INFLUENCE OF PRE–DRYING TREATMENTS AND DRYING METHODS ON DIFFERENT RECIPES OF AONLA (*Emblica officinalis* GAERTN) PRODUCT PREPARATION

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"INFLUENCE OF PRE–DRYING TREATMENTS AND DRYING METHODS ON DIFFERENT RECIPES OF AONLA (*Emblica officinalis* Gaertn.) PRODUCT PREPARATION."

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ABSTRACT

An experiment was conducted at Department of Horticulture, N. M. College of Agriculture; N. A. U., Navsari, entitled "Influence of pre–drying treatments and drying methods on different recipes of aonla (*Emblica officinalis* G.) Product preparation." The experiment was conducted during Dec. 06- May 07 in P.G. Laboratory in completely randomized design with factorial concept and replicated thrice for various treatments, two levels of pre-drying (i.e. blanching and blanching with sulphitation), four levels of recipe (i.e., Fruit pieces with 3 per cent black salt and 3 per cent common salt with and without ginger juice 10 per cent), two drying methods (i.e., sun drying and oven drying) and their combinations were used. Therefore seventeen treatment combinations were tried in the present investigations. Among various treatments, the value of organoleptic acceptance is improved and recovery percentage was

increase by oven drying of fruits while colour was improved by blanching of fruits with sulphitation (KMS @ 1000 mg/l). In case of recipes, fruit pieces with 3 per cent common salt 3 per cent were more preferable. In case of drying methods, oven drying was more effective for physico-chemical parameters of dehydrated aonla product during storage.

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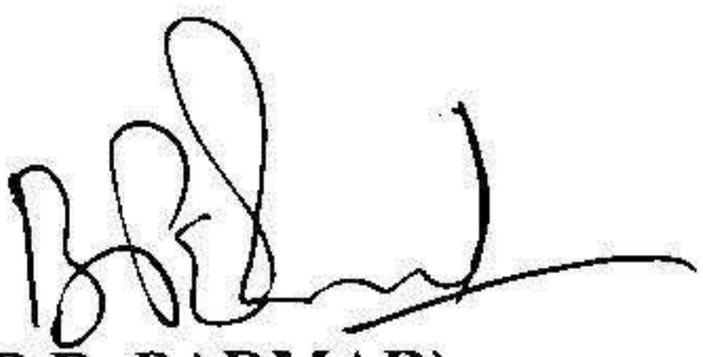
CERTIFICATE

This is to certify that the thesis **"INFLUENCE OF PRE–DRYING TREATMENTS AND DRYING METHODS ON DIFFERENT RECIPES OF AONLA (*Emblica officinalis*) PRODUCT PREPARATION."** submitted by **SUMER SINGH RAJPUROHIT** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICUTURE** of Navsari Agricultural University, Navsari, is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed on the basis for the award of any degree, diploma or other similar title.



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DECLARATION

This is to certify that the whole of the research work reported here now submitted in this thesis for the partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** is the result of investigation done by the undersigned under the direct guidance and supervision of **Dr. B.R. PARMAR, ASSOCIATE PROFESSOR (HORTICULTURE)** Department of Horticulture, N. M. College of Agriculture, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

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(Sumer Sing Rajpurophit)

I. INTRODUCTION

The aonla or Indian goose berry (*Emblica officinalis* Gaertn, syn *phyllanthus emblica* Linn) is one of the most important indigenous fruit crop of India. It belongs to the family Euphorbiaceae and sub family phyllanthoidae of tropical South Eastern Asia, particularly in Central and Southern India. (Firminger, 1947).

Aonla plants thrive well through the tropical and sub tropical parts of India (Sant Ram, 1983). It is spreading rapidly in the semi-arid regions of Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka, Tamilnadu and some parts of Haryana, Punjab and Himachal Pradesh. In India aonla grown an area of 63,543 hectars with production of 2.25 million tonne (Anonymous, 2006) Uttar Pradesh is the largest producer in India. In Gujarat it is commonly cultivated in Kheda, Anand, Mehshana, Patan, Panchmahal, Rajkot, Sabarkantha, Ahmedabad, Banaskantha and Bhavnagar with the total area of 12,256 hectars and production of 116128 MT (Shah *et al.*, 2006).

It is a hardy plants and can successfully grown in different agro-climatic and soil conditions, It having to immense potentiality of cultivation on wasteland and great tolerance to salinity, alkalinity and sodicity nature of soil. It is a very hardy and prolific bearer and highly remunerative crop without much care. In recent years aonla has emerged as the most important commercial fruit crop for the farmers because of its low water

requirement habit. It can be grown easily in calcareous and slightly saline as well as alkaline soils. Hence, common fruit crops do not survive on that place.

Aonla is known for its great medicinal and therapeutic properties from the ancient times in India. It is not only a source of nutrients and medicine for human being, but growing this crop has also proved to be highly remunerative.

The aonla fruit is one of the richest source of vitamin-'C' after Barbados cherry (*Malpighia glabra* L.). It contains 500 to 1500 mg ascorbic acid (100^{-1}g pulp). This fruit is valued high in indigenous medicines in India (Lal *et al.*, 2006). Nutritional composition of aonla fruits presented in Appendix-I.

The vitamin 'C' content found to be superior in aonla juice, which 20 times higher than the orange juice. It is also rich in lysine and phenol content. But, it has very little table value due to its acid and bitter nature. Therefore, the fruits are utilize after processing. The fruits are made into various post harvest products, i.e., murabba, squash, dried chips, tablets, jam, jelly, pickle, toffees, powder, juice, pulp, *Mukhwas*, chocolate, candy, drops swarasa, mouthwash, *Kulfi*, biscuit, *Shrikhand*, *Ghanvati*, *Pan masala*, *Amchoor*, *Churan*, *Chywanprash*, mouth freshner, *Laddoo*, *Chutney*, *Avleha*, *Sabzi*, ice-cream, *Supari*, cold drinks, capsules, aonal pak (Sharma, 2006), Garg and Goel, (2006) and Singh *et al.* (2006) .

Aonla becomes ready for harvesting from mid November to first week of January. The produce remains in the market for a very short period. Since it is a perishable commodity it needs quick disposal. Huge harvest of produce during peak harvesting season creates glut and the growers are compelled to sell their produce at distress prices. Owing to restricted availability and high perishability of aonla fruits, value addition through processing would be the only effective tool for economic utilization for increase production of aonla fruits. The post harvest losses in aonla vary from 30 to 40 per cent due to its perishable nature and glut during harvesting time, which reduce the market value of the fruit. Hence, dehydration of aonla is one of the solutions to overcome the problem of post harvest losses as well as to provide high returns to the growers and the availability of the fruits to consumers during off season. Dehydrated aonla products like shred, pulp, *Supari*, etc., can also be made to reduce post harvest losses. The dehydrated aonla is used in table *Chutney* and coocked vegetable. Aonla powder is used in various types of medicines on commercial scale.

