composition of ber candy. The result showed that the candy dried by solar cabinet drier gave a better quality product.

Kannan and Susheela Thirumaran (2002) observed that the ber candy dried in solar drier to a moisture content of 17.5 to 18.5 per cent resulted in a better quality product with least changes in chemical composition. The drying temperature in solar drier varied from 38 to 65°C.

2.2.3 Electric drying

Thonta and Patil (1988) reported that TSS content in oven dried fig fruits treated with dry sugar and sugar solution were 46.00 and 44.00 per cent, respectively. Lowest TSS was recorded in dry sugar treatment and dried in open-condition.

Mali (1997) reported that the figs exhibited maximum total sugar content of 59.00 per cent when pre-treated with sulphitation and dried in drier at 60°C with dry sugar, while minimum total sugar content of 47.00 per cent was observed in figs which were blanched and dried under shade.

Khurdiya and Susanta (1974) found that drying guava fruit pieces for 18 hours at 60±5°C in a cross flow cabinet drier was satisfactory to obtain three per cent moisture level. However, Mehta and Tomar (1980) found that dehydration of guava slices in an electric cabinet cross flow drier for 6 to 10 hours at 60°C was satisfactory to obtain a moisture level of 8 to 18 per cent. The reconstitution ratio varied from 1 : 1.68 to 1 : 2.50.

Ambadan (1985) reported that drying the deseeded sapota halves in an electric drier, maintained initially at a temperature of 70°C and finally at 55°C took about four days to complete the drying. Oven operated only for eight hours a day. The yield of the dried product was 30 per cent and it had appealing chocolate brown colour, mild chikku flavour, sweet taste and appearance of dried figs.

Thimmareddy *et al.* (1988) reported that 32 and 23 days were needed for drying grapes under shade and the sun drying, respectively, while only 70 hours was required for preparing raisins if dried in the oven at 70°C initially and latter at 50°C till complete drying.

Dehydration of apricot in a cross flow drier at 50±2°C for about 36 hours to a moisture content of 17 to 20 per cent yielded 30 to 31 per cent dried product which had minimum non-enzymatic browning but retained more sulphur dioxide (Sharma *et al.*, 1993).

Naikar *et al.* (1995) developed a model for dehydration of strawberry by using osmodehydration technique. The process involved blanching, pricking, osmodehydration in a 60°B hypertonic solution (sugar and 0.1 per cent sodium benzoate) for six hours at 20±2°C temperature than dehydrating in a cabinet drier at 50±2°C for 24 hours resulted in excellent quality products.

Bhutani and Sharma (1996) reported that dehydration of apricots in the cross flow dehydrator were superior with respect to quality of the dried product than in the sun drying.

Agarwal *et al.* (1997) conducted a study on dehydration of ber cultivars for making chuhars. Fruits of four cultivars harvested at early ripe stage were dried in a mechanical drier at 65±2°C for 31 hours. The variety Sanaur-3 and Nalagarh were found to have maximum dried weight (26.00%) followed by Sanaur-2 (25.00%) after dehydration.

Papoff *et al.* (1998) reported that fig fruits, cv. Niedda Longa were dried using an industrial two-stage dehydration system, require no blanching treatment or a simulated sun drying procedure. During the industrial process, fruits initially moved for 3 hours in a tunnel with a gradient air temperature for 95°C to 85°C than moved into a second tunnel at 85°C for 14 hours. The results indicated that industrial dehydration gave good results.

Sagar *et al.* (1998) reported that mango slices loaded on aluminium trays (1.05 x 0.45 m) at the rate of 1.5 kg per square meter in a cabinet drier with cross flow of hot air at 1.20 to 1.80 m per second at a temperature of 58 to 60°C were dried to a moisture level of about 5 per cent without loosing their colour, flavour and texture.

The dehydrated mango slices had superior colour, flavour, texture and taste when the ripe mango slices were dried in a cross flow cabinet drier at 60°C for 4 to 7 hours to a moisture level of 11 to 14.45 per cent (Amitabh *et al.*, 2000).

Kannan and Susheela Thirumuran (2001) dried guava slices in a cabinet drier at 65 to 75°C for 8 hours to a moisture content of 10 to 11 per cent and they observed that chemical constituents like moisture, acidity and reducing sugar content were found to increase and pH, total sugar, vitamin C content were found to decrease when stored for 6 months.

Nagaraju (2002) reported that time taken for drying of ber slices was minimum in electric drying (21.96 hours) as compared to sun drying (31.80 hours) and solar drying (22.80 hours). Rehydration ratio was found maximum in electrically dried samples (3.25%) as compared to sun dried samples (2.95%).

Time taken for drying of sapota slices was found minimum in electric drier (25.20 hours) and in solar drier (27.57 hours) as compared to sun drying (Lakkond, 2002).

Aonla fruits dried under solar drier had showed maximum recovery of 29.30 per cent when compared to sun dried fruits (28.70%), but time taken for drying was found minimum in electric drying (14.33 hours) compared to sun drying (20.33 hours) and solar drying (16.78 hours) (Kustagi, 2002).

2.3 ORGANOLEPTIC EVALUATION OF DEHYDRATED PRODUCTS

Thonta and Patil (1988) reported that the organoleptic evaluation of fruits treated with different treatments indicated that fruits in dry sugar and subjected to oven treatments followed by pricked fruits and non-pricked fruits in sugar solution and placed in oven gave quality dry fig fruits, which were comparable to excellent grade dry fig fruits from market.

Mohammad *et al.* (1988) reported that radiation treatment (0.25 KGy) in combination with low temperature (10-20°C) checked infestation for one year and resulted in a better product than any other treatment tested. Storage of figs in coloured polyethylene protected their colour and ascorbic acid more than clear polyethylene during one year storage.

Jacob (1944) reported that raisins obtained by pre-treatment with dip oil and K_2CO_3 solution were good and non-sticky. Dip oil with K_2CO_3 solution treatment followed by sulphuring destroyed the colour development, while dipping in NaOH solution improved the colour.

Teotia *et al.* (1976) studied the dehydration of mango slices steeping in 40°B in presence of 3000 ppm SO_2 + 0.2 per cent ascorbic acid and one per cent citric acid for 18 hours and dehydrated in an electric cabinet drier for 8 to 12 hours at 60°C gave the best product with highest scores for colour, flavour and texture.

Mehta and Tomar (1980) found that dehydration of ripe papaya slices after steeping in 70°B syrup containing 1000 ppm SO_2 gve the best product and maximum scores for overall acceptability.

Vaghani and Chundawat (1986) reported that osmotically dehydrated sapota slices were organoleptically superior to other methods of drying. The organoleptic qualities of these slices could be retained for 9 to 11 months, texture upto 11 months and taste upto 9 months at ambient temperature.

Nandini Sonde (1989) reported that the bulbs of jack fruit dehydrated at 60°C in hot air oven scored best for its appearance, texture, flavour, taste and overall acceptability upto 9 months of storage.

Kattimani (1993) reported that the organoleptic evaluation of different pre-treatments recorded maximum scores, when berries treated with boiling NaOH with sulphuring followed by a mixture of dip oil and K_2CO_3.

Naikar *et al.* (1995) reported that the quality of osmo-dehydrated strawberry was significantly superior with respect to colour, taste, flavour, appearance and overall acceptability when evaluated as fresh and after three months of storage.

The investigation on osmotic dehydration of papaya by Jasimahmed and Choudhary (1995) revealed that the osmotically dehydrated papaya slices had good colour, flavour and texture and could be used as snack food when packed in high density polyethylene pouch. These slices remained acceptable upto six months at room temperature.

Organoleptic evaluation of rehydrated ber slices revealed that overall acceptability was found maximum (2.81) in case of ber slices steeped in 50°Brix syrup with 0.5 per cent citric acid and 0.2 per cent KMS for 15 hours before drying (Nagaraju, 2002).

Kustagi (2002) revealed that, blanching of aonla fruits for two minutes and steeping aonla fruits in 50°Brix sugar syrup containing 0.2 per cent KMS for 24 hours recorded highest organoleptic scores for colour and appearance (3.75), texture (3.34), taste (3.71) and overall acceptability (3.64) when compared to other treatments.

Maximum scores for colour and appearance (4.03), taste (3.64), texture (4.00) and overall acceptability (3.39) of dehydrated sapota slices was found in the treatment of steeping sapota slices in 50°Brix sugar syrup with 0.1 per cent KMS and 0.5 per cent citric acid for 12 hours before drying (Lakkond, 2002).

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The investigation on 'Standardisation of drying techniques in fig fruits' was carried out in the Department of Post-harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, district Belgaum, Karnataka during the year 2002-2003. The materials used and the methods followed are described in this chapter.

3.1 GEOGRAPHICAL LOCATION AND CLIMATE

Arabhavi is situated in Northern dry zone (Zone-3) of Karnataka. It lies at 60°12' North latitude and 75°45' East longitude at an altitude of 640 m from mean sea level. The average annual rainfall at Arabhavi is about 530 mm and it is distributed over a period of seven months from May to November. The mean maximum temperature goes upto 36.40°C (May) and mean minimum temperature drops down to 13.40°C (February). The relative humidity varies between 57.6 per cent (April) and 81.4 per cent (December). The data on temperature and relative humidity recorded during the period of investigation are given in Appendix-I.

3.2 MATERIAL

Fig fruits, cv. Bellary were procured from Hiriyur fruit market of Chitradurga district. Fruits of uniform size, shape and maturity were selected and carefully packed in CFB boxes of one kg capacity, having holes for ventilation with paper straw as cushioning material and brought to Arabhavi campus immediately for further experimentation.

3.3 EXPERIMENT DETAILS

3.3.1 Experiment-I

STANDARDISATION OF PRE-TREATMENTS

The design of the experiment was Factorial Completely Randomised Design (CRD) with three replications. There were 10 treatments and two stages of storage. The details of treatments are as follows.

Factor-I: Treatments

T_1 : Control (No pre-treatment)

T_2 : Blanching fruits in boiling water for two minutes + dipping in 2% KMS solution for 30 minutes

T_3 : Blanching fruits in boiling water for four minutes + dipping in 2% KMS solution for 30 minutes

T_4 : Steeping in 60°Brix sugar syrup for 24 hours

T_5 : Dipping fruits in solution of 1% dip oil + 1% K_2CO_3 for 3 minutes

T_6 : Dipping fruits in solution of 1% dip oil + 1.5% K_2CO_3 for 3 minutes

T_7 : Dipping fruits in solution of 1.5% dip oil + 1% K_2CO_3 for 3 minutes

T_8 : Dipping fruits in solution of 1.5% dip oil + 1.5% K_2CO_3 for 3 minutes

T_9 : Dipping fruits in solution of 2.0% dip oil + 1% K_2CO_3 for 3 minutes

T_{10} : Dipping fruits in solution of 2.0% dip oil + 1.5% K_2CO_3 for 3 minutes

Factor II: Storage period

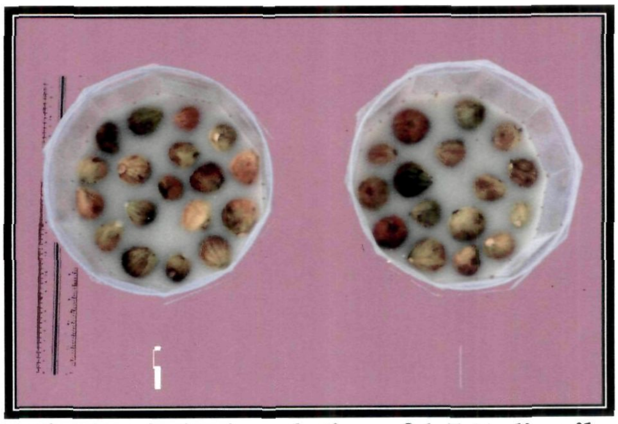
S_1 : Initial

S_2 : Four months after storage (4 MAS)

Fruits of uniform colour, size and shape were selected. Diseased and damaged ones were discarded. Fruits were washed in clean potable water. One kilogram fruits were taken for each treatment/replication. The fig fruits were further treated with blanching water, potassium metabisulphite, sugar syrup and dip oil (a commercial drying liquid containing 57% ethyl oleate) plus potassium carbonate solution as mentioned in treatment details (3.3.1) (Plates 1 and 2).

Immediately after treating the fruits as mentioned above, they were placed in a single layer on aluminium trays. The loaded trays were placed in electric cabinet drier for drying. A temperature of 60°C was maintained during first 20 hours and the finish drying was done at a temperature of 55°C. The drying was continued till a constant weight was obtained.

Blanching for 4 min + Dipping in 2% KMS solution for 30 min



Dipping fruits in solution of 1.5 % dip oil + 1.0 % K_2Co_3

Plate 1: **Pretreatment to fig fruits**

Plate 2: **Treated fig fruits for drying**

3.3.2 EXPERIMENT-II

STANDARDISATION OF DRYING METHOD

Based on the results of the experiment-1, the best two prê-treatments were selected and repeated with three methods of drying. The design adopted in the experiment was Factorial Completely Randomised design with three replications. There were three treatments as factor I, three methods of drying as factor II and two stages of storage as factor III. The details of the treatments are as follows:

Factor-I: Treatments

T_1 : Control (No treatment)

T_2 : Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 : Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

Factor-II: Methods of drying

D_1 : Sun drying

D_2 : Solar drying

D_3 : Electric drying

Factor-III: Storage period

S_1 : Initial

S_2 : Four months after storage (4 MAS)

Plate 3: **Drying of fig fruits in solar drier**

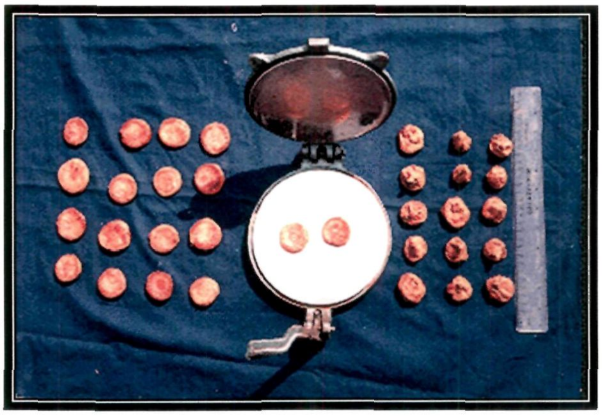


Plate 4: **Pressing of partially dried fig fruits**

The pre-treatments were given to the fruits (as described in 3.3.2) and were kept in trays for drying in sun, solar cabinet drier (Plate-3) and electric drier as given in the treatment details. The temperature of electric cabinet drier was maintained at 60±2°C and finish drying was done at 55°C. The temperature within the solar drier varied between 50 and 55°C. The maximum temperature of atmosphere during the period of drying ranged between 25 and 38°C. Half dried fruits, i.e., when about 50 to 60 per cent moisture was removed from the fruits during the process of drying, were taken out and pressed carefully using papad pressing equipment. The stage for pressing of fruits was carefully selected so that the pressed fruits neither showed oozing (higher moisture) nor cracking (lower moisture) (Plate-4).