A number of economically cheaper techniques has been evaluated to improve the quality of dehydrated fruits and vegetables. Among these the treatment of blanching before drying, checks the enzymatic spoilage, removes astringency and also improved the texture of fruits. After blanching sulphitation is done, since it improves the quality and increases the shelf life of dehydrate products (Bhatia *et al.*, 1962). This entirely depends on

the process, i.e., blanching and drying. Sulphur dioxide acts as a disinfectant and prevents the oxidation and darkness of fruits on exposure and thus, improves the colour. It also acts as preservative by checking the growth of mould.

Sun drying of fruits and vegetables is a cheap method of preservation. This method can be used on commercial scale as well as home scale provided that sunshine intensity is relatively more after the normal harvesting period. The sun drying is simple and cheaper to several conditions and small scale food processing industries. Besides there use of various recipes for value addition and improve organoleptic acceptance have been found to be quite effective in dehydrated fruit products. In view of the above facts very little research work has been carried out in India and perhaps no attempt have yet been made under Navsari agro climatic condition for the preparation of dehydrated aonla product.

Therefore, keeping these points in view the present investigation was undertaken with following objectives.

1. To evaluate the effect of blanching and sulphitation as pre-drying treatments on physico-chemical quality of dehydrated aonla product during storage.
2. To find out most appropriate of recipe for preparation of dehydrated aonla products
3. To study the effect of sun and oven drying methods on physico-nutritional quality of dehydrated aonla product during storage
4. To find out economic feasibility of various treatments

II. REVIEW OF LITERATURE

In the present chapter attempt has been made to compile the available literature pertaining to the influence of pre-drying treatments (i.e., blanching and sulphitation) and drying methods (i.e., Sun and oven drying) on different recipes of aonla (*Emblica officinalis* Gaertn.) product preparation.

2.1 Effect of blanching

2.1.1 Aonla

Geetha *et al.* (2006 a) studies that effect of blanching on physico-chemical characteristics of aonla fruits and found decreases in TSS, ascorbic acid, pectin, acidity compared to fresh aonla fruits.

Tripathi *et al.* (1988) studied that during the preparation of chywanprash, fruits are required to be pricked blanched and processed in sugar syrup. This process is similar to processing methodology for the preparation of jam like fruits are pricked, blanched and boiled in sugar. In this process, there is an increase in the level of TSS and decline in vitamin C and acidity.

Anand (1970) studied the effect of certain parameters on the loss of tannins and vitamin-C in aonla preserve in treatments of soaking and blanching of fruits resulted in heavy losses of constituents.

Sethi (1986) examined the effect of blanching on drying of aonla. Among fresh fruit, blanched dried fruits,

unbleached dried fruits and dried fruit pulps the highest storage stability was in dried fruit pulps (12 months) while fresh fruit stored up to 45 days which was recorded as minimum storage stability. The lesser the drying period, the nutrient losses found minimum as compared to prolonged storage period.

Tandon *et al.* (2003) reported that the effect of blanching and lyepeeling on the quality of aonla candy. The candy prepared from lye peeled fruits having lower acidity and found better quality may be due to the shining colour and better sugar acid blend as compared to blanched fruits.

Chauhan *et al.* (2005) conducted a laboratory experiment on the development of aonla blanched sauce by using aonla pulp blended with tomato pulp (50:50). The pH, TSS and ascorbic acid content found decreased while acidity increased after 90 days of storage passage at room temperature.

Patel *et al.* (2006) observed that the organoleptic test of *mukhwas* of two varieties of aonla viz., Gujarat aonla-1 and NA-7 under sun drying condition among the different treatments in organoleptic taste, ginger and sugar of different preparations recorded higher scores and variety NA-7 registered higher scores for organoleptic test than that of Gujarat aonla-I.

Geetha *et al.* (2006 b) observed that the effect of blanching on physico-chemical characteristics of aonla found reduced physico-chemical characteristics as compared to fresh fruit except TSS content after blanching.

Verma and Gupta (1996) conducted an experiment on aonla cv. Banarasi in which fruits were dried in the open sun following various pre-drying treatments i.e., slicing or pricking or a combination of pricking + bleaching, pricking + blanching + flaking, pricking + blanching + sulphitation (soaking in 0.1% potassium metabisulfite for 5 min.) or pricking + blanching + sulphitation + flaking. They reported that ascorbic acid retention after drying was highest (64%) in sliced samples and lowest (18.0%) in untreated control. All the treatments significantly improved colour and overall acceptability as compared with control.

Sethi (1986) suggested that keeping qualities of dehydrated aonla may be improved by blanching of fruits in boiling water. The non-enzymatic browning was minimum in the dried aonla pulp and maximum in the whole unblanched fruits. Blanching of whole fruits showed less browning due to inactivation of polyphenol oxidase that caused browning during storage.

2.1.2 Other fruits

2.1.2.1 Banana

Dandamrongrak *et al.* (2003) studied the effect of four pre-treatments (blanching, chilling, freezing and combined blanching and freezing) on the drying rate and quality of banana (*Musa accmuminata* cv. Williams). An untreated sample was used as control. The initial drying rate was highest for the blanched

treated sample was sued as control. The initial drying rate was highest for the blanched treatment whereas, the two pre-treatments involving freezing resulted in the shortest drying times. The blanched samples were most preferred in terms of colour while the frozen samples exhibited extensive browning. Texture and flavour were significantly reduced in all the samples that involved blanching of freezing.

2.1.2.2 Ber

Khurdiya (1980) advocated blanching time of 2 minutes for cardemom; 4 minutes for *Bagwari* and *Chhuhara* and 6 minutes for Katha cultivars, Kumar and Nath (2002) reported that blanching in boiling water gave a product of poor quality in ber, dipping in 1 per cent solution of NaOH for 1 minute, followed by rinsing in water and 5 per cent citric acid and dipping in 4000 ppm KMS solution for 12 hours was found to be the best pre- treatment to prepare *chhuhara* like product from ber.

Narwadkar and Rodge (2003) studied the equilibrium of ber powder from ber cv. Kadaka. The powder was prepared from unblanched, blanched and sulfate treated samples of Kadaka. At 65 per cent relative humidity, the mould growth was observed after 10, 12 and 18 days in unblanched, blanched and blanched with sulfate treatments, respectively.

2.1.2.3 Dates

Kalra *et al.* (1978) prepared dry dates by curing of dates of doka stage in boiling water for 4-10 minutes and drying

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in oven at 49 ± 1°C from four different cultivars (medjool, hillawi, khudrawi and Shermaj). The average weight of the fruit decreased with increase in time of dipping in each cultivar.

Gupta and Siddiqui (1986) demonstrated that for making dry dates from Khadrauly and Shamrah cultivars cooking for 10-15 minutes for making soft dates, curing for much shorter period i.e. for 20-25 seconds followed by dehydration at 30-40°C was required.