3.4 OBSERVATIONS RECORDED

The following physico-chemical parameters were recorded immediately after preparation and organoleptic evaluation of dehydrated fruits was done.

3.4.1 Physico-chemical parameters

The physico-chemical parameters of fresh fruits were recorded and given in Appendix-II.

3.4.2 Moisture content

Moisture content of fresh fruits was determined by AOAC method (AOAC, 1975). Weighed samples were dried in electric drier upto a constant weight and from the loss in weight, the moisture content was calculated by the formula:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

3.4.3 Total soluble solids

The total soluble solids (TSS) of fresh fig pulp was measured by using an 'Erma' make hand refractometer and expressed as percentage after necessary corrections.

3.4.4 Dehydration ratio

It is the ratio of weight of fresh fruit to the weight of dehydrated fruit. It was calculated by the following formula:

$$\text{Dehydration ratio} = \frac{\text{Weight of fresh fruit}}{\text{Weight of dehydrated fruit}}$$

3.4.5 Recovery of dehydrated fruit

The weight of dehydrated fruit at the end of drying obtained from each treatment was noted down and the percentage recovery of dehydrated fruit was calculated.

$$\text{Recovery percentage} = \frac{\text{Weight of dehydrated fruit}}{\text{Weight of fresh fruit}} \times 100$$

3.4.6 Drying time

The number of hours taken for attaining a constant moisture level, i.e., to reach final moisture content of dehydrated fruit was noted down.

3.4.7 Final moisture content of dehydrated fruit

Final moisture content of the dehydrated fruits was determined in Ohaus Halogen Moisture Analyser.

3.4.8 Ascorbic acid

Ascorbic acid content was estimated titrimetrically using 2,6-Dichloro phenol indophenol dye as per the modified procedure of AOAC (Anon., 1984). One gram of fruit extract was taken and diluted to a known volume with four per cent oxalic acid. This was filtered through muslin cloth to get a clear juice. One ml of the aliquot was titrated against 2,6-Dichloro phenol indophenol. The result was expressed as milligram of ascorbic acid per 100 g of fruit.

3.4.9 Sugars

Representative samples from each dehydrated fruits in each treatment were ground to a fine powder and preserved in 80 per cent alcohol in a refrigerator. These samples were used for estimation of reducing, non-reducing and total sugars.

3.4.9.1 Reducing sugar

Reducing sugar in the fresh fruit pulp preserved in 80 per cent alcohol was estimated as per the dinitro salicylic acid (DNSA) method (Miller, 1972). The values were expressed as percentage on fresh weight basis.

The sugars from the powdered fig fruits was extracted with 80 per cent alcohol using a centrifuge at 4000 rpm and the alcohol free extract was used for estimation of sugars as per the dinitro salicylic acid method (Miller, 1972). The values obtained were expressed as percentage on dry weight basis.

3.4.9.2 Total sugar

The total sugar present in fresh fruit and dehydrated fruit was estimated by the same method as in case of reducing sugar after inversion of the non-reducing sugar using dilute hydrochloric acid (Anon., 1984). The values obtained were expressed as percentage on fresh and dry weight basis.

3.4.9.3 Non-reducing sugar

The percentage of non-reducing sugar was obtained by substracting the values of reducing sugar from total sugar (Somogyi, 1952).

3.4.10 Non-enzymatic browning

Ten ml of the sample extract was centrifuged at 4000 rpm for 15 minutes. The supernatant was collected and made upto 10 ml and to this, 15 ml of 60 per cent alcohol was added, mixed thoroughly and filtered. The absorbance of the filtrate at 440 nm was recorded in spectrophotometer (Genova make) using 60 per cent alcohol as blank. The value of non-enzymatic browning was expressed as optical density (OD) (Srivastava and Sanjeevkumar, 1998).

3.4.11 Organoleptic characters

Organoleptic evaluation of dehydrated fig fruits was carried out by a team of 10 semi-trained judges consisting of teachers and PG students of Kittur Rani Channamma College of Horticulture, Arabhavi. The organoleptic characters like colour and appearance, taste, texture, flavour and overall acceptability of dehydrated fig fruits were evaluated on a five point Hedonic scale using the scorecard mentioned below. The mean scores given by ten judges were used for statistical analysis.

Score card for organoleptic evaluation

Hedonic scale	Scores				
	Colour and appearance	Texture	Taste	Flavour	Overall accepta-bility
Highly acceptable	5	5	5	5	5
Acceptable	4	4	4	4	4
Fairly acceptable	3	3	3	3	3
Poorly acceptable	2	2	2	2	2
Not acceptable	1	1	1	1	1

3.4.12 Statistical analysis

The data on physico-chemical parameters and organoleptic characters recorded in case of experiment I and II were subjected to Factorial Completely Randomised Design. Interpretation of data was carried out in accordance with Panse and Sukhatme (1985). The level of significance used in 'F' test and 't' test was $p = 0.01$. Critical difference values were calculated whenever 'F' test was significant.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the investigation on standardisation of drying techniques in fig fruits conducted at the Department of Post-harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi during 2002-2003 are presented in this chapter.

4.1 EXPERIMENT-I

STANDARDISATION OF PRE-TREATMENTS

4.1.1 Physico-chemical characters of fresh fig fruits

The physico-chemical characters of fresh fruits meant for the process of dehydration were recorded and the values are presented in Appendix-II.

The data indicated that the fruits had an average fruit weight of 36.00 g with total soluble solids (18.90%), moisture content (76.00%), ascorbic acid (5.1 mg/100 g) and total sugars (17.05%).

4.1.2 Recovery percentage and dehydration ratio

The data pertaining to the recovery percentage of dehydrated fig fruits and dehydration ratio as influenced by different pre-treatments are presented in Table-1 and depicted in Fig.-1.

Table 1. Recovery percentage and dehydration ratio of dehydrated fig fruits as influenced by pre-treatments

Treatments	Recovery (%)	Dehydration ratio
T_1 – Control	21.04	4.75
T_2 – Blanching 2 minutes + dipping in 2% KMS	20.13	4.96
T_3 – Blanching 4 minutes + dipping in 2% KMS	20.58	4.86
T_4 – Steeping in 60°Brix sugar syrup	25.27	3.99
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	22.68	4.40
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	22.58	4.42
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	21.63	4.63
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	21.38	4.67
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	22.22	4.53
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	20.50	4.88
Mean	21.80	4.61
S.Em±	0.741	0.140
C.D. (0.01)	2.981	0.564

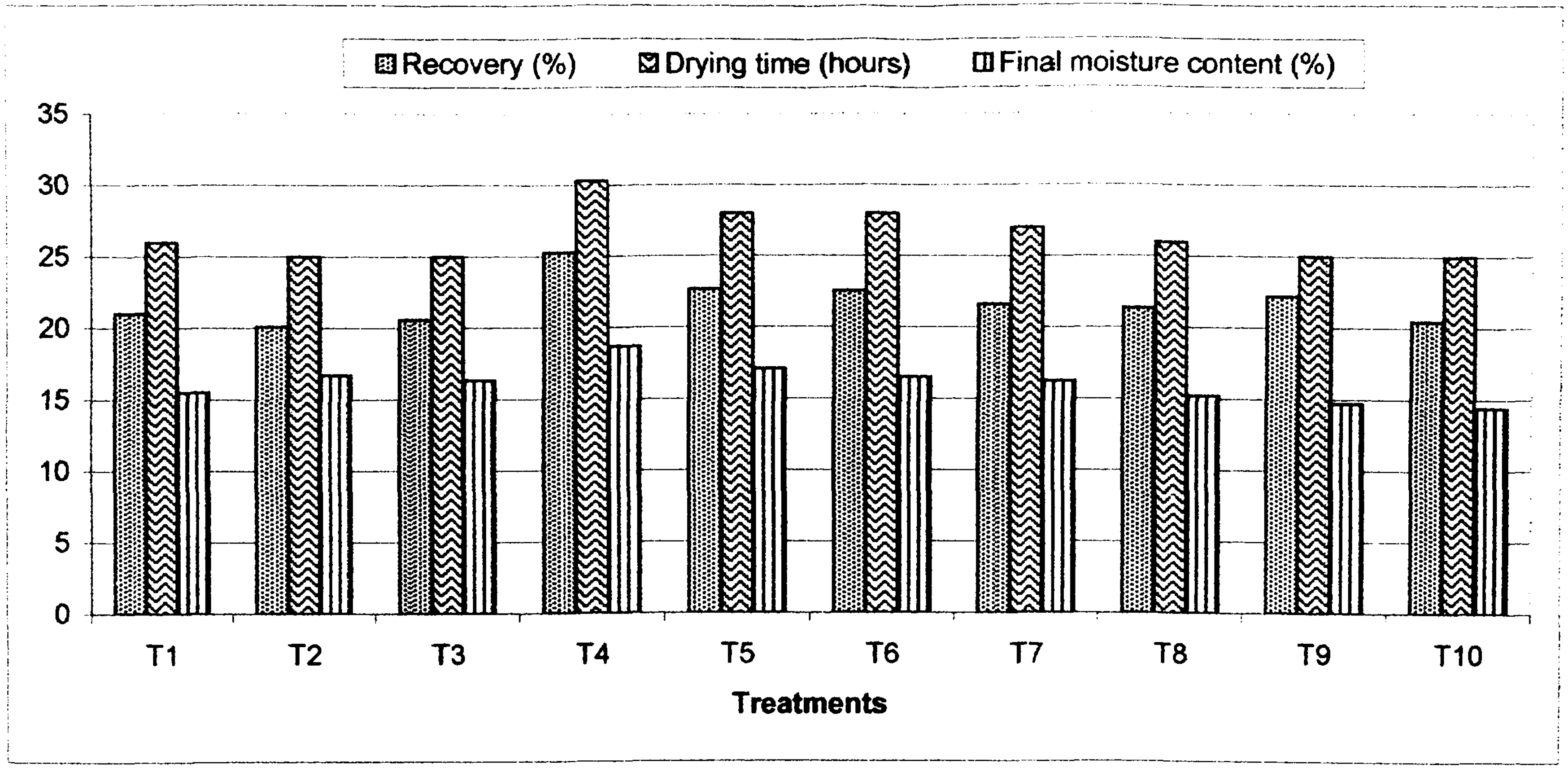


Fig. 1. Recovery percentage, drying time and moisture content of dehydrated fig fruits as influenced by pre-treatments

T_1 – Control

T_2 – Blanching 2 minutes + dipping in 2% KMS

T_3 – Blanching 4 minutes + dipping in 2% KMS

T_4 – Steeping in 60°Brix sugar syrup

T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3

T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3

T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3

T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3

T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3

T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3

The results indicated that there was a significant difference between the treatments with respect to recovery percentage and dehydration ratio of dehydrated fig fruits.

Significantly highest recovery percentage of dehydrated fig fruits was recorded in fruits steeped in 60°Brix sugar syrup for 24 hours (T_4) (25.27%), which was on par with fruits dipped in 1.0 per cent dip oil + 1.0 per cent K_2CO_3 for 3 minutes (22.68%) and fruits dipped in 1.0 per cent dip oil + 1.5 per cent K_2CO_3 for 3 minutes (T_6), whereas lowest recovery was recorded in fruits blanched for 2 minutes + dipping in 2 per cent KMS solution for 30 minutes (T_2) (20.13%). However, it was on par with control (T_1) (21.04%) and all other treatments except T_4.

Significantly lower dehydration ratio was recorded in T_4 (3.99) and T_5 (4.40), whereas highest dehydration ratio was recorded in T_2 (4.96).

4.1.3 Drying time (hours) and moisture content (%)

The data pertaining to time required for dehydration and moisture content (%) of dehydrated fig fruits as influenced by treatments are presented in Table-2 and depicted in Fig.-1.

The results showed that there was a significant difference between the treatments with respect to drying time (hours) and moisture content (%) of dehydrated fig fruits. Significantly minimum drying time (hours) was observed in T_2, T_3, T_9, T_{10} (25.00 hours), whereas maximum drying

Table 2. Drying time and moisture content of dehydrated fig fruits as influenced by pre-treatments

Treatments	Drying time (hours)	Final moisture content (%)
T_1 – Control	26.00	15.50
T_2 – Blanching 2 minutes + dipping in 2% KMS	25.00	16.73
T_3 – Blanching 4 minutes + dipping in 2% KMS	25.00	16.36
T_4 – Steeping in 60°Brix sugar syrup	30.30	18.70
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	28.00	17.10
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	28.00	16.53
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	27.00	16.23
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	26.00	15.23
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	25.00	14.70
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	25.00	14.40
Mean	26.53	16.50
S.Em±	0.106	0.165
C.D. (0.01)	0.427	0.665

time was observed in T_4 (30.30 hours). Significantly lower moisture content (%) was observed in T_{10} (14.40%), which was on par with T_9 (14.70%), whereas highest moisture content was observed in T_4 (18.70%).

4.1.4 Reducing sugar (%), non-reducing sugar (%), total sugar (%) and ascorbic acid (mg/100 g)

The data on reducing sugar (%), non-reducing sugar (%), total sugar (%) and ascorbic acid (mg/100 g) of dehydrated fig fruits as influenced by different treatments are presented in Table-3.

The results indicated that there was a significant difference between the treatments with respect to reducing sugar, non-reducing sugar, total sugar and ascorbic acid content of dehydrated fig fruits. Significantly highest reducing sugar was observed in T_4 (52.15%) followed by T_8 (45.93%), whereas lowest reducing sugar was observed in T_3 (40.70%).

Significantly highest non-reducing sugar was observed in T_9 (9.23%), which was on par with T_7 (9.07%), whereas lowest value was observed in T_4 (3.05%). Significantly highest total sugar was observed in T_4 (55.20%), which was on par with T_5 (53.53%), whereas lowest total sugar was observed in T_3 (49.46%).