2.1.2.4 Litchi

Jain (1959) stated that bright attractive white colored dried litchi fruits were obtained by first blanching followed by dipping in boiling water for five minutes or in live steam at atmospheric pressure for about 15-20 minutes, followed by sulphitation for about 15-20 minutes, which were further treated with sulphitation of the fruits by immersion in 2.0 per cent solution of KMS (1 x ¼ lbs of solution per Ib of fruit) for 48 hours after which it was dried in the sun.

2.1.2.5 Mango

Dabhade and Khedker (1980a) observed heavy leaching losses of acids, sugars and ascorbic acid during blanching in boiling water and sulphitation of raw pieces of Totapuri mango. The losses of ascorbic acid were more during blanching and sulphitation.

The application of blanching and sulphitation treatment to *amchur* (a dehydrated product of unripe mango)

resulted in the higher organleptic score as compared to untreated control (Dabhade and Khedkar, 1980 b).

2.1.2.6 Drum stick

Amutha and Krishnamoorhty (1999) reported that the colour was better in blanched and sulphited dried slices of drumstick

2.2 Effect of sulphitation

2.2.1 Aonla

Srivastava and Kumar (1994) observed that sulpher dioxide fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus improved their colour. This phenomenon is generally seen in sliced fruits, which found darker in colour, due to oxidization of the coloring matter. Fumes of Sulpher also act as preservative and, check the growth of moulds etc and prevent cut fruit pieces from fermentation while drying in the sun. Vitamins in sulphered fruits were also protected but not in ansulphered ones.

2.2.2 Mango

Mango powder made after blanching and sulphuring was of better quality (Dabhade and Khedkar, 1980 c)

Mehta and Tomar (1982) advocated treatment of mango slices with 0.1 per cent KMS before dehydration. They observed that slices treated with 0.1 percent KMS gave best dehydrated product and on conversion in to product such as mango chutney, mango pickle and raw mango powder etc.

Khedkar and Roy (1983) concluded that absorption and retention of SO_2 in raw mango slices increased with increasing concentration of KMS solution and during of steeping sun drying and cabinet drying.

Teotia *et al.* (1987) recommended steam blanching and exposure to dry sulpher fumes at 10 g/kg/h., to mango slices, as a good alternative of blanching to obtain better quality powder avoiding heavy leaching losses.

2.2.3 Ber

In ber, pre-drying treatment with burning sulpher at 150g/8kg fruits for 3 hours was considered optimum (Khurdiya, 1980).

Gadakh *et al.* (1999) studied the effect of pre-treatments like blanching and sulphuring on quality of dried ber product. The highest over all acceptability of dried ber fruit was recorded at fruit slices with sulphuring treatments (7.67) followed by destined fruits with blanching + sulphuring treatment (7.33) while, untreated fruits resulted the minimum over all acceptability (5.38).

2.2.4 Sapota

In sapota, Vaghani and Chundawat (1986) reported that dried slices of sapota steeped in 40 per cent sugar syrup contained 1 percent KMS for 20 minutes gave the most stable and quality product which contained 40-52 percent sugar. The organoleptic quality of these slices could be retained for 9-11 months, texture up to 11 month and taste upto 9 months at ambient temperature.

Similarly, Vaghani and Chundawat (1997) reported that sapota slices steeped in 70 percent syrup + 1 percent KMS for 3 hour and than sun dried for 37 hour resulted in the best quality product. The dried slices have high ratings for taste, texture, colour and appearance and remained acceptable for 11 months when stored in heat sealed polythene bags at room temperature (20-35^{0}C).

2.2.5 Apple

Alizai *et al.* (1997) reported that Sulphuring in apple fruits was more effective for maintaining the self life beyond 6 months after dehydration.

2.3.1 Effect of recipes

Damame *et al.* (2002) prepared aonla *supari* with three treatments i.e. aonla pieces + 2 per cent common salt (T_1), aonla pieces + 3 percent black salt (T_2) and aonla pieces + 10 per cent ginger juice (T_3). They observed that all the treatments exhibited acceptable scores for their organoleptic evaluation. Similarly, Mehta and Tomar (1982) observed that mango slices treated with 5 per cent salt before dehydration gave the best dehydrated product and on conversion into product such as mango chutney, mango pickle and raw mango powder etc.

Verma and Gupta (2004) studied the effect of pre-treatments on quality of solar dried aonla. Among all the pre-treatments viz., flaking, pricking, pricking + blanching, pricking + blanching +flaking. pricking + blanching + sulphitation, pricking + blanching + flaking + sulphitation with untreated

sample, the dehydrated moisture content, dehydration ration, coefficient of restoration and ascorbic acid to be maximum in the flaked aonla. While, these values were minimum in the untreated (control) sample.

Singh *et al.* (2005 a) studied the processing of aonla fruits various recipes were evaluated for commercial processing with composition of 25% aonla pulp + 5% asparagus root extract + 2% ginger juice with 50% TSS and 1.2 % acidity for herbal squash; 50% aonla pulp + 5% asparagus root extract + 2% *ashwagandha* extract with 68% TSS and 2% acidity for herbal jam; segmented candy with pectin coating 55% aonla pulp + 2.5% butter + 0.5% custard powder + 42% sugar for toffees was found excellent for preparation of value added products.

Tandon *et al.* (2005) studied the development of *churan* from dried aonla powder and found 1.5 gm higher and 0.5 gm ajwain and 1.0 g ginger and 2.5 gm mint. Apart from other ingredients they found to be most acceptable among 14 different combinations of treatments.

Makwana *et al.* (2006) analysed the delicious drink from aonla and give the recipes for commercially RTS beverage viz. aonla (blend) beverage, aonla nectar and aonla syrup as well as the methods of extraction of aonla pulp, aonla juice and the methods for processing of RTS beverage.

Jain *et al.* (2006) observed the standardization of recipes for preparation for aonla beverages which are easily acceptable in the markets. Aonla products like RTS, nectar and

squash were acceptable for 3, 4 and 6 months during storage, respectively.

2.3.2 Bael

Singh *et al.* (2005) conducted an experiment on preparation and storage of blended bael fruit jam with different recipes like bael, bael + mango (75: 75), bael + Mango (50: 50), bael + papaya (75: 50) and bael + papaya (50: 50) mixed with 0.750 kg sugar and 3.0 g citric acid. The best recipe found was bael + papaya (50: 50) during 6 months of storage.

2.4 Effect of drying methods

2.4.1 Aonla

Sethi (1986) reported that the drying of aonla gave better organalpetically acceptable product as compared to drying of blanched and unbalanced whole fruit.

Pragati *et al.* (2000) evaluated nutritional quality of aonla var. 'Chakaiya' following 4 different methods of dehydration like solar drying (direct), solar drying (indirect), hot air oven drying and OSMO air drying. The recovery of fruit was maximum in OSMO air drying aonla.The tannin content and browning were the lowest. Indirect solar drying method was found to be comparatively better than direct solar drying method for dehydration of aonla fruit.