Significantly highest ascorbic acid was recorded in T_4 (1.85 mg/100 g), whereas in all other treatments it was less than one mg per

Table 3. Reducing sugar, non-reducing sugar, total sugar and ascorbic acid content of dehydrated fig fruits as influenced by pre-treatments

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg /100g)
T_1 – Control	42.33	8.37	50.70	0.54
T_2 – Blanching 2 minutes + dipping in 2% KMS	41.38	8.85	50.23	0.32
T_3 – Blanching 4 minutes + dipping in 2% KMS	40.70	8.77	49.46	0.22
T_4 – Steeping in 60°Brix sugar syrup	52.15	3.05	55.20	1.85
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	44.66	8.87	53.53	0.91
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	43.33	7.60	50.93	0.85
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	41.93	9.07	51.00	0.98
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	45.93	8.63	51.23	0.89
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	42.27	9.23	51.53	0.92
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	44.47	8.03	52.50	0.94
Mean	43.917	8.050	51.63	0.84
S.Em±	1.038	0.402	0.507	0.018
C.D. (0.01)	4.183	1.620	2.043	0.072

100 g However, lowest ascorbic acid was observed in T_3 (0.22 mg/100 g).

4.1.5 Non-enzymatic browning (OD at 440 nm)

The non-enzymatic browning of dehydrated fig fruits as influenced by pre-treatments and storage periods are presented in Table-4 and depicted in Fig.-2.

The data indicated that there were significant differences among treatments and also between the storage periods.

The mean OD values of the treatments irrespective of storage period varied between 0.631 and 0.200. Treatments T_2 and T_3 recorded lowest OD value (0.200) followed by T_1 (0.238), whereas highest OD value (0.631) was observed in T_4 followed by T_{10} (0.543).

The mean OD values of the storage periods irrespective of treatments were found to increase from an initial value of 0.359 to 0.524 at four month after storage (MAS).

The interaction between treatments and storage period were also found significant. Lowest OD value of 0.187 was recorded in T_2 and T_3 at initial period of storage, whereas highest value of 0.762 was observed in T_4 at 4 MAS.

Table 4. Non-enzymatic browning of dehydrated fig fruits as influenced by pre-treatments and storage period (OD at 440 nm)

Treatments	Initial	4 MAS	Mean
T_1 – Control	0.200	0.277	0.238
T_2 – Blanching 2 minutes + dipping in 2% KMS	0.187	0.213	0.200
T_3 – Blanching 4 minutes + dipping in 2% KMS	0.187	0.213	0.200
T_4 – Steeping in 60°Brix sugar syrup	0.537	0.762	0.631
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	0.430	0.625	0.527
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	0.403	0.653	0.528
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	0.407	0.637	0.522
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	0.413	0.617	0.515
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	0.387	0.630	0.508
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	0.437	0.650	0.543
Mean	0.359	0.524	0.441
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.0071	0.0266	
Storage (S)	0.0032	0.0119	
Interaction (T x S)	0.0101	0.0378	

MAS = Months after storage

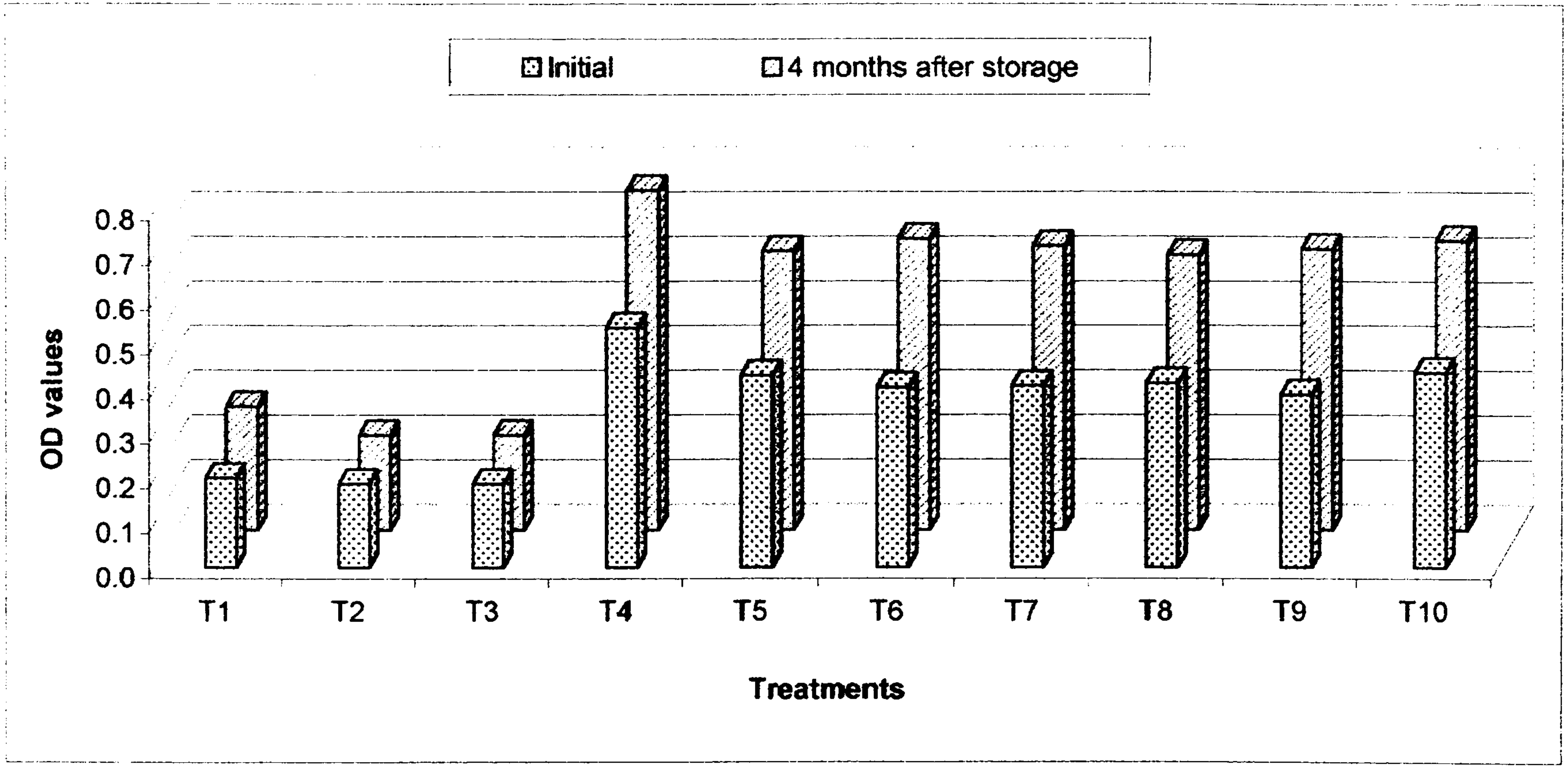


Fig. 2. Non-enzymatic browning of dehydrated fig fruits as influenced by pre-treatments and storage period

T_1 – Control

T_2 – Blanching 2 minutes + dipping in 2% KMS

T_3 – Blanching 4 minutes + dipping in 2% KMS

T_4 – Steeping in 60°Brix sugar syrup

T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3

T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3

T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3

T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3

T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3

T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3

4.1.6 Organoleptic evaluation of dehydrated fig fruits (scores out of 5.00)

4.1.6.1 Colour and appearance

The data pertaining to the colour and appearance of dehydrated fig fruits as influenced by pre-treatments, storage period and their interaction effects are presented in Table-5 and depicted in Fig.-3.

The detailed study of the data presented in the table indicated that the treatments storage period and their interaction effects between time showed significant differences.

The organoleptic scores for overall treatment means were found to differ significantly. The highest mean score of 4.59 was recorded in T_3 followed by T_2 (4.03), whereas lowest score was recorded in T_1 (1.00).

The mean organoleptic scores for colour and appearance for storage period irrespective of treatments indicated that there was a marginal reduction in scores from 2.69 (initial) to 2.16 at 4 MAS.

The interaction between treatments and storage period were also significant. Significantly highest scores were recorded in T_3 at initial period of storage (4.92) followed by the same treatment at 4 MAS, whereas lowest score was observed in T_1 at both initial period and 4 MAS (1.00).

Table 5. Effect of pre-treatments and storage period on colour and appearance of dehydrated fig fruits (scores out of 5.00)

Treatments	Initial	4 MAS	Mean
T_1 – Control	1.00	1.00	1.00
T_2 – Blanching 2 minutes + dipping in 2% KMS	4.08	3.96	4.03
T_3 – Blanching 4 minutes + dipping in 2% KMS	4.92	4.27	4.59
T_4 – Steeping in 60°Brix sugar syrup	3.75	2.17	2.96
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	1.33	1.13	1.23
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	2.42	1.58	2.00
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	2.80	2.08	2.44
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	2.33	2.18	2.26
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	2.17	1.90	2.03
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	2.17	1.30	1.73
Mean	2.69	2.16	2.43
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.1019	0.3818	
Storage (S)	0.0456	0.1708	
Interaction (T x S)	0.1441	0.540	

MAS = Months after storage

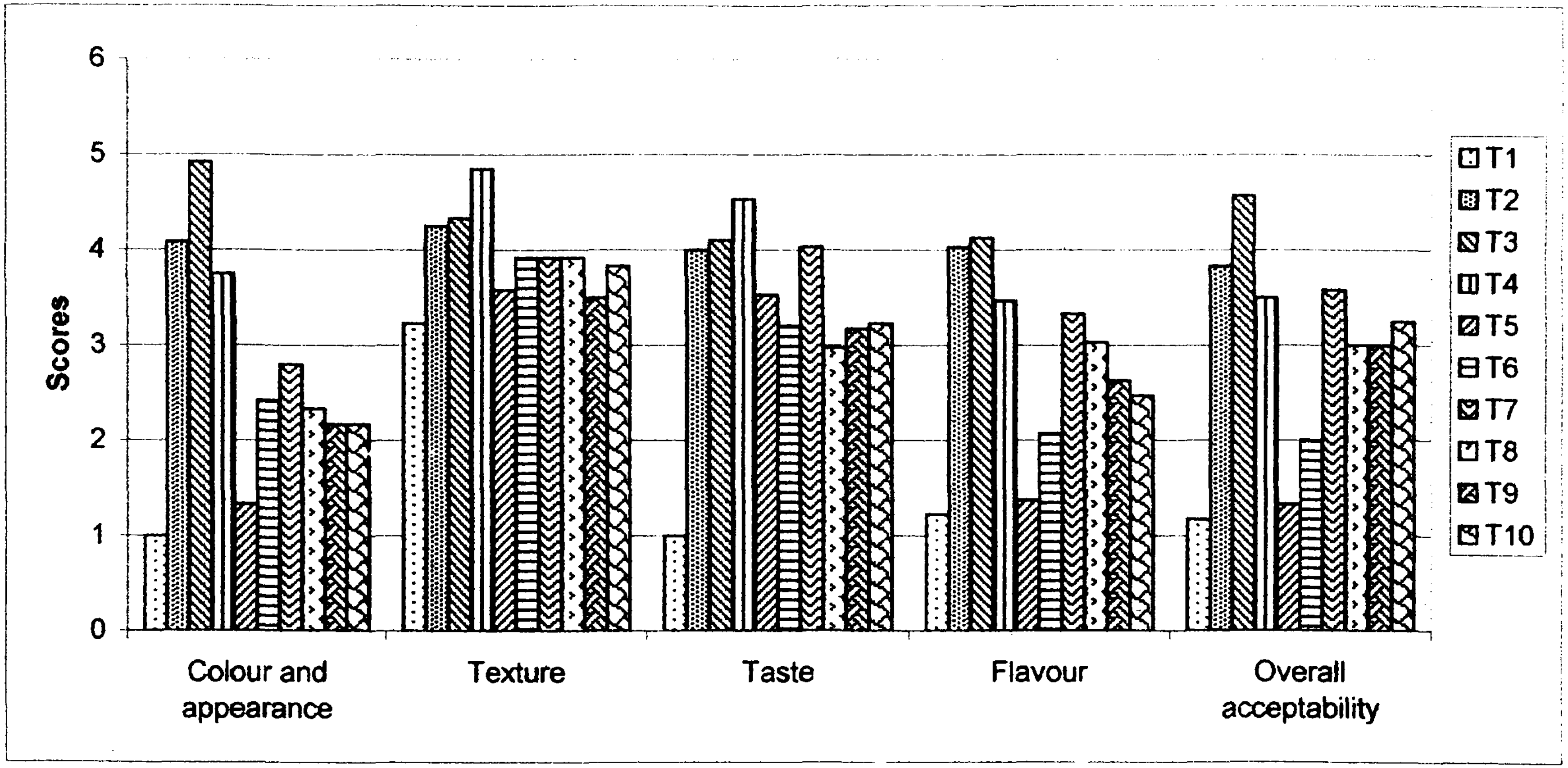


Fig. 3. Organoleptic evaluation of dehydrated fig fruits as influenced by pre-treatments

T_1 – Control

T_2 – Blanching 2 minutes + dipping in 2% KMS

T_3 – Blanching 4 minutes + dipping in 2% KMS

T_4 – Steeping in 60°Brix sugar syrup

T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3

T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3

T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3

T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3

T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3

T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3

4.1.6.2 Texture

The data pertaining to the texture of dehydrated fig fruits as influenced by treatments, storage period, and their interaction effects are presented in Table-6 and depicted in Fig.-3.

The data presented in the table indicated that there was significant difference among the treatments and also between the storage period.

The overall treatment mean scores irrespective of storage period was highest in T_4 (4.68) followed by T_3 (4.28), whereas lowest score was noticed in T_1 (3.12).

The mean scores of storage period irrespective of treatments found to decrease from 3.93 to 3.63 during the storage period of 4 months. However, the interaction effects between the treatments and storage period were not significant.

4.1.6.3 Taste

The data pertaining to the taste of dehydrated fig fruits as influenced by treatments, storage period and their interaction effects are presented in Table-7 and depicted in Fig.-3. The data presented in the table indicated that there was significant difference noticed between the treatments.