Jayaraman *et al.* (1991) showed that drying by direct exposure to sun resulted in significant loss of pigment and development of rancid odour due to accelerated lipid oxidation

while indirect sun drying inside the cabinet minimized these changes and products obtained were comparable with artificially ones. Main hindrance seems to be indement weather due to which there is risk of losses and difficulties in maintaining high degree of sanitation.

Srivastava (1960) stated that aonla powder prepared by drying the fruits under the sun had 10-16 mg ascorbic acid 100 g^{-1} which can be increased by regiment of the process.

Singh *et al.* (2006) studied the effect of pre drying treatments and drying methods on quality of dehydrated aonla shreds. The pre-treatments viz., blanching and blanching combined with sulphitation and solar drying treatment recorded higher ascorbic acid content during earlier storage. The ascorbic acid content of absolute control remained lower at initial and fourth month of storage.

Rokhade *et al.* (2006) studied changes in physico-chemical characteristics of sweetened dehydrated aonla slices during six months of storage involving 15 treatments and found blanched aonla fruits followed by steeping in 2 per cent salt for 2 hrs. And 60 brix sugar syrup for 24 hrs and drying under sun gave best quality sweetened dehydrated aonla slices.

Patel *et al.* (2006) observed the organoleptic test of *mukhwas* of two varieties of aonla viz., Gujarat aonla-1 and NA-7 under sun drying condition under the different treatments in organoleptic taste, ginger and sugar of different preparations

recorded higher scores and variety NA-7 registered higher scores for organoleptic taste that of Gujarat aonla-1.

2.4.2 Ber

Khurdiya and Roy (1986) found that solar dryer was more efficient for drying retaining high So_2 contents with less changes in reducing and total sugars than open sun drying.

Gadakh *et al.* (1999) dried ber fruits as whole, destoned or sliced using three drying methods (tray, solar cabinet and sun). The maximum drying rate was observed with tray drying (187 g/h/100g dry matter) and the slowest drying rate was observed during sun drying of whole ber fruits (3.6g/h/100g dry matter) Also, the sun dried fruits lost almost all asborbic acid (vitamin-C) content.

2.4.3 Mango

Dabhade and Khedkar (1980 a) found that mango powder made after blanching and sulphuring, reduced the time taken for drying. They also found that drying in cabinet dryer with 0.6 kg/sq. ft. load in trays took only 10 hours as compared to 15 hours in sun drying and resulted in better retention of ascorbic acid. The retention of ascorbic acid was better and browning was less when the *amchur* was dried in cabinet dryer after sulphite treatement (Dabhade and Khadkar; 1980 b). During storage, a progressive decrease in ascorbic acid, acidity and starch contents and an increase in reducing and total sugars were observed (Dabhade and Khedkar, 1980c).

Teotia *et al.* (1987) recommended 16-18 hours exposure to Sun at 35-40^{0}C for complete drying of the raw mango.

2.4.4 Sapota

Ganjyal *et al.* (1999) reported that total soluble solids and ascorbic acid value increased after dehydration and were highest in the sapota powder obtained at the 65^{0}C drying temperature.

Desai *et al.* (2001) studied the performance of mini multi-rack solar dryer for drying sapota cv. 'Kalipatti'. The results indicated that the drying time observed for unpeeled full, half and quarter cut fruits was 60, 52 and 42 hours respectively for solar drying while the corresponding drying time for sun drying was 96, 76 and 64 hours, respectively. These resulted in 37.5, 31.5 and 34.4 per cent less in drying time for full, half and quarter cut fruits respectively, in solar drying, oven drying, sun drying.

2.4.5 Banana

Kad *et al.* (2001) found very good quality of dehydrated banana slices when treated with 0.25% KMS + 0.5% $Cacl_2$, 0.25% KMS + 1% $CaCl_2$ or 60^0 brix + 0.5% $CaCl_2$.

Abhijit *et al.* (2003) reported that microwave convective drying was found to be the quickest method of drying (45 minutes) for banana with high sensory and an excellent energy use efficiency (56.73%). Whereas, freeze dried product

was found to be the best in terms of retention of total and reducing sugars (89 and 93%), tannin content, while NEB and total carbon dehydrated content (81%) was recorded.

2.4.6 Others

Thonte and Patil (1988) reported that the drying of fig fruits was faster after dipping in 5000 ppm ethrel for 3 minutes but the total sugars were higher in untreated dry product in grapes.

Brar and Kaur (1989) found that blanching in boiling water for 90 seconds resulted in the development of a desirable check on berries to reduce the time for their drying. The raising has 15-18 per cent moisture, 72-80 per cent TSS giving 44 dehydration ratio and were comparable to those imported from Afghanistan.

Godara *et al.* (1995) prepared soft dates from four different varieties 'Khadarwy', 'Shamran', 'Zahidi and 'Zaglour' by thawing and dehydrated for 24 and 40 hours at 40^0C and 50^0C respectively. The best quality of soft dates were obtained from 'Shamran' with organoleptic rating 8.3/10 but the maximum recovery was obtained from 'Shamran' with organoleptic rating from 'Zagloul' due to higher TSS of fresh fruits and maximum water retention after dehydration.

Bhutani and Sharma (1980) reported that the drying in cross flow dehydration yielded better quality dried apricot than open sun drying.

Mehta and Tomar (1980) reported that in an experiment to standardize procedure for dehydration of ripe papaya slices, steeping in 70^0 brix syrup containing 1000 ppm SO_2 gave the best product.

Alizai *et al.* (1997) reported that the dehydration ratio of sun dried apple fruits was higher than that dehydrated fruits.

III. MATERIALS AND METHODS

An investigation entitled "Influence of Pre–drying treatments and drying methods on different recipes of aonla (*Emblica officinalis* Gaertn.) Product preparation." Was conducted at the Department of Horticulture, N.M. College of Agriculture, N.A.U., Navsari during December 2006 to March 2007. The detail of techniques followed and materials used during the experimentation, are described below.

3.1 Materials

Fully matured fruits of aonla cultivar 'Gujarat aonla-1' were purchased from the Agricultural University Farm, Anand and brought to the laboratory. The diseased, spotted and bruised fruits were sorted out in the laboratory. The fruits of uniform shape and size were used for experimentation the selected fruits were thoroughly washed with tap water and cut into small pieces, then placed under different treatments after initial physico-chemical analysis.

For various treatments, two levels of pre-drying treatments (blanching and blanching with sulphitation), four levels of recipe (fruit pieces with 3 per cent common salt, fruit pieces with 3 per cent black salt, fruit pieces with 3 per cent common salt and 10 per cent ginger juice and fruit pieces with 3 per cent black salt and 10 per cent ginger juice), two drying methods (Sun drying, oven drying) and their combinations were used. Thus seventeen treatments combinations were tried in the

present investigation. The details of various treatments and their combinations are presented in Table 3.1 and 3.2

Table -3.1: The details of various treatments

Sr. No.	Treatments	Symbols
A Pre-drying treatments		
1	Blanching of fruits	D_1
2	Blanching of fruits with sulphitation (KMS @ 1000 mg/1)	D_2
B Recipes		
1	Fruit pieces with common salt (3%)	R_1
2	Fruit pieces with black salt (3%)	R_2
3	Fruit pieces with common salt (3%) and ginger juice (10%)	R_3
4	Fruit pieçes with black salt (3%) and ginger juice (10%)	R_4
C Drying method		
	Sun drying	M_1
	Oven drying	M_2
D	**Absolute control**	C_0

Table -3.2: Treatments combinations

$D_1 R_1 M_1$	$D_2 R_1 M_1$
$D_1 R_1 M_2$	$D_2R_1 M_2$
$D_1 R_2 M_1$	$D_2R_2 M_1$
$D_1 R_2 M_2$	$D_2R_2 M_2$
$D_1 R_3 M_1$	$D_2 R_3 M_1$
$D_1 R_3 M_2$	$D_2 R_3M_2$
$D_1 R_4 M_1$	$D_2 R_4M_1$
$D_1 R_4 M_2$	$D_2R_4 M_2$
Control	

Other details of experiment are as follows

I	Total number of treatment combination	17
II	Number of repetition	3
III	Variety	Gujarat aonla -1
IV	Quantity of fruits used per treatment	3 kg.
V	Period/interval of observation	1 month interval
VII	Statistical design	FCRD (Completely Randomized Design with Factorial Concept)

3.2 Technique of treatments

Fresh, fully matured, healthy and uniform fruits were used for experimentation. The selected fruits were washed with tap water to remove all dirt, dust and other extraneous material from the surface of fruits. The fruits were placed in 25 groups containing 1kg fruit in each treatment. The selected fruits were cut into small pieces (4-8 mm size/and subjected to various treatment. Each treatment was replicated three times. In case of combinations of pre-drying treatments, recipe and drying methods, fruit pieces were first given pre-drying treatment, than placed in different recipe treatments for 24 hours. Thereafter, the fruit pieces were dried by different drying methods. In case of control, the fruit pieces were dried in sun as such without treatments.

For blanching treatment, the fruit pieces were dipped in boiling water for 3 minutes. To prevent the excess cooking, fruit pieces were immediately dipped in cold water. Similarly for sulphitation treatment, the blanched fruit pieces were soaked in cold water containing KMS @ 1000 ppm for 3 minutes. As far as different recipe treatment is concerned, 3 per cent common salt/black salt treatment, 90 g common salt/black salt were added to the 3 kg fruit pieces after blanching/blanching with sulphitation. After giving salt treatment, the fruit pieces were kept for 24 hours. Similarly, for 10 per cent ginger juice treatment, 100 ml ginger juice/kg fruit pieces was added as per treatment combination and kept for 24 hours.

3.2.1 Drying and recipes treatments

After giving different pre-drying and recipe treatments, the fruit pieces were dried by the following drying methods as of per treatment combinations.

(a) Sun drying

After giving the pre-drying and treatments, the fruit pieces were well spread on the Muslin cloth and exposed to the sun until completely dried. The completion of drying process was judged by weighing the dried fruit pieces until the weight was constant for 3 consecutive days. The maximum and minimum day temperature was 20 and 31°C respectively, at the time of experiment.

(b) Oven drying

After giving the preliminary treatments, the fruit pieces were spread on trays with tray load of 500 g per sq. ft. tray area. The trays were then kept for dehydration in the oven. The trays were changed in rotation from lower shelf to the upper one in order to ensure uniform drying of the entire mass and to avoid quick burning of lower one due to excessive heat. The temperature of oven drying ranged from 50-55^{0}C. The fruit pieces were dried in 70-75 hours.

3.3 Packing and storage of dried fruits

Dried fruit pieces of aonla were kept in plastic containers. They were stored in dried place at ambient temperature for further study.

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3.4 Observations

Observations were recorded for fresh fruits, just after drying and than at an interval of 30 days up to 4 months of storage. The following observations were recorded.

(a)Fresh fruits : The following observations of fruit were recorded.

(I) Acidity (%)

(II) Ascorbic acid (mg/100g)

(III) Sugars

(a) Reducing sugar (%)

(b) Non-reducing sugar (%0

(c) Total sugar (%)

(b) Dried product: The following physical and chemical observations were recorded immediately after drying for about four Months of storage at 30 days interval

(I) Physical characteristics

(i) Colour

(ii) Taste

(iii) Organoleptic acceptance

(iv) Recovery percentage

(v) Storability

(II) Chemical characteristics

(i) Acidity (%)

(ii) Ascorbic acid (mg/100 g.)

(iii) TSS (%)

(iv) Sugar (%)

(a) Reducing sugar

(b) Non-reducing sugar

© Total sugar

(C) Economics : The relative economics of the treatments were calculated on the basis of cost and benefit ratio.

3.5 Methodology used for observations

The details of the techniques used for recording observations are given below .

3.5.1 Physical characteristics

3.5.1.1 Colour

The colour of the dried aonla product was judged by visual method. For this, a panel of six judges was chosen, who examined the product and marks given by them were averaged. The grading was done by following pattern.

Category	Marks/range
Yellowish white	7.5-10.0
Light brown	5.0-7.49
Brown	2.5-4.49
Dark brown	<2.50

3.5.1.2 Taste

The taste of the product was evaluated by panel of six judges by using Hedonic rating scale out of 10 marks (Rangana, 1978).The marks given by them were averaged. The grading was done by the following pattern.

Category	Marks/range
Like extremely	10
Like very much	9
Like moderately	8
Like slightly	7
Neither like nor dislike	6
Dislike slightly	5
Dislike moderately	4
Dislike very much	3
Dislike extremely	2

3.5.1.3 Organoleptic acceptance

The organoleptic acceptability which includes the overall acceptance of the product with respect to colour, flavour, taste and appearance was evaluated by a panel of six judges by using Hedonic Rating scale out of 10 marks (Ranganna, 1978).

The marks given by them were averaged. The grading was done by the following pattern.

Category	**Marks/range**
Extremely acceptable	10
Very much acceptable	9
Moderately acceptable	8
Slightly acceptable	7
Neither acceptable nor non acceptable	6
Slightly non acceptable	5
Moderately non acceptable	4
Very much non acceptable	3
Extremely non acceptable	2

3.5.1.4 Recovery percentage

The recovery percentage of dehydrated product was calculated by the following formula:

$$\text{Percent recovery} = \frac{\text{Weight of dried fruits (g)}}{\text{Weight of fresh fruits (g)}} \times 100$$

3.5.1.5 Storability

The storability of the product was accessed on the basis of growth of micro organisms, partaining to overall physical and chemical performance of the product during storage upto 4 months.