Table 6. Effect of pre-treatments and storage period on texture of dehydrated fig fruits (scores out of 5.00)

Treatments	Initial	4 MAS	Mean
T_1 – Control	3.23	3.02	3.12
T_2 – Blanching 2 minutes + dipping in 2% KMS	4.25	4.00	4.13
T_3 – Blanching 4 minutes + dipping in 2% KMS	4.33	4.23	4.28
T_4 – Steeping in 60°Brix sugar syrup	4.85	4.53	4.68
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	3.58	3.37	3.47
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	3.92	3.22	3.57
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	3.92	3.58	3.75
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	3.92	3.53	3.72
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	3.50	3.25	3.37
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	3.83	3.58	3.71
Mean	3.93	3.63	3.78
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.1045	0.3916	
Storage (S)	0.0467	0.1750	
Interaction (T x S)	0.1478	NS	

MAS = Months after storage NS = Non-significant

Table 7. Effect of pre-treatments and storage period on taste of dehydrated fig fruits (scores out of 5.00)

Treatments	Initial	4 MAS	Mean
T_1 – Control	1.00	1.00	1.00
T_2 – Blanching 2 minutes + dipping in 2% KMS	4.00	4.00	4.00
T_3 – Blanching 4 minutes + dipping in 2% KMS	4.10	4.03	4.07
T_4 – Steeping in 60°Brix sugar syrup	4.53	4.47	4.50
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	3.53	3.43	3.48
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	3.20	3.17	3.18
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	4.03	3.93	3.98
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	2.97	2.90	2.93
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	3.17	2.97	3.07
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	3.23	3.20	3.22
Mean	3.38	3.31	3.34
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.0962	0.3605	
Storage (S)	0.0430	NS	
Interaction (T x S)	0.1360	NS	

MAS = Months after storage NS = Non-significant

The overall treatment mean scores irrespective of storage period was highest in T_4 (4.50) followed by T_3 (4.07), whereas lowest score was noticed in T_1 (1.00).

However, the storage period and interaction between treatments and storage period were found to be non-significant.

4.1.6.4 Flavour

The data pertaining to the flavour of dehydrated fig fruits as influenced by treatments storage period and their interaction effects are presented in Table-8 and depicted in Fig.-3. The data presented in the table indicated that there was significant difference between the treatments.

The overall treatment mean scores irrespective of storage period was highest in T_3 (4.08), which was on par with T_2 (3.93), whereas the least score was noticed in T_1 (1.17). However, the data on storage period and interaction between treatments x storage period were found non-significant.

4.1.6.5 Overall acceptability

The data pertaining to the overall acceptability of dehydrated fig fruits as influenced by treatments and storage period and their interaction effects are presented in Table-9 and depicted in Fig.-3.

Table 8. Effect of pre-treatments and storage period on flavour of dehydrated fig fruits (scores out of 5.00)

Treatments	Initial	4 MAS	Mean
T_1 – Control	1.22	1.13	1.17
T_2 – Blanching 2 minutes + dipping in 2% KMS	4.03	3.83	3.93
T_3 – Blanching 4 minutes + dipping in 2% KMS	4.13	4.03	4.08
T_4 – Steeping in 60°Brix sugar syrup	3.47	3.40	3.43
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	1.37	1.30	1.33
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	2.07	2.07	2.07
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	3.33	3.03	3.18
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	3.03	2.90	2.97
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	2.63	2.33	2.48
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	2.47	2.40	2.43
Mean	2.77	2.64	2.71
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.0881	0.3301	
Storage (S)	0.0394	NS	
Interaction (T x S)	0.1246	NS	

MAS = Months after storage NS = Non-significant

Table 9. Effect of pre-treatments and storage period on overall acceptability of dehydrated fig fruits (scores out of 5.00)

Treatments	Initial	4 MAS	Mean
T_1 – Control	1.17	1.00	1.08
T_2 – Blanching 2 minutes + dipping in 2% KMS	3.83	3.67	3.75
T_3 – Blanching 4 minutes + dipping in 2% KMS	4.57	4.33	4.45
T_4 – Steeping in 60°Brix sugar syrup	3.50	3.05	3.27
T_5 – Dipping in 1.0% dip oil + 1.0% K_2CO_3	1.33	1.08	1.21
T_6 – Dipping in 1.0% dip oil + 1.5% K_2CO_3	2.00	1.67	1.83
T_7 – Dipping in 1.5% dip oil + 1.0% K_2CO_3	3.58	3.23	3.41
T_8 – Dipping in 1.5% dip oil + 1.5% K_2CO_3	3.00	2.96	2.98
T_9 – Dipping in 2.0% dip oil + 1.0% K_2CO_3	3.00	2.77	2.88
T_{10} – Dipping in 2.0% dip oil + 1.5% K_2CO_3	3.25	2.97	3.11
Mean	2.92	2.67	2.80
For comparing the means	S.Em±	C.D. (0.01)	
Treatments (T)	0.1042	0.3904	
Storage (S)	0.0466	0.1746	
Interaction (T x S)	0.1474	NS	

MAS = Months after storage NS = Non-significant

The data presented in the table indicated that the treatments and storage period differed significantly among themselves.

Considering the overall treatment mean scores irrespective of storage period, it was noticed that the significantly highest score was obtained in T_3 (4.45) followed by T_2 (3.75) and T_7 (3.41), whereas least score was observed in control (1.08), which was on par with T_5 (1.21).

It was noticed that the scores irrespective of treatments found to decrease from 2.92 to 2.67 during the storage period of 4 months. However, the interaction effects between the treatments and storage period were found non-significant.

4.2 EXPERIMENT-II

STANDARDISATION OF DRYING METHOD

4.2.1 Recovery of dehydrated fig fruits (%)

The data on recovery of dehydrated fig fruits as influenced by treatments and drying methods are presented in Table-10 and depicted in Fig.-4.

The data revealed that there were significant differences between the treatments, irrespective of drying methods. Significantly highest recovery of dehydrated fruits was recorded in fruits blanched for 4

Table 10. Recovery percentage of dehydrated fig fruits as influenced by treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	22.27	21.50	19.50	21.09
T_2	23.40	22.17	20.47	22.01
T_3	22.87	21.87	20.37	21.70
Mean	22.84	21.84	20.11	21.60

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.1242	0.5055
Drying methods (D)	0.1242	0.5055
Interaction (T x D)	0.2152	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS = Non-significant

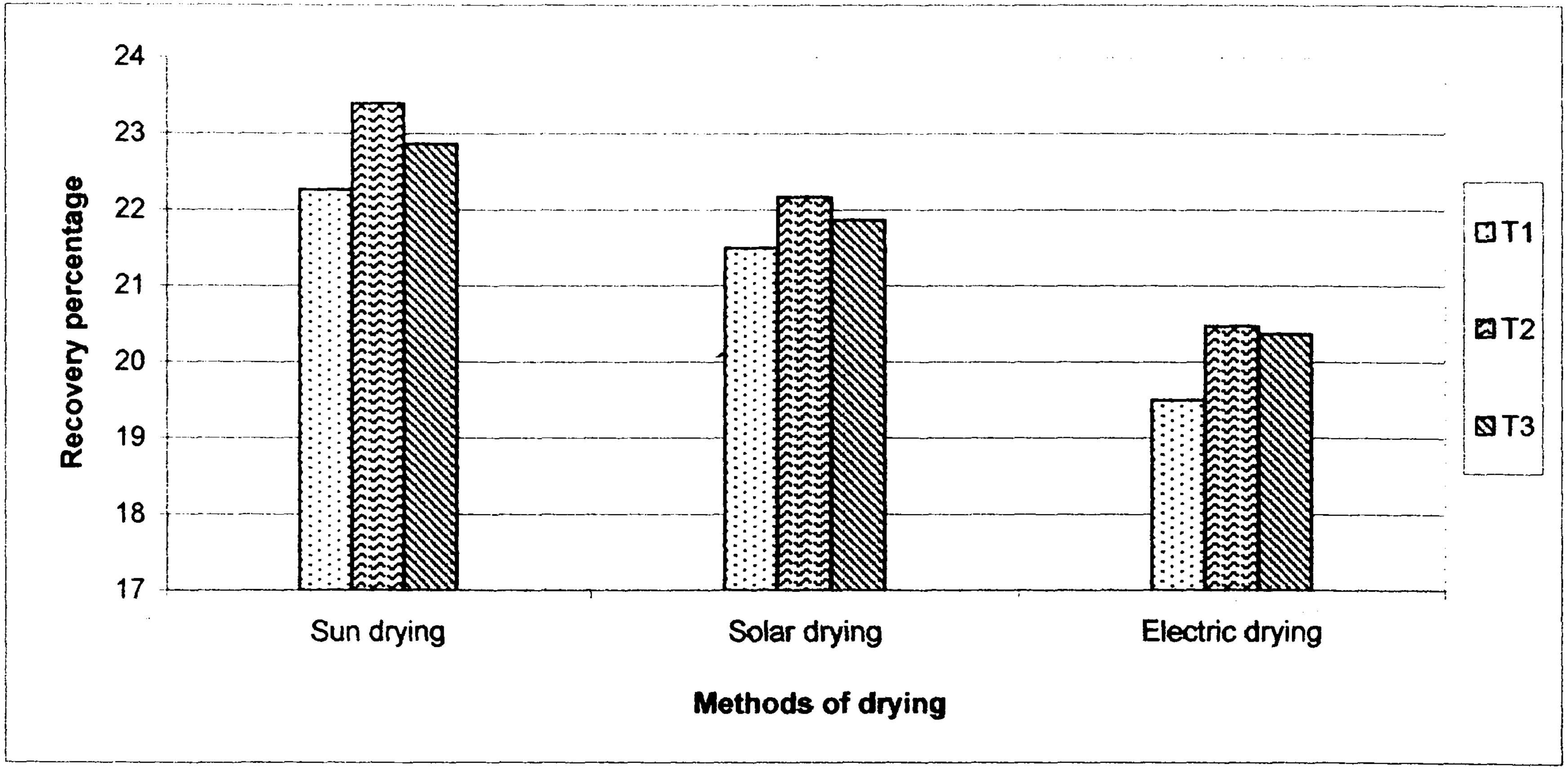


Fig. 4. Recovery percentage of dehydrated fig fruits as influenced by pre-treatments and drying methods

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

minutes + dipping in 2 per cent KMS solution for 30 minutes (T_2) (22.01%), whereas lowest recovery was recorded in control (T_1) (21.09%).

There were significant differences between the drying methods irrespective of treatments. Significantly highest recovery was recorded in sun drying (22.84%), whereas least recovery was recorded in electric drying (20.11%). The interaction effects between the treatments and drying methods were found non-significant.

4.2.2 Dehydration ratio

The data on dehydration ratio of fig fruits as influenced by treatments and drying methods are presented in Table-11.

The data revealed that there were significant differences between the treatments, irrespective of drying methods. Significantly lower dehydration ratio was recorded in T_2 (4.544), whereas higher dehydration ratio was recorded in T_1 (4.767).

There were significant differences between the drying methods, irrespective of treatments. Significantly lower dehydration ratio was recorded in sun drying (4.364), whereas higher dehydration ratio was recorded in electric drying (5.004). The interaction effects between the treatments and drying methods were found non-significant.

Table 11. Dehydration ratio of fig fruits as influenced by treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	4.457	4.627	5.217	4.767
T_2	4.270	4.477	4.887	4.544
T_3	4.367	4.567	4.910	4.614
Mean	4.364	4.557	5.004	4.642

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0292	0.1188
Drying methods (D)	0.0292	0.1188
Interaction (T x D)	0.0506	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS - Non-significant

4.2.3 Time taken for drying (hours)

The data on time taken for drying of fig fruits as influenced by treatments and drying methods are presented in Table-12 and depicted in Fig.-5.

The data showed that there were significant differences between the treatments, irrespective of drying methods. Significantly minimum time was taken for drying in T_2 (35.95 hours), whereas maximum time was required in T_1 (37.28 hours).

There were significant differences between drying methods irrespective of treatments. Significantly minimum time taken for drying was in electric drying (25.67 hours), whereas maximum time for drying was under sun drying (47.61 hours).

The interaction effects between treatments and drying methods were also found significant. Minimum time taken for drying was observed in T_2 under electric drying (24.167 hours) followed by T_1 under electric drying, whereas maximum time taken for drying was observed in T_1 under sun drying (48.167 hours).

4.2.4 Moisture content (%)

The data pertaining to moisture content of the dehydrated fig fruits as influenced by treatments and drying methods are presented in the Table-13 and depicted in Fig.-6.

Table 12. Time (hours) taken for drying of fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	48.167	38.00	25.667	37.278
T_2	47.33	36.33	24.167	35.948
T_3	47.33	36.33	27.167	36.944
Mean	47.61	36.889	25.667	36.722

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.1322	0.538
Drying methods (D)	0.1322	0.538
Interaction (T x D)	0.2291	0.933