3.5.2 Chemical characteristics

3.5.2.1 Ascorbic acid :

The ascorbic acid content of the product was determined by grounding the known quantity of dried product with 3 percent metaphosphoric acid and filtered through filter paper and titrating with 2, 6 dichlorophenol indophenols dye solution (A.O.A.C. 1980) until the stable light pink colour was obtained. Standardization of 2, 6 dichlorophenol indophenols dye solution was done by titrating it against standard ascorbic acid solution. For this purpose 100 mg of ascorbic acid was dissolved in 3 per cent metaphosphoric acid and the volume was made to 100 m from this 1ml of ascorbic acid solution was used for titration. The results were expressed in mg ascorbic acid (Vitamin-C) content per 100 g of fruits.

3.5.2.2 Acidity

Acidity was determined by diluting the known weight of dry sample. The sample was weighed and ground with pestle mortal and titrating the same against standard N/10 sodium hydroxide solution using phenolphthalein as indicator. It was expressed as percentage.

3.5.2.3 Sugars

(a) Reducing

Reducing sugar was estimated by di-nitro salicylic acid method. The 100 mg of the dried sample was weight and sugar extracted with hot 80 per cent ethenol, twice (5 ml each time). Supernatant was collected and evaporated by keeping it on a water both at 80^0C. Then 10 ml of water was added to dissolve the sugars from which 0.05 ml of the extract was taken in the test tube and volume was made up to 3 ml with distilled water. To this, 3 ml of DNS reagent was added. The content was heated in boiling water bath for 5 min. when the content of the tube was still warm, 1 ml of 40 per cent Rochelle salt solution was added, cooled to room temperature and absorbance was measured at 510 nm. The amount of sugar present in the sample was plotted against standard curve prepared form glucose. The reducing sugar content was expressed on percentage basis.

(b) Non-reducing sugars

The amount of non-reducing sugar of the product was obtained by subtracting reducing sugar from total sugars and multiplying the same with the factor 0.95.

Non-reducing sugar (%) = (Total sugar- reducing sugar) x 0.95

(c) Total Sugars

For estimation of total sugar content, 100 mg of the dried sample was weighed and sugar was extracted with hot 80 per cent ethanol : twice (5ml each time) supernatant was collected

and evaporated by keeping it on a water bath at 80^{0}C. Total sugar was determined by using anthrone reagent method (Dubois *et al.*, 1951). The 0.5 ml of this supernatant (100 times diluted), 5ml of anthrone reagent was added then heated for 10 to 15 minutes in a water both, cooled to room temperature and observance was measured at 620 nm. The amount of sugars present in the sample was plotted against standard curve prepared from glucose. The total sugar content was expressed on percentage basis.

3.6 Economics of the treatments

The costs of different treatments were considered for calculating the economics of the treatments.

3.7 Statistical analysis

To test the significance of variation in the data obtained, the analysis of variance technique was adopted as suggested by Fisher (1950) for completely randomized design. The significance of the differences in the treatments effect were tested through 'F' test.

3.8 Chemical composition of fresh fruits

The data presented in Table-3.3 reveals that fresh fruit which were used for the preparation of dehydrated aonla product contain 557.35 mg/100 g ascorbic acid. The acidity of the fresh fruit was found to be 2.98%. The amount of different sugars total sugar, reducing sugar and non reducing sugars was recorded of 7.18, 2.76, 4.42 and TSS as 14.98 per cent.

Table-3.3 : Physico-chemical composition of fresh fruit of aonla cv. Gujarat aonla-1.

Sr. No.	Constituents	Values (%)
1	Acidity	2.98
2	Ascorbic acid	557.38 mg/100 g
3	TSS	14.98
4	Sugars	
	a. Reducing sugar	2.76
	b. Non-reducing sugar	4.42
	c. Total sugar	7.18

Sun drying

Treated product ready for drying

Oven drying

IV. EXPERIMENTAL RESULTS

The result of the present investigation entitled "Influence of pre–drying treatments and drying methods on different recipes of aonla (*Emblica officinalis* Gaertn.) Product preparation" conducted at fruit and vegetable preservation laboratory Department of Horticulture, N.M.College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) is being presented in this chapter. The product was examined for different physico-chemical changes at monthly interval up to 4 months of storage. The results along with statistical inference are presented here under different sub headings of experimental results.

4.1 Physical characteristics

4.1.1 Colour

Data pertaining to colour of aonla product as influenced by pre-drying treatments, recipes and drying methods are presented in Table 4.1. The score for colour decreased considerably in all treatments with increase in storage period. Control recorded lowest value of colour for aonla product during entire storage period.

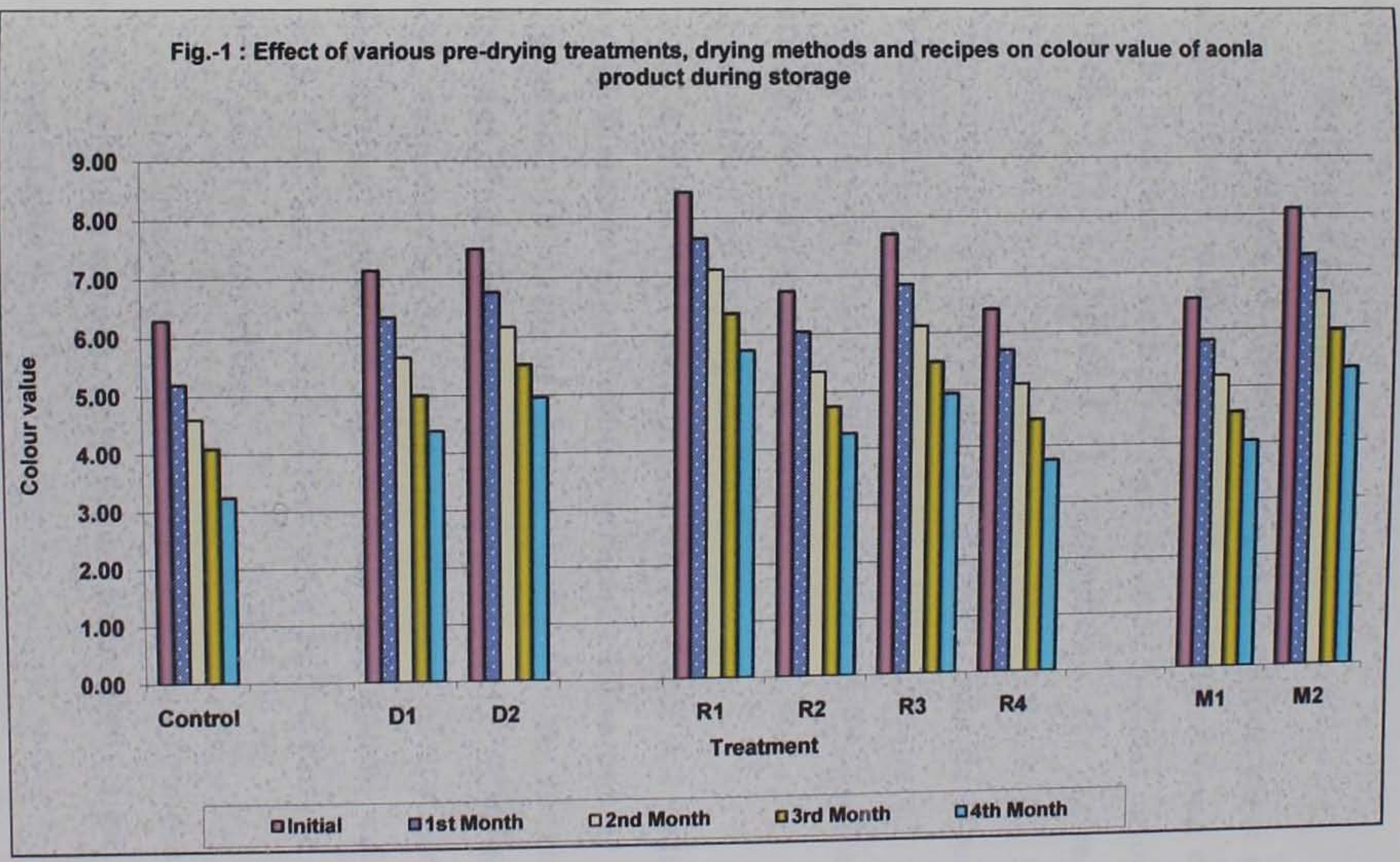
4.1.1.1 Effect of pre-drying treatments

It is evident from the data presented in Table 4.1 that the pre-drying treatments had significant effect on the colour value of aonla product. Significantly higher colour value (7.51,

Table- 4.1: Effect of various pre-drying treatments, drying methods and recipes on colour value of aonla product during storage

Treatments	Colour				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	6.30	5.20	4.80	4.30	3.25
Pre-drying treatments					
D_1	7.15	6.35	5.66	5.01	4.39
D_2	7.51	6.77	6.17	5.53	4.96
S. Em ±	0.040	0.057	0.051	0.048	0.037
C. D. at 5 %	0.11	0.16	0.15	0.14	0.11
Recipes					
R_1	8.45	7.66	7.12	6.37	5.73
R_2	6.74	6.04	5.34	4.74	4.27
R_3	7.71	6.85	6.12	5.50	4.94
R_4	6.40	5.69	5.09	4.47	3.75
S. Em ±	0.056	0.080	0.072	0.067	0.052
C. D. at 5 %	0.16	0.23	0.21	0.19	0.15
Drying methods					
M_1	6.55	5.82	5.19	4.55	4.04
M_2	8.11	7.30	6.64	5.98	5.31
S. Em ±	0.040	0.057	0.051	0.048	0.037
C. D. at 5 %	0.11	0.16	0.15	0.14	0.11
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	Sig.	Sig.	Sig.	Sig.	Sig.
D x R x M	NS	NS	NS	NS	NS
C.V. %	2.66	4.24	4.21	4.43	3.83

Fig.-1 : Effect of various pre-drying treatments, drying methods and recipes on colour value of aonla product during storage



6.77, 6.17, 5.53 and 4.96, respectively for initial to 4th month of storage) was recorded in D_2 treatment followed by D_1 (7.15, 6.35, 5.66, 5.01 and 4.39, respectively for initial to 4th month of storage).

4.1.1.2 Effect of recipes

The effect of different recipes on colour value of aonla product was found to be significant (Table 4.1). Among different recipes, R_1 treatment recorded significantly highest colour value (8.45, 7.66, 7.12, 6.37 and 5.73, respectively for entire storage period) followed by R_3 treatment i.e., (7.71, 6.85, 6.12, 5.50 and 4.94, respectively for entire storage period). The R_4 (fruit pieces with black salt 3% + ginger juice 10%) treatment recorded significantly lowest colour value 6.40, 5.69, 5.09, 4.47 and 3.75, respectively for entire storage period.

4.1.1.3 Effect of drying methods

A perusal of data presented in Table 4.1 indicate that the drying methods significantly influenced the colour value of aonla product. In case of drying methods, M_2 (oven drying) recorded significantly higher colour value (8.11, 7.30, 6.64, 5.98 and 5.31, respectively for initial to 4th month of storage). While, M_1 (Sun drying) recorded significantly less colour value (6.55, 5.82, 5.19, 4.55 and 4.04, respectively for entire storage period).

4.1.1.4 Interaction effect

The interaction effect of R x M was found significant while rest of interactions were found to be non- significant for colour value (Table 4.1.1).

Table-4.1.1: Combined effect of drying methods and recipes on *colour* of aonla product during storage

Treatments	Colour				
	Initial	1st Month	2nd Month	3rd Month	4th Month
R_1M_1	7.30	6.62	6.00	5.33	4.79
R_2M_1	6.00	5.36	4.69	4.12	3.70
R_3M_1	6.88	5.97	5.35	4.69	4.18
R_4M_1	6.01	5.33	4.74	4.08	3.50
R_1M_2	9.61	8.69	8.24	7.42	6.68
R_2M_2	7.49	6.72	5.99	5.36	4.85
R_3M_2	8.55	7.74	6.89	6.30	5.71
R_4M_2	6.80	6.06	5.43	4.86	4.00
S. Em ±	0.080	0.114	0.102	0.095	0.073
C. D. at 5 %	0.23	0.33	0.29	0.27	0.21

The treatment combination R_1M_2 recorded significantly higher colour value of aonla product (9.61, 8.69, 8.24, 7.42 and 6.68, respectively for initial to 4th month of storage) followed by R_3M_2 treatment combination (8.55, 7.74,

6.89, 6.30 and 5.71, respectively from initial to 4th month of storage). The treatment combination R_4M_1 recorded significantly reduced colour value (6.01, 5.33, 4.74, 4.08 and 3.50, respectively for entire storage period).

4.1.2 Taste

The data on taste as influenced by various pre-drying treatments, recipes and drying methods are furnished in Table 4.2. It is clear from the data that taste value of aonla product gradually decreased with increase in storage period. The score of taste value of aonla product was minimum in control throughout the storage period.

4.1.2.1 Effect of pre-drying treatment

It is evident from the data of Table 4.2 that the value of taste was non significant due to various pre-drying treatments. Howerer, two different pre-drying treatments, D_1 recorded highest taste value (8.16, 7.26, 6.46, 6.00 and 5.42, respectively, for entire storage period). While, lowest score of taste was recorded in D2 (8.01, 7.11, 6.35, 5.87 and 5.31, respectively for entire storage period).