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

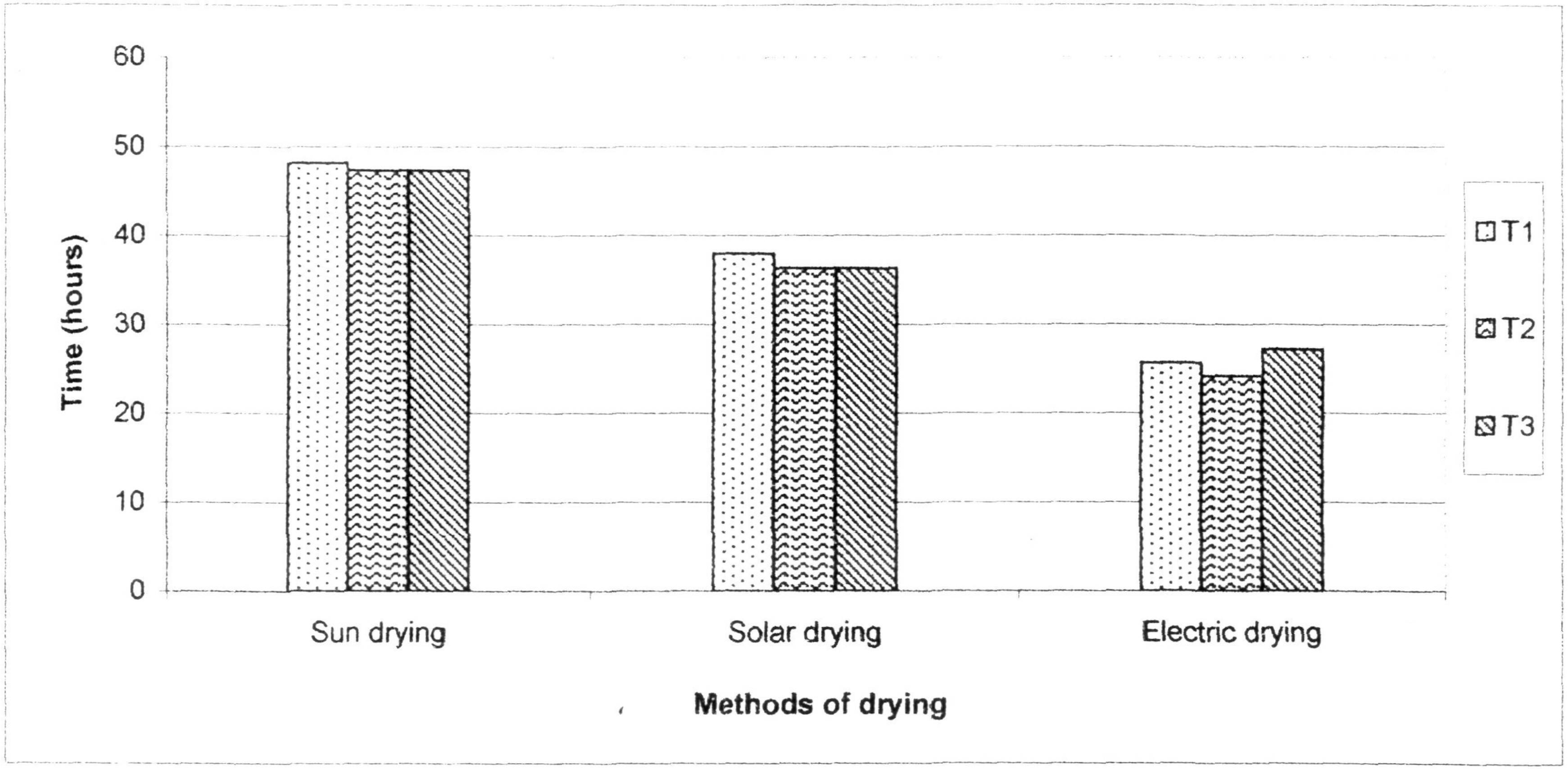


Fig. 5. Time (hours) taken for drying of dehydrated fig fruits as influenced by pre-treatments and drying methods

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

Table 13. Moisture content (%) of dehydrated fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	18.540	15.180	17.633	17.118
T_2	16.950	16.283	16.400	16.544
T_3	15.100	15.190	15.447	15.246
Mean	16.863	15.551	16.493	16.303
For comparing the means	S.Em±		C.D. (0.01)	
Treatments (T)	0.635		0.258	
Drying methods (D)	0.635		0.258	
Interaction (T x D)	0.1101		0.448	

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

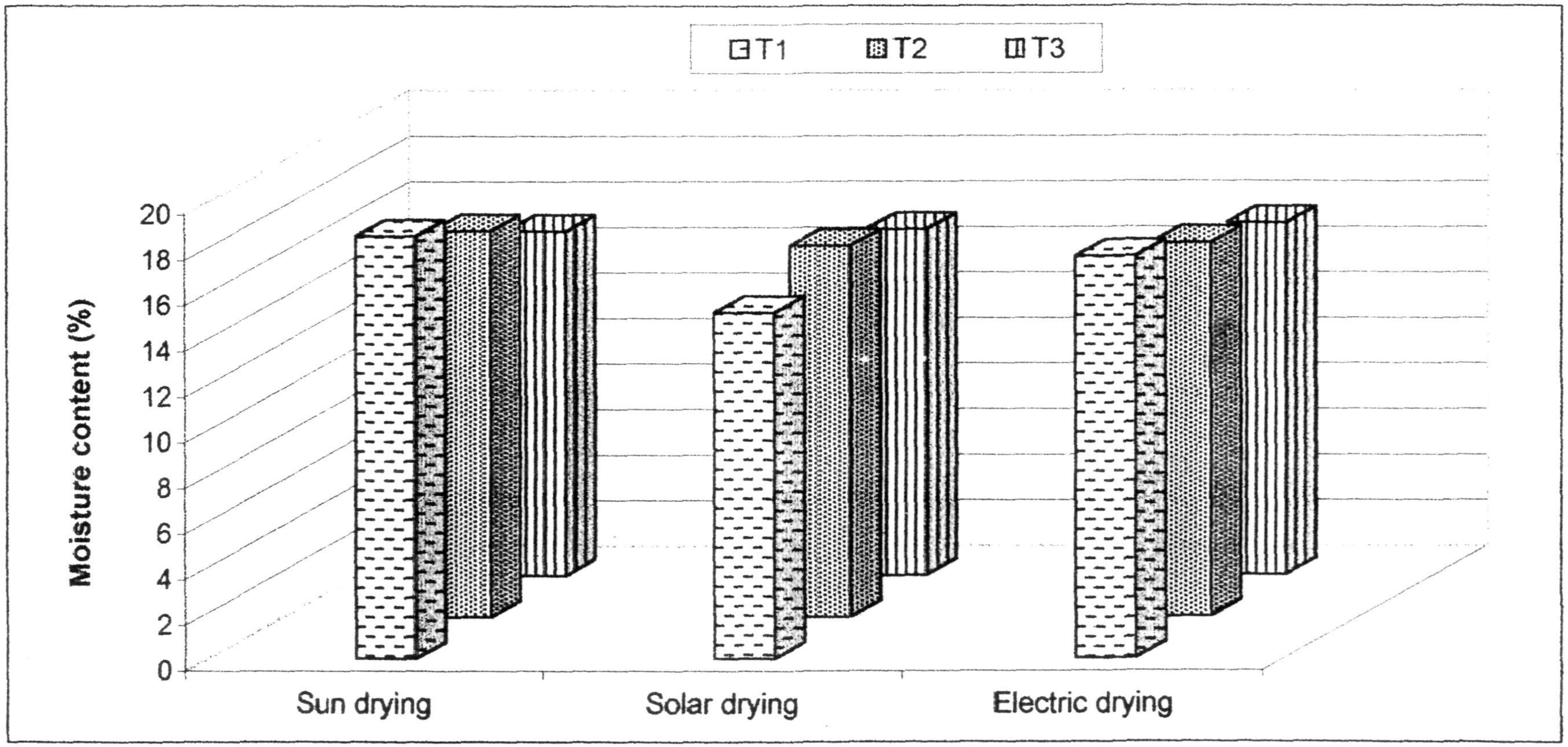


Fig. 6. Moisture content (%) of dehydrated fig fruits as influenced by pre-treatments and drying methods

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

The data revealed that there were significant differences between the treatments, irrespective of drying methods. Significantly lower moisture content was observed in T_3 (15.246%), whereas highest moisture content was recorded in T_1 (17.118%).

There were significant differences between the drying methods irrespective of treatments. Significantly lowest moisture content was recorded under solar drying (15.551%), whereas highest moisture content was recorded in sun drying (16.863%).

The interaction effects between the treatments and drying methods were found significant. Significantly lowest moisture content was recorded in T_3 under sun drying (15.100%), which is on par with T_1 under solar drying (15.180%), T_3 under solar drying (15.190%) and T_3 under electric drying (15.447%), whereas highest moisture content was recorded in T_1 under sun drying (18.540%).

4.2.5 Reducing sugar (%)

The data pertaining to reducing sugar content of the dehydrated fig fruits as influenced by treatments and drying methods are presented in Table-14.

The results indicated that only treatments had significant effect on reducing sugar content. Significantly highest reducing sugar was

Table 14. Reducing sugar content (%) of the dehydrated fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	41.55	41.233	41.43	41.406
T_2	40.78	41.43	41.88	41.364
T_3	42.23	41.96	42.40	42.20
Mean	41.52	41.54	41.90	

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.1774	0.722
Drying methods (D)	0.1774	NS
Interaction (T x D)	0.3073	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS = Non-significant

recorded in T_3 (42.20%), whereas lowest reducing sugar was recorded in T_2 (41.364%).

4.2.6 Non-reducing sugar (%)

The data pertaining to non-reducing sugar content of the dehydrated fig fruits as influenced by treatments and drying methods are presented in Table-15.

The results indicated that only treatments had significant effect on non-reducing sugar content. Significantly highest non-reducing sugar was recorded in T_1 (9.583%), which was on par with T_3 (9.067%), whereas lowest non-reducing sugar was recorded in T_2 (7.947%).

4.2.7 Total sugar (%)

The data pertaining to total sugar content of the dehydrated fig fruits as influenced by treatments and drying methods were presented in Table-16.

The results indicated that only treatments had significant effect on total sugar content. Significantly highest total sugar was recorded in T_3 (51.26%), which was on par with T_1 (51.10%), whereas lowest total sugar was recorded in T_2 (49.81%).

Table 15. Non-reducing content (%) o the dehydrated fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	9.517	9.833	9.400	9.583
T_2	8.453	8.467	6.920	7.947
T_3	9.267	9.033	8.900	9.067
Mean	9.079	9.111	8.407	
For comparing the means	S.Em±		C.D. (0.01)	
Treatment (T)	0.2712		1.104	
Drying methods (D)	0.2712		NS	
Interaction (T x D)	0.4697		NS	

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS = Non-significant

Table 16. Total sugar content (%) of the dehydrated fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	51.067	51.067	51.167	51.10
T_2	49.233	49.900	48.800	49.81
T_3	51.500	51.000	51.300	51.26
Mean	50.600	50.650	50.420	
For comparing the means	S.Em±		C.D. (0.01)	
Treatments (T)	0.2047		0.833	
Drying methods (D)	0.2047		NS	
Interaction (T x D)	0.3545		NS	

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS = Non-significant

4.2.8 Ascorbic acid (mg/100 g)

The data on ascorbic acid content of the dehydrated fig fruits as influenced by treatments and drying methods are presented in Table-17.

The results indicated that only treatments had significant effect on ascorbic acid content. Significantly highest ascorbic acid was recorded in T_3 (1.012 mg/100 g), whereas lowest ascorbic acid was recorded in T_2 (0.253 mg/100 g).

4.2.9 Non-enzymatic browning (OD at 440 nm)

The data on non-enzymatic browning of dehydrated fig fruits as influenced by treatments, drying methods and storage period are presented in Table-18 and depicted in Fig.-7.

The detailed study of the data presented in the table indicated that the treatments, drying methods and storage period differed significantly among themselves. Also, the interaction effects between treatments and storage period showed significant difference.

The mean OD values of the treatments irrespective of drying methods and storage period was significantly lowest in T_2 (0.210), whereas highest OD value was observed in T_3 (0.547).

The mean OD values of drying methods irrespective of treatments and storage period was significantly lowest in sun drying (0.324), which

Table 17. Ascorbic acid content (mg/100 g) of the dehydrated fig fruits as influenced by pre-treatments and drying methods

Treatments	Methods of drying			Mean
	Sun drying	Solar drying	Electric drying	
T_1	0.550	0.560	0.533	0.548
T_2	0.277	0.210	0.273	0.253
T_3	1.033	1.027	0.977	1.012
Mean	0.620	0.599	0.594	

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0112	0.0456
Drying methods (D)	0.0112	NS
Interaction (T x D)	0.0194	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

NS = Non-significant

Table 18. **Effect of pre-treatments, drying methods and storage period on non-enzymatic browning of dehydrated fig fruits (OD at 440 nm)**

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	0.214	0.267	0.241	0.209	0.245	0.227	0.226	0.287	0.257	0.216	0.266	0.241
T_2	0.196	0.215	0.206	0.172	0.226	0.199	0.209	0.240	0.224	0.192	0.227	0.210
T_3	0.412	0.637	0.525	0.433	0.663	0.548	0.453	0.682	0.568	0.433	0.661	0.547
Mean	0.274	0.373	0.324	0.271	0.378	0.325	0.296	0.403	0.349	0.280	0.385	0.333

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0046	0.0175
Drying methods (D)	0.0046	0.0175
Storage (S)	0.0037	0.01409
Interaction (T x D)	0.0079	NS
Interaction (T x S)	0.0065	0.02475
Interaction (D x S)	0.0065	NS
Interaction (T x D x S)	0.0112	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

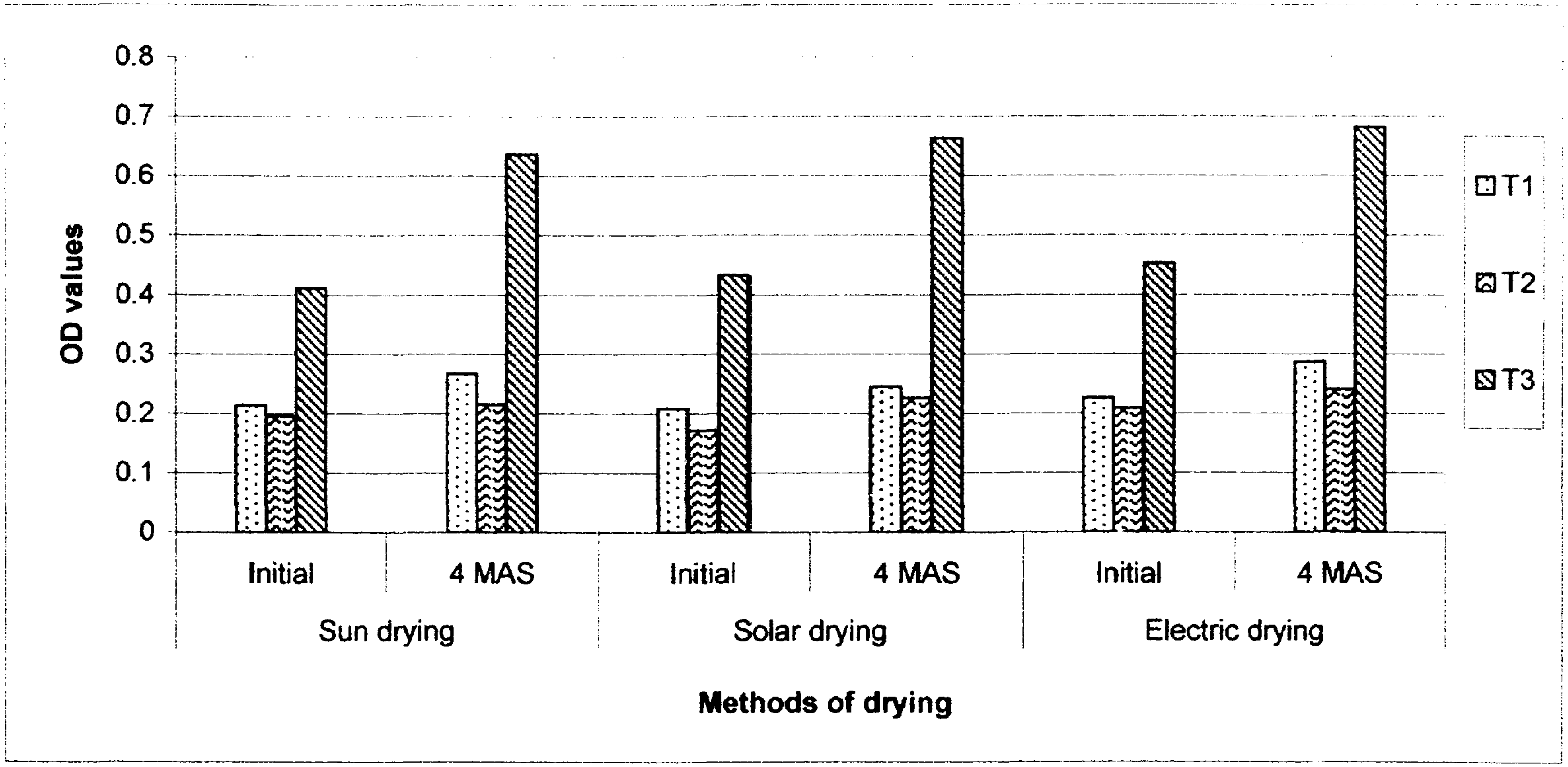


Fig. 7. Effect of pre-treatments, drying methods and storage period on non-enzymatic browning of dehydrated fig fruits (OD at 440 nm)

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

was on par with solar drier (0.325), whereas highest OD value was observed in electric drying (0.349).

The mean OD value of storage periods irrespective of treatments and drying methods found to increase from 0.280 to 0.385 during the period of 4 months.

The interaction between treatments and storage period were also significant. Significantly lowest OD value was recorded in T_2 a initial period (0.192), which was on par with T_1 at initial period (0.261), whereas highest OD value was recorded in T_3 at 4 MAS (0.661).

4.2.10 Organoleptic evaluation of dehydrated fig fruits (scores out of 5.00)

4.2.10.1 Colour and appearance

The data pertaining to the colour and appearance of dehydrated fig fruits as influenced by treatments, drying methods, storage period and their interaction effects are presented in Table-19 and depicted in Fig.-8 (Plates 5 and 6).

The detailed study of the data presented in the table indicated that the treatments drying methods and storage period differed significantly among themselves. Also, the interaction effects between treatments and drying methods showed significant differences.

The organoleptic score for overall treatment means was maximum (4.489) in T_2, whereas minimum score was recorded in T_1 (1.056).

Table 19. Organoleptic scores (out of 5.0) for colour and appearance of dehydrated fig fruits as influenced by pre-treatments, drying methods and storage period

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	1.033	1.000	1.017	1.067	1.000	1.033	1.167	1.067	1.117	1.089	1.022	1.056
T_2	4.567	4.367	4.467	4.400	4.133	4.267	4.833	4.633	4.733	4.600	4.378	4.489
T_3	2.233	2.167	2.200	2.433	2.267	2.350	3.633	3.433	3.533	2.767	2.622	2.694
Mean	2.611	2.511	2.516	2.633	2.467	2.550	3.211	3.044	3.128	2.819	2.674	2.746

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0309	0.1172
Drying methods (D)	0.0309	0.1172
Storage (S)	0.0253	0.0960
Interaction (T x D)	0.0536	0.2034
Interaction (T x S)	0.0437	NS
Interaction (D x S)	0.0437	NS
Interaction (T x D x S)	0.0758	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

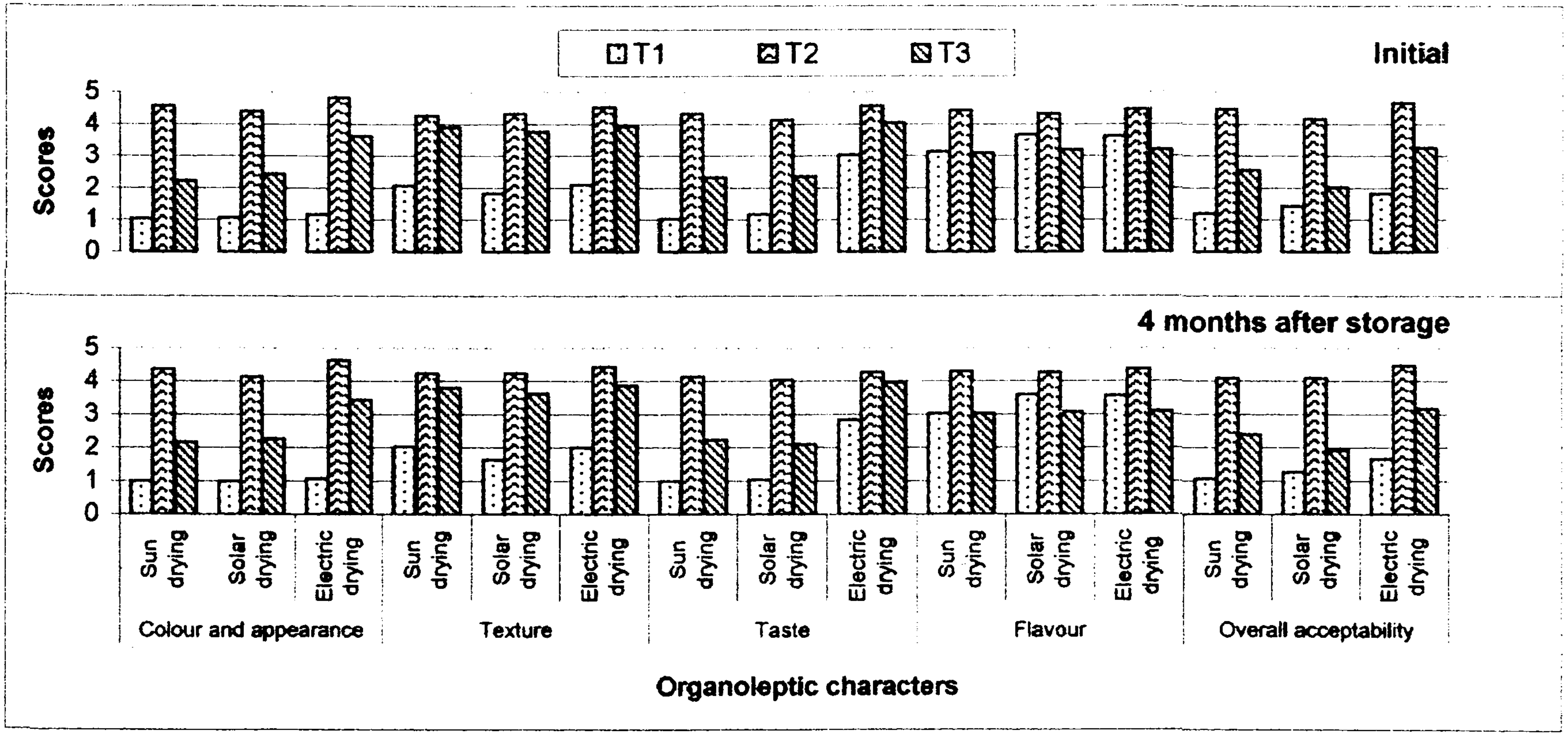


Fig. 8. Organoleptic scores (out of 5.0) of dehydrated fruits as influenced by pre-treatments, drying methods and storage period

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 1.0% K_2CO_3 for 3 minutes

Plate 5: **Partially dried fig fruits under different methods of drying**

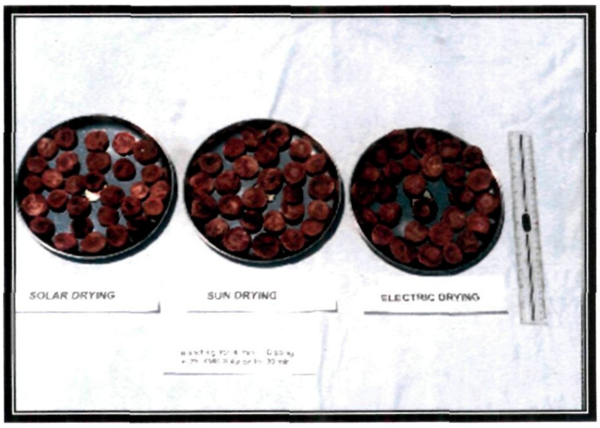


Plate 6: **Dehydrated fig fruits under different methods of drying**

The mean organoleptic scores for colour and appearance for different drying methods irrespective of treatments and storage period indicated that, significantly highest score was observed in electric drier (3.128), whereas lowest score was observed in sun drying (2.516).

The mean organoleptic scores for colour and appearance for storage period irrespective of treatments and drying methods indicated that, there was a marginal reduction in scores from 2.819 (initial) to 2.674 at 4 MAS.

The interaction between treatments and drying methods were also found significant. Significantly highest score was recorded in T_2 under electric drier (4.733), followed by T_2 in sun drying (4.467), which was on par with T_2 in solar drying (4.267), whereas lowest score was observed in T_1 under sun (1.017).

4.2.10.2 Texture

The data pertaining to the texture of dehydrated fig fruits as influenced by treatments, drying methods and storage period and their interaction effects are presented in Table-20 and depicted in Fig.-8.

The detailed study of the data presented in the table indicated that the treatments and drying methods differed significantly among themselves.

Table 20. Organoleptic scores (out o 5.0) for texture of dehydrated fig fruits as influenced by pre-treatments, drying methods and storage period

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	2.067	2.033	2.050	1.833	1.633	1.733	2.100	2.000	2.050	2.000	1.889	1.944
T_2	4.267	4.233	4.250	4.333	4.233	4.383	4.533	4.433	4.483	4.378	4.300	4.339
T_3	3.900	3.800	3.850	3.767	3.633	3.700	3.933	3.867	3.900	3.867	3.767	3.817
Mean	3.411	3.356	3.383	3.311	3.239	3.239	3.522	3.433	3.478	3.415	3.319	3.367

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0375	0.1423
Drying methods (D)	0.0375	0.1423
Storage (S)	0.0307	NS
Interaction (T x D)	0.0650	NS
Interaction (T x S)	0.0531	NS
Interaction (D x S)	0.0531	NS
Interaction (T x D x S)	0.0920	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

Considering the overall treatment means scores irrespective of drying methods and storage period, it was noticed that significantly highest scores were recorded in T_2 (4.339) followed by T_3 (3.817), whereas lowest score was recorded in T_1 (1.944).

Considering the mean scores of drying method irrespective of treatments and storage period, it was noticed that significantly highest scores were recorded in electric drier (3.478), which was on par with sun drying (3.383), whereas lowest scores were recorded in solar drier (3.239).

4.2.10.3 Taste

The data pertaining to the taste of dehydrated fig fruits as influenced by treatments, drying methods, storage period and their interaction effects are presented in Table-21 and depicted in Fig.-8.

The data presented in the table indicates that the treatments, drying methods and storage period differed significantly among themselves.

The overall treatment mean scores irrespective of drying methods and storage period was highest in T_2 (4.244) followed by T_3 (2.839), whereas lowest score was noticed in T_1 (1.683).

The mean scores of drying methods irrespective of treatments and storage period were maximum in electric drying (3.783), whereas lowest

Table 21. Organoleptic scores (out of 5.00) for taste of dehydrated fig fruits as influenced by pre-treatments, drying methods and storage period

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	1.033	1.000	1.017	1.167	1.033	1.100	3.033	2.833	2.933	1.744	1.622	1.683
T_2	4.333	4.133	4.233	4.133	4.033	4.083	4.567	4.267	4.417	4.344	4.144	4.244
T_3	2.333	2.233	2.283	2.367	2.100	2.233	4.033	3.967	4.000	2.911	2.767	2.839
Mean	2.567	2.456	2.511	2.556	2.389	2.472	3.878	3.689	3.783	3.000	2.844	2.922

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0326	0.1237
Drying methods (D)	0.0326	0.1237
Storage (S)	0.0266	0.1009
Interaction (T x D)	0.0564	0.2140
Interaction (T x S)	0.0460	NS
Interaction (D x S)	0.0460	NS
Interaction (T x D x S)	0.0797	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

score was observed in solar drying (2.472), which is on par with sun drying (2.511).

The mean scores of storage period irrespective of treatments and drying methods was found to decrease from 3.00 to 2.84 during the storage period of 4 months.

The interaction between treatments and drying methods were also found significant. The highest score was obtained in T_2 (4.417) in electric drying, which is on par with T_2 (4.233) in sun drying, whereas lowest score was obtained in T_1 under sun drying (1.017).

4.2.10.4 Flavour

The data pertaining to the flavour of dehydrated fig fruits as influenced by treatments drying methods and storage period and their interaction effects are presented in Table-22 and depicted in Fig.-8.

The data presented in the table indicates that the treatments drying methods and interaction between treatments x drying method showed significant differences.

Considering the overall treatment mean scores irrespective of drying methods and storage period, it was noticed that the significantly highest score was observed in T_2 (4.316) followed by T_1 (3.439), whereas lowest score was recorded in T_3 (3.117).

Table 22. Organoleptic scores (out of 5.00) for flavour of dehydrated fig fruits as influenced by pre-treatments, drying methods and storage period

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	3.133	3.033	3.083	3.667	3.600	3.633	3.633	3.567	3.600	3.478	3.400	3.439
T_2	4.433	4.300	4.367	4.333	4.267	4.300	4.467	4.367	4.417	4.411	4.311	4.316
T_3	3.100	3.033	3.067	3.200	3.067	3.133	3.200	3.100	3.150	3.167	3.067	3.117
Mean	3.556	3.456	3.506	3.733	3.644	3.689	3.767	3.678	3.722	3.689	3.593	3.639

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0416	0.1579
Drying methods (D)	0.0416	0.1579
Storage (S)	0.0339	NS
Interaction (T x D)	0.0720	0.2732
Interaction (T x S)	0.0588	NS
Interaction (D x S)	0.0588	NS
Interaction (T x D x S)	0.1018	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

Considering the mean scores of drying methods irrespective of treatments and storage periods, it was noticed that the significantly highest score was observed in electric drying (3.722), which was on par with solar drying (3.689), whereas lowest score was observed in sun drying (3.506).

The interaction between treatments and drying methods was significant. Maximum score was obtained in T_2 under electric drying (4.417), which is on par with T_2 under sun drying (4.367) and solar drying (4.300), whereas lowest score was observed in T_1 and T_3 under sun drying (3.033).

4.2.10.5 Overall acceptability

The data pertaining to the overall acceptability of dehydrated fig fruits as influenced by treatments drying methods and storage period and their interaction effects are presented in Table-23 and depicted in Fig.-8.

The data presented in the table indicated that the treatments, drying methods and storage periods differed significantly among themselves. The interaction between treatments and drying methods also showed significant differences.

Considering overall treatment mean scores irrespective of drying methods and storage period, it was noticed that significantly highest

Table 23. Organoleptic scores (out of 5.00) for overall acceptability of dehydrated fig fruits as influenced by pre-treatments, drying methods and storage period

Treatments	Methods of drying											Over all treat-ment mean
	Sun drying			Solar drying			Electric drying			T x S		
	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	Mean	Initial	4 MAS	
T_1	1.200	1.067	1.133	1.433	1.267	1.350	1.833	1.667	1.750	1.489	1.333	1.411
T_2	4.467	4.100	4.283	4.167	4.100	4.133	4.667	4.467	4.567	4.433	4.222	4.328
T_3	2.567	2.400	2.483	2.033	1.933	1.983	3.267	3.167	3.217	2.622	2.500	2.561
Mean	2.744	2.522	2.633	2.544	2.433	2.489	3.256	3.100	3.178	2.848	2.685	2.767

For comparing the means	S.Em±	C.D. (0.01)
Treatments (T)	0.0429	0.1628
Drying methods (D)	0.0429	0.1628
Storage (S)	0.0350	0.1328
Interaction (T x D)	0.0743	0.2820
Interaction (T x S)	0.0607	NS
Interaction (D x S)	0.0607	NS
Interaction (T x D x S)	0.1051	NS

T_1 – Control

T_2 – Blanching fruits in boiling water for 4 minutes + dipping in 2% KMS solution for 30 minutes

T_3 – Dipping fruits in solution of 1.5% dip oil + 0.1% K_2CO_3 for 3 minutes

MAS = Months after storage

NS = Non-significant

score was obtained in T_2 (4.328) followed by T_3 (2.561), whereas least score was observed in T_1 (1.411).

Considering the mean scores of drying methods irrespective of treatments and storage period, it was noticed that significantly highest score was obtained in electric drying (3.178), whereas least score was obtained in solar drying (2.489).

Considering the mean scores of storage period irrespective of treatments and drying methods, it was noticed that there was a marginal reduction in scores from 2.848 (initial) to 2.685 at 4 MAS.

The interaction between treatments x drying methods showed significant differences. Significantly highest scores were recorded in T_2 (4.563) under electric drying, whereas lowest score was obtained in T_1 (1.133) in sun drying.

DISCUSSION

V. DISCUSSION

Fig is one of the commercial fruit crops of Karnataka, grown in arid and semi-arid zones. The nutritive index of fig is as high as 11 as compared to 9 of apple, 8 of raisin and 6 of dates and pears (Chadha, 2001). Fig fruits being perishable need to be consumed or processed immediately after harvest. Increased production of fig has led to seasonal glut in the market, fetching uneconomic prices to farmers. In the absence of commercially available and economically viable technology for processing of fig, fruits are now being disposed off only through fresh market. This has caused considerable reduction in the price of fresh fruit.

After reviewing the literature, it has become evident that little attention has been given to develop the processing technology for fig. Based on the available technology for other fruits, few products such as fig burfi, fig toffee, dehydrated fig fruits, fig meat, jam, syrup and wine have been tried for the domestic as well as for international markets. Further, sincere efforts need to be made to standardise the drying technique and evaluate the consumer acceptance and economic viability of commercialisation of these products. Out of several products that can be prepared from fruits, dehydrated fig fruits are most popular in India as well in the world (Woodroof, 1975). Most of the dehydrated fig fruits available in the market are imported ones. In absence of economic and easily available standard technology for dehydration of fig fruits in India, large scale processing of fig through dehydration is not being taken up. Therefore an attempt has been made in the present investigation to standardise the drying techniques in fig fruits. The results obtained are discussed in this chapter.

5.1 STANDARDISATION OF PRE-TREATMENTS

Pre-treatments before drying are necessary in order to check the undesirable physico-chemical and other qualitative changes that may occur during the drying process. The changes in the physico-chemical characteristics such as discolouration and off flavour development in the product are mainly attributed to the enzymes present in the fruit. Therefore, it is necessary to check the undesirable changes that may occur during the drying process and also hasten the drying process. Various pre-treatments like sulphuring, steeping in sugar syrup, dipping in solution of dip oil and potassium carbonate, blanching in hot water have been reported by different workers in different kinds of fruits (Khurdiya, 1980 in ber; Mehta *et al.*, 1982 in pineapple; Vaghani and Chundawat, 1986 in sapota; Khurdiya and Roy, 1986 in ber; Thonta and Patil, 1988 in fig; Pawar *et al.*, 1992 and Mali, 1997 in fig; Kaleemullah *et al.*, 2002 in papaya). Therefore an attempt was made to find out suitable pre-treatments for fig fruits which would not only help for getting good quality dehydrated fig fruits but also hasten the drying process.

In the present investigation, the recovery of dehydrated fig fruits as well as dehydration ratio showed significant variations due to different pre-treatments. The highest recovery of dehydrated fig fruits and lowest dehydration ratio were observed in pre-treatment of steeping in 60°Brix sugar syrup for 24 hours (Table-1). Similar increase in recovery of dried fruits was observed by Vaghani and Chundawat (1986) in sapota slices pre-treated with sugar syrup (40%) + KMS (1.0%) and Mehta *et al.* (1982) in pineapple slices pre-treated with 70°Brix sugar syrup. The increase in yield, i.e., dehydration percentage of dried fruits may be attributed to the transfer of sugars from the syrup to the fruit through osmosis (Agarwal *et al.*, 1997). This is further evidenced by significant increase in the total sugar content of dried fig fruits treated with sugar syrup (Table-3). These results are further supported by Somogyi and Luh (1975) who stated that during osmotic dehydration, the total solids, viz., sugars, organic acids, etc., are concentrated through osmotic pressure, apart from drawing moisture from the fruit. Whenever dehydration percentage was higher, dehydration ratio was lower, which indicates the inverse relationship between them. From the point of getting higher yield of dehydrated fruit, lower dehydration ratio is preferable which was obtained in fruits steeped in 60°Brix sugar syrup.

In the present investigation, the moisture content of dehydrated fig fruits showed significant variation due to pre-treatments. The yield of dehydrated product is governed by its final moisture content. Lower levels of moisture were retained in fruits treated with a mixture of dip oil and K_2CO_3 solution (Table-2). This might be due to the action of dip oil and K_2CO_3 to dissolve the waxy bloom present on the skin of fruits and also to develop cracks on the skin. As a result of which, it hastens the process of moisture loss from fresh fruits during drying. This work is in line with the reports of Thimmareddy *et al.* (1988) and Kattimani (1993) in grapes.

It is desirable to dry a product in as short time as possible in order to attain the desirable moisture content. Though drying methods do influence the number of hours required for drying to a great extent, the pre-treatments may also have an influence on the time taken for a product in any particular method of drying. In the present investigation, the pre-treatments did significant influence on the number of hours taken for drying (Table-2). In case of fig fruits dried after steeping in sugar syrup, the period of drying was higher than that of control, whereas in case of fig fruits dried after blanching + sulphitation and dipping in mixture of dip oil and K_2CO_3, the number of hours required for drying was lower than that in control. This variation in the number of hours may be attributed to the pre-treatments. The increased concentration of sugar in the fruit might have increased the time taken for drying because the sugar layer present at the surface of fruits hinders with the free escape of moisture from the fruits, especially during later period of drying, i.e., 'falling rate of drying'. Similar results of enhanced drying period in fruits pre-treated with sugar syrup have been reported by Mehta and Tomar (1980) in guava, Kaleemullah *et al.* (2002) in papaya and Thonta and Patil (1988) in fig.

In case of processed products, yield is not the sole criteria for evaluating the efficiency of treatment. Quality of a product is given prime importance as it is directly related to the consumer acceptability in the commerce. The physico-chemical composition determines the quality of a product. It is evident from the present investigation that the level of total sugars were significantly higher in the fruits, steeped in sugar syrup as compared to control (Table-3). The osmotic process initiated between the fig fruits and the sugar syrup used for steeping the fruits, due to the difference in the osmotic potential between them, has resulted in the transfer of sugar molecule to the fruit. Similar result of increased concentration of sugar in fruits treated with sugar syrup has also been reported by Thonta and Patil (1988), Mali (1997) and Pawar *et al.* (1992) in fig, Vaghani and Chundawat (1986) in sapota and Devaraju (2001) in ber.

Ascorbic acid is one of the important parameters from the nutritional point of view. In the present investigation ascorbic acid in the dehydrated fig fruits treated with sugar syrup was significantly higher than that in control (Table-3), indicating that the sugar syrup treatment helped in retaining ascorbic acid. Similar findings were reported by Somogyi and Luh (1975) and Mali (1997) in fig.

Non-enzymatic browning is a common phenomenon observed in dehydrated products. This non-enzymatic browning is more specific with the products having high sugar content. In the present investigation, the OD values for non-enzymatic browning measured immediately after preparation and four months after storage were found to be much lower in T_2 and T_3 (blanching plus sulphitation) as compared to control (Table-4). This may be due to the antioxidant properties of the SO_2 used in the treatments. Similar results were also reported by Kattimani (1993) and Ambadan *et al.* (1977) in grapes.

Evaluation of sensory qualities of a product is an important tool for deciding the consumer acceptability. Human element plays an important role in the evaluation of organoleptic characters of a product. For a new product, the consumer acceptability needs to be evaluated first at the laboratory level. Hence, in the present investigation, 10 semi-trained panellists comprising of the teachers and post-graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi were involved in the evaluation process.

In the present investigation, the results of organoleptic evaluation of dehydrated fig fruits at the beginning and four months after storage has clearly indicated that all the treatments have helped to improve the organoleptic characters as compared to the control. However, different treatments have shown significant variation among themselves with respect to various parameters. Among the treatments tried, blanching + sulphitation by way of dipping in two per cent KMS for 30 minutes has improve the colour and appearance significantly with a score of more than four indicating its ready acceptance by the consumer. Eventhough steeping in 60°Brix sugar syrup had comparatively a good colour of dehydrated fig initially but during storage over a period of four months, there was discolouration leading to blackening. This might be due to non-enzymatic browning during storage, which is indicated by highest OD value (Table-4). This may be attributed to high sugar content of the fruits steeped in 60°Brix sugar syrup which might have reacted with the acids present in the fruit leading to non-enzymatic browning. Similar results were observed by Pawar (1989) and Mali (1997) in fig, Mehta and Tomar (1980) in guava, Sagar and Khurdiya (1999) in mango. The colour and appearance of fig fruits treated with dip oil + K_2CO_3 was also found to be just acceptable. Similar results were observed by Thimmareddy *et al.* (1988) and Kattimani (1993) in grapes.

Texture is an important quality parameter of dehydrated fruits. The scores for texture in blanching + sulphitation treatment and also in 60°Brix sugar syrup treatment have been found to be more than four at initial stage as well as at four months after storage, indicating that these pre-treatments were readily acceptable with respect to texture. The scores on texture in other treatments consisting of dip oil + K_2CO_3 were also found to be quite acceptable as the scores ranged between 3.37 and

3.75 as compared to the control fruits (3.12). The highest score obtained in 60°Brix sugar syrup treatment may be attributed to the higher sugar content in the treated fruits. This observation is in line with Agarwal *et al.* (1997) in ber and Somogyi and Luh (1975).

Ultimately the taste and flavour of the product play a decisive role in the acceptability of the product by the consumer. The scores for taste were highest for the treatment 60°Brix sugar syrup but were also more than or equal to four in blanching + sulphitation treatment indicating that these treatments were superior to other treatments. The best treatment with respect to taste in dip oil + K_2CO_3 treatment was 1.5 per cent dip oil + 1.0 per cent K_2CO_3 (T_7) which had a score of around four. However, with respect to flavour, maximum scores were recorded in blanching + sulphitation treatment followed by steeping in 60°Brix sugar syrup which indicated the superiority of blanching + sulphitation, as sulphur dioxide provided through KMS is a known antioxidant which has helped not only in preventing discolouration but also preventing off flavour development (Jacob, 1944; Thimmareddy *et al.*, 1988 and Kattimani, 1993).

Based on the four important organoleptic parameters discussed so far and also based on score for overall acceptability, it can be inferred that blanching + dipping in two per cent KMS solution is a superior treatment among the treatments tried followed by dipping in 1.5 per cent dip oil + 1.0 per cent K_2CO_3 and steeping in 60°Brix sugar syrup. Even though 60°Brix sugar syrup treatment has improved the texture and taste, it has scored low for overall acceptability because of its poor colour.

Based on organoleptic evaluation, blanching for four minutes + dipping in two per cent KMS solution for 30 minutes (T_3) and dipping in 1.5 per cent dip oil + 1.0 per cent K_2CO_3 for three minutes were selected as suitable pre-treatments for further evaluation under different methods of drying.

5.2 STANDARDISATION OF DRYING METHOD

Drying or dehydration is a method of preservation of fruits practised by human being since time immemorial. In primitive days, man used to dry the fruits like grapes, dates under sun and preserve them for use in off-season. Drying or dehydration is a cheaper method of preservation of fruits as compared to canning, freezing and fermentation. Several drying techniques using different equipments have been developed for various fruits and vegetables. Among the drying techniques, sun drying, i.e., drying under sun light has been found to be the cheapest method of dehydration. It is commonly practised in places where there is plenty of sunshine and dry atmosphere (low relative humidity). But this method has certain limitations, i.e., it cannot be practised at all places during all the seasons of the year. It takes more time for drying and also quality and cleanliness cannot be ensured. Solar drying, wherein drying is accomplished using various types of solar driers, has distinct advantages over drying under direct sun. Solar drying not only helps in efficient use of sunlight, but also minimises the pollution problem. The retention of plant pigments, especially chlorophyll carotenoids and anthocyanins, was better in the products dried in solar drier (Roy and Khurdiya, 1983). Dehydration of fruits by using an electric tray drier (mechanical drier) is a popular and commercially adopted drying technique. Uniform quality product can be obtained when dried under controlled conditions of an electric tray drier as compared to the ones dried in open sun or solar drier. Therefore, in the present investigation, these three drying methods were employed to find out the efficiency and suitability of these methods for drying fig fruits and also to investigate their effects on the quality of dehydrated produce.

The different drying methods in the present investigation differed significantly. The highest dehydration ratio (5.004) and lowest yield (20.11%) was obtained in electric drying as compared to sun drying and solar drying (Tables 10 and 11). This may be due to oozing of some soluble solids, which was observed from the fruit during the process of drying. Similar results were also obtained by Pawar (1989) in fig.

The various drying methods tried showed significant effect on the time required for drying fig fruits. A maximum of 47.61 hours were needed for drying under sun, whereas only 25.667 and 36.889 hours were required in electric cabinet drier and solar drier, respectively (Table-12). Lesser number of hours required for drying in electric and solar drier may be due to the higher temperature of drying in electric cabinet drier (60±2°C) and in solar drier (50-55°C) as compared to a temperature of 35 to 38°C maintained in the surrounding atmosphere of drying trays kept in open sun. Similar results were also observed by Bhardwaj and Lalkaushal (1990) in apple, Sharma *et al.* (1993) in apricot and Pawar *et al.* (1992) in fig.

Final moisture content of dehydrated fig fruits dried under different methods of drying varied significantly and it was higher (16.86%) under sun drying as compared to that in electric drying (16.49%) and solar drying (15.55%) methods (Table-13). The lower moisture content of fruits dried under electric and solar drier may be attributed to the presence of higher temperature and adequate hot air circulation in both driers as compared to sun drying. These results were in accordance with Sharma *et al.* (1993) and Pawar *et al.* (1992) in fig.

The lower levels of moisture were retained in fruits treated with mixture of dip oil and K_2CO_3 solution. This might be due to the action of dip oil containing 57 per cent ethyl oleate and K_2CO_3, which dissolves the waxy bloom present on the skin of fruits, and also forms cracks on the skin. As a result of which, it hastens the process of moisture loss from fresh fruits during drying. This work is in line with the reports of Thimmareddy *et al.* (1988) and Kattimani (1993) in grapes.

It is observed that the drying methods had no influence in altering the sugars and ascorbic acid content of the dried fruits, thus indicating that either of these three methods tried had no significant effect on the nutritional content of the fruit with respect to sugars and ascorbic acid.

The non-enzymatic browning varied significantly due to different methods of drying. It was low in dried figs obtained from sun drying as compared to that obtained from electric drying (Table-18). As figs are exposed to low temperatures in sun drying, the non-enzymatic browning process was slow. Similar observations have also been made by Thimmareddy *et al.* (1988) and Kattimani (1993) in grapes.

The method of drying also had significant effect on the organoleptic characters of dehydrated fig fruits. Electric drying was found to be superior to solar drying and sun drying with respect to different organoleptic characters. The organoleptic scores for colour and appearance, taste and overall acceptability were much higher in electric drying as compared to sun drying and solar drying. Even in case of texture and flavour, electric drying was found to be significantly superior to other methods of drying. The higher scores given to colour and appearance, texture, taste, flavour and overall acceptability (Tables, 19, 20, 21, 22 and 23) for a product dried in electric drier may be attributed to the uniform temperature of drying and shorter period of drying, better removal of moisture leading to crisp texture as compared to sun and solar drying. Similar results of superiority of electric drying over sun drying with respect to organoleptic quality has been reported by Teotia *et al.* (1976), Mehta and Tomar (1980), Jasimahmed and Choudary (1995) in papaya and Pawar (1989) in fig.

Among the three treatments including control, blanching + sulphitation treatment had a score of more than 4 in all the parameters indicating its superiority as a pre-treatment in obtaining good quality dried fig. Even its interaction with electric drying was found to be superior with respect to organoleptic characters. This may be attributed to effect of blanching in checking enzymatic and related bio-chemical changes and SO_2 (KMS) in preventing the discolouration and off-flavour development. Similar results were also reported by Pawar (1989), Thonta and Patil (1988), Mali (1997) in fig, Mehta and Tomar (1980) in guava and Teotia *et al.* (1976) in papaya.

Maintenance of quality of the product during storage is important in obtaining a good quality product. In the present investigation, the organoleptic quality of the dried fig was found to be influenced by the colour and appearance, taste and overall acceptability during the storage period of four months, but texture and flavour were unaffected by the storage period.

Keeping in view of the above discussion, it can be inferred that good quality dehydrated figs can be obtained with a pre-treatment of blanching the fruits for four minutes + dipping in two per cent KMS solution for 30 minutes and drying in electric drier. However, wherever the electric drier is not available, sun drying can be the next choice.

SUMMARY

VI. SUMMARY

An investigation was carried out to standardise the drying techniques in fig fruits at the Department of Post-harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi during the year 2002-2003.

The first experiment conducted to standardise the pre-treatments before dehydration of fig fruits consisted of blanching fruits for 2 and 4 minutes and dipping in 2 per cent KMS solution for 30 minutes; steeping in 60°Brix sugar syrup for 24 hours; dipping fruits in solution of 1.0, 1.5 and 2.0 per cent dip oil and 1.0 and 1.5 per cent K_2CO_3 for 3 minutes and untreated control. The pre-treated fruits were dried in electric drier. The second experiment consisted of blanching fruits for 4 minutes and dipping in 2 per cent KMS solution for 30 minutes; dipping fruits in solution of 1.5 per cent dip oil and 1.0 per cent K_2CO_3 for 3 minutes and untreated control. The treated fruits were dried in electric drier, solar cabinet drier and directly under sun light. The dehydrated fruits were stored in polyethylene bags upto 4 months at ambient conditions. The physico-chemical and organoleptic characters of dehydrated fruits were recorded. The important findings of the present investigation are summarised hereunder.

6.1 STANDARDISATION OF PRE-TREATMENTS

The maximum recovery of dehydrated fig fruits and lowest dehydration ratio was recorded in pre-treatment of fig fruits, i.e., steeping in 60°Brix sugar syrup for 24 hours (25.27% and 3.99 respectively), whereas minimum recovery and highest dehydration ratio was observed in the treatment of blanching for two minutes + dipping in two per cent KMS solution for 30 minutes (20.13% and 4.96, respectively).

The lower moisture content of dehydrated fig fruits was recorded in dipping fruits in 2.0 per cent dip oil + 1.5 per cent K_2CO_3 solution for 3 minutes (14.40%), whereas higher moisture content (18.70%) was observed in fruits steeped in 60°Brix sugar syrup for 24 hours.

The time required for drying of fig was minimum (25.00 hours) in the treatment of blanching for 2 minutes + dipping in 2 per cent KMS solution for 30 minutes, blanching for 4 minutes + dipping in 2 per cent KMS solution for 30 minutes, dipping fruits in 2.0 per cent dip oil + 1.0 per cent K_2CO_3 solution for 3 minutes and dipping fruits in 2.0 per cent dip oil + 1.5 per cent K_2CO_3 solution for 3 minutes, whereas maximum time required was observed in steeping fruits in 60°Brix sugar syrup for 24 hours (30.3 hours).

The highest reducing and total sugar contents were observed in the fruits steeped in 60°Brix sugar syrup for 24 hours (52.15% and 55.20%, respectively), whereas lowest reducing and total sugar were observed in fruits subjected to blanching for 4 minutes + dipping in 2.0 per cent KMS solution for 30 minutes (40.70% and 49.46%, respectively).

The highest non-reducing sugar content was observed in dipping fruits in 2.0 per cent dip oil + 1.0 per cent K_2CO_3 solution for 3 minutes (9.23%), whereas lowest non-reducing sugar content (3.05%) was recorded in fruits steeped in 60°Brix sugar syrup for 24 hours.

The highest ascorbic acid content was observed in the fruits steeped in 60°Brix sugar syrup for 24 hours (1.85 mg/100g), whereas lowest ascorbic acid content was observed in treatment with blanching for 4 minutes + dipping in 2.0 per cent KMS solution for 30 minutes (0.22 mg/100 g).

The OD values for non-enzymatic browning of dehydrated fig fruits was lowest (0.200) in blanching for 2 minutes + dipping in 2.0 per cent KMS solution for 30 minutes and blanching for 4 minutes + dipping in 2.0 per cent KMS solution for 30 minutes, whereas highest OD values was observed in fruits steeped in 60°Brix sugar syrup for 24 hours (0.631).

The highest scores for colour and appearance, flavour and overall acceptability were observed in fruits blanched for four minutes + dipping in 2.0 per cent KMS solution for 30 minutes (4.59, 4.08 and 4.45, respectively), whereas lowest scores were observed in control for the above characters (1.00, 1.11 and 1.08, respectively).

The highest scores for texture and taste were observed in dehydrated fig fruits obtained from steeping in 60°Brix sugar syrup for 24 hours (4.68 and 4.50, respectively), whereas lowest scores were observed in control (3.12 and 1.00, respectively).

6.2 STANDARDISATION OF DRYING METHODS

The highest recovery of dehydrated fig fruits and lowest dehydration ratio were recorded in sun drying (22.84% and 4.364, respectively), whereas lowest recovery and highest dehydration ratio was observed in electric drying (20.11% and 5.004, respectively).

The minimum time required for drying of fig fruits was observed in electric drying, (25.667 hours), whereas maximum drying time was recorded in fruits dried under sunlight (47.61 hours).

The lowest moisture content was recorded in solar dried fruits (15.551%), whereas highest moisture content was recorded in sun dried fruits (16.863%).

The OD values for non-enzymatic browning was lowest in sun dried fruits (0.324), whereas highest OD value was observed in electric dried fruits (0.349).

Significantly highest scores for organoleptic evaluation were observed in dehydrated fruits obtained from electric drying (3.128 for colour and appearance, 3.478 for texture, 3.783 for taste, 3.722 for flavour and 3.178 for overall acceptability), whereas lowest scores for colour and appearance and flavour were observed in sun drying. The lowest scores for texture, taste and overall acceptability were observed in solar dried fruits.

Blanching + sulphitation treatment dried in electric drier was found superior with respect to organoleptic characters.

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* Originals not seen.

APPENDICES

APPENDIX-I

Maximum and minimum temperature and relative humidity as recorded at meteorological observatory, Agricultural Research station, Arabhavi

Date	Temperature (°C)		Relative humidity (%)
	Minimum	Maximum	
15.03.03	18	34	57.5
16.03.03	19	35	55.0
17.03.03	18	31	34.0
18.03.03	18	35	36.0
19.03.03	18	35	51.0
20.03.03	17	35	46.0
21.03.03	19	35	46.0
22.03.03	18	34	35.5
23.03.03	18	35	46.0
24.03.03	18	35	39.0
25.03.03	18	35	39.0
26.03.03	18	34	39.0
27.03.03	18	35	36.0
28.03.03	19	36	36.5
29.03.03	27	37	50.0
30.03.03	27	36	36.5
31.03.03	29	36	42.5
15.04.03	30	36	38.5
16.04.03	28	32	45.2
17.04.03	27	39	52.5
18.04.03	27	36	38.5
19.04.03	26	37	38.5
20.04.03	28	32	44.0
21.04.03	25	39	44.5
22.04.03	30	31	36.5
23.04.03	30	36	36.5
24.04.03	30	32	38.5
25.04.03	32	38	49.0
26.04.03	29	35	41.0
27.04.03	28	36	52.5
28.04.03	28	37	40.0
29.04.03	29	37	44.5
30.04.03	29	38	49.5

APPENDIX-II

Physico-chemical characters of fresh fig fruits (cv. Bellary)

Sl. No.	Particulars	
1.	Shape	Pear
2.	Colour	
	a) External	Reddish green
	b) Internal	Pinkish
3.	Average length (cm)	4.80
4.	Average Diameter (cm)	5.10
5.	Average weight (g)	36.00
6.	Average volume (ml)	31.18
7.	Total soluble solids (%)	18.90
8.	Moisture (%)	76.00
9.	Ascorbic acid (mg/100 g)	5.10
10.	Total sugars (%)	17.05
11.	Reducing sugars (%)	13.95
12.	Non-reducing sugars (%)	3.10

APPENDIX-III

Cost of production for 50 kg dried fig

Sl. No.	Particular	Sun drying	Solar drying	Electric drying
1.	Raw material cost, 200 kg @ Rs. 30/kg	6000	6000	6000
2.	Chemical cost	50	50	50
3.	Packing cost	50	50	50
4.	Labour cost @ Rs. 40/day	360	320	280
5.	Electricity charge	-	-	2000
6.	Miscellaneous	100	100	100
	Total	6560	6520	8480

STANDARDISATION OF DRYING TECHNIQUES IN FIG FRUITS

INDUDHARA S.M. 2003 DR. G.S.K. SWAMY
MAJOR ADVISOR

ABSTRACT

An investigation was carried out to standardise the drying techniques in fig fruits at the Department of Post-harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi during the year 2002-2003.

The dehydrated fig fruits obtained from pre-treatment of blanching for 4 minutes + dipping in 2 per cent KMS solution for 30 minutes recorded better organoleptic scores for colour and appearance (4.59), flavour (4.08) and overall acceptability (4.45). The highest organoleptic scores for texture (4.68) and taste (4.50) was recorded in steeping fruits in 60°Brix syrup for 24 hours. Recovery of dehydrated fig fruits was maximum (25.27%) in treatment of steeping fruits in 60°Brix sugar syrup for 24 hours. The lowest moisture content of dehydrated fig fruits was recorded in dipping fruits in 2 per cent dip oil + 1.5 per cent K_2CO_3 solution for 3 minutes (14.40%). The highest total sugar (55.20%) and ascorbic acid (1.85 mg/100 g) content were recorded in fruits steeped in 60°Brix sugar syrup for 24 hours. The OD value for non-enzymatic browning of dehydrated fig fruits was lowest (0.200) in blanching + sulphitation treatment.

Among the different methods of drying, the highest recovery (22.84%) of dehydrated fig fruits was recorded in sun drying. The minimum drying time was observed in electric drying (25.67 hours) followed by solar drying (36.89 hours) and the maximum in sun drying (47.61 hours). The OD values for non-enzymatic browning was the lowest in sun dried fruits (0.324). The highest scores for organoleptic evaluation were observed in dehydrated fruits obtained from electric drying, 3.13 for colour and appearance, 3.48 for texture, 3.78 for taste, 3.72 for flavour and 3.18 for overall acceptability.

Organoleptically accepted dehydrated fruits were obtained in blanching + sulphitation treatment and dried in electric drier.