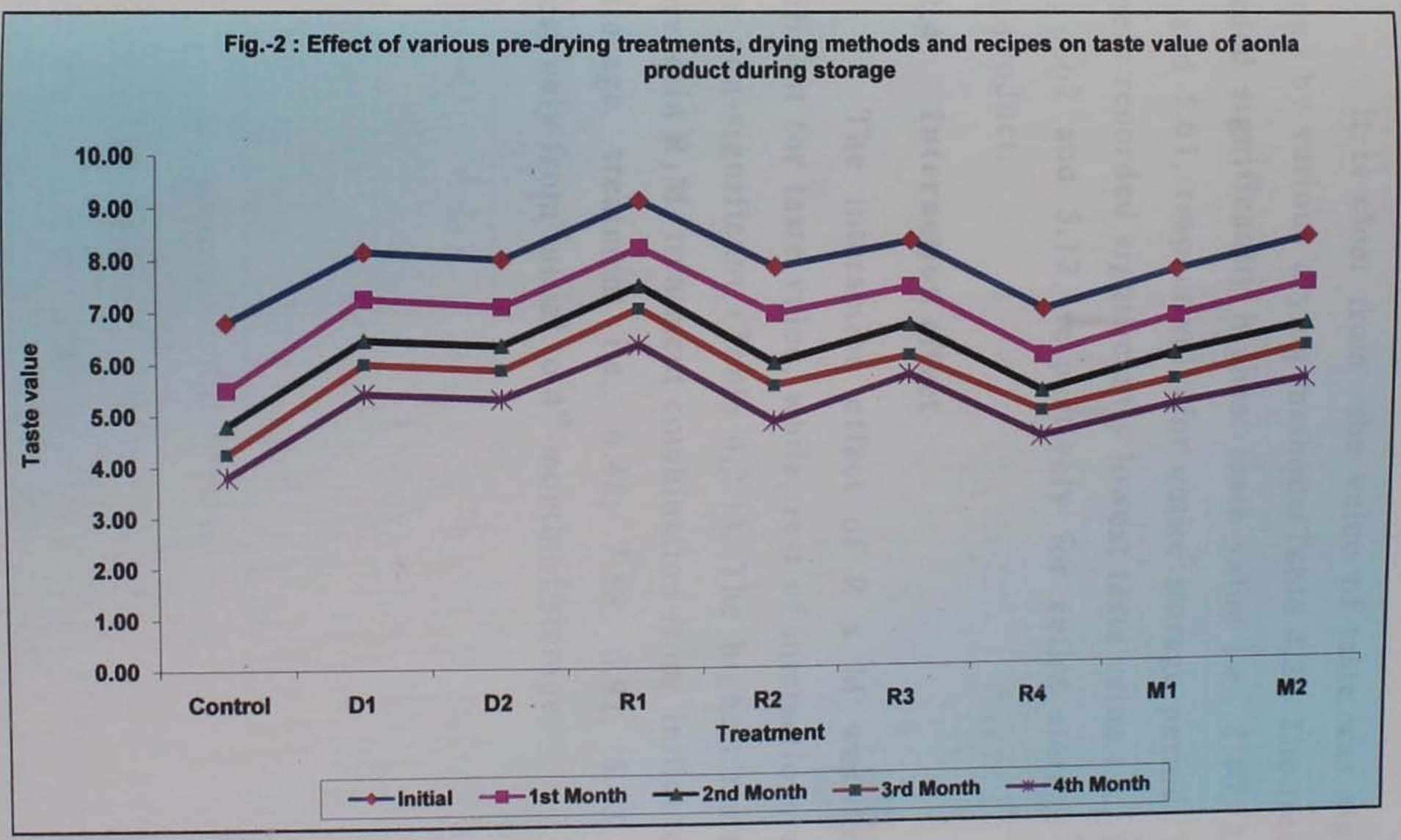
4.1.2.2 Effect of recipes

It is evident from the data that the taste value was significantly influenced by different recipes during storage (Table 4.2). Among different recipes, R_1 treatment recorded significantly highest taste value i.e., 9.13, 8.23, 7.50, 7.06 and 6.36, respectively for entire storage period followed by R_3 . The recipe

Table-4.2: Effect of various pre-drying treatments, drying methods and recipes on taste value of aonla product during storage

Treatments	Taste				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	6.80	5.50	4.80	4.25	3.80
Pre-drying treatments					
D_1	8.16	7.26	6.46	6.00	5.42
D_2	8.01	7.11	6.35	5.87	5.31
S. Em ±	0.058	0.059	0.044	0.053	0.048
C. D. at 5 %	NS	NS	NS	NS	NS
Recipes					
R_1	9.13	8.23	7.50	7.06	6.36
R_2	7.85	6.95	5.99	5.55	4.85
R_3	8.35	7.46	6.73	6.13	5.75
R_4	7.01	6.11	5.41	5.02	4.51
S. Em ±	0.082	0.083	0.062	0.075	0.067
C. D. at 5 %	0.24	0.24	0.18	0.22	0.19
Drying methods					
M_1	7.77	6.87	6.13	5.62	5.12
M_2	8.40	7.50	6.69	6.26	5.61
S. Em ±	0.058	0.059	0.044	0.053	0.048
C. D. at 5 %	0.17	0.17	0.13	0.15	0.14
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	Sig.	Sig.	Sig.	Sig.	Sig.
D x R x M	NS	NS	NS	NS	NS
C.V. %	3.51	3.99	3.37	4.36	4.35

Fig.-2 : Effect of various pre-drying treatments, drying methods and recipes on taste value of aonla product during storage



R_4 recorded lowest taste value i.e., 7.01, 6.11, 5.41, 5.02 and 4.51, respectively during entire storage period.

4.1.2.3 Effect of drying methods

It is clear from the value of taste was significantly affected by various drying methods(Table 4.2). The treatment M_2 recorded significantly highest taste value i.e., 8.40, 7.50, 6.69, 6.26 and 5.61, respectively for entire storage period. While, M_1 tretment recorded significantly lowest taste value i.e., 7.77, 6.87, 6.13, 5.62 and 5.12, respectively for entire storage period of aonla product.

4.1.2.4 Interaction effect

The interaction effect of R x M was found to be significant for taste value, while, rest of interactions were found to be non-significant (Table 4.2.1). The highest taste valuewas observed in R_1M_2 treatment combination from initial to 4th month of storage. treatment i.e., 6.48, 7.58, 6.91, 6.43 and 5.91, respectively from initial to 4th month of storage.

Table-4.2.1: Combined effect of drying methods and recipes on taste of aonla product during storage

Treatment	Taste				
	Initial	1st Month	2nd Month	3rd Month	4th Month
R_1M_1	8.48	7.58	6.91	6.43	5.91
R_2M_1	7.67	6.77	5.80	5.08	4.58
R_3M_1	8.12	7.22	6.59	6.10	6.64
R_4M_1	6.83	5.93	5.22	4.85	4.34
R_1M_2	9.78	8.88	8.09	7.68	6.81
R_2M_2	8.03	7.13	6.17	6.01	5.12
R_3M_2	8.58	7.70	6.87	6.15	5.85
R_4M_2	7.19	6.29	5.60	5.19	4.68
S. Em ±	0.116	0.117	0.088	0.106	0.095
C. D. at 5 %	0.33	0.34	0.25	0.30	0.27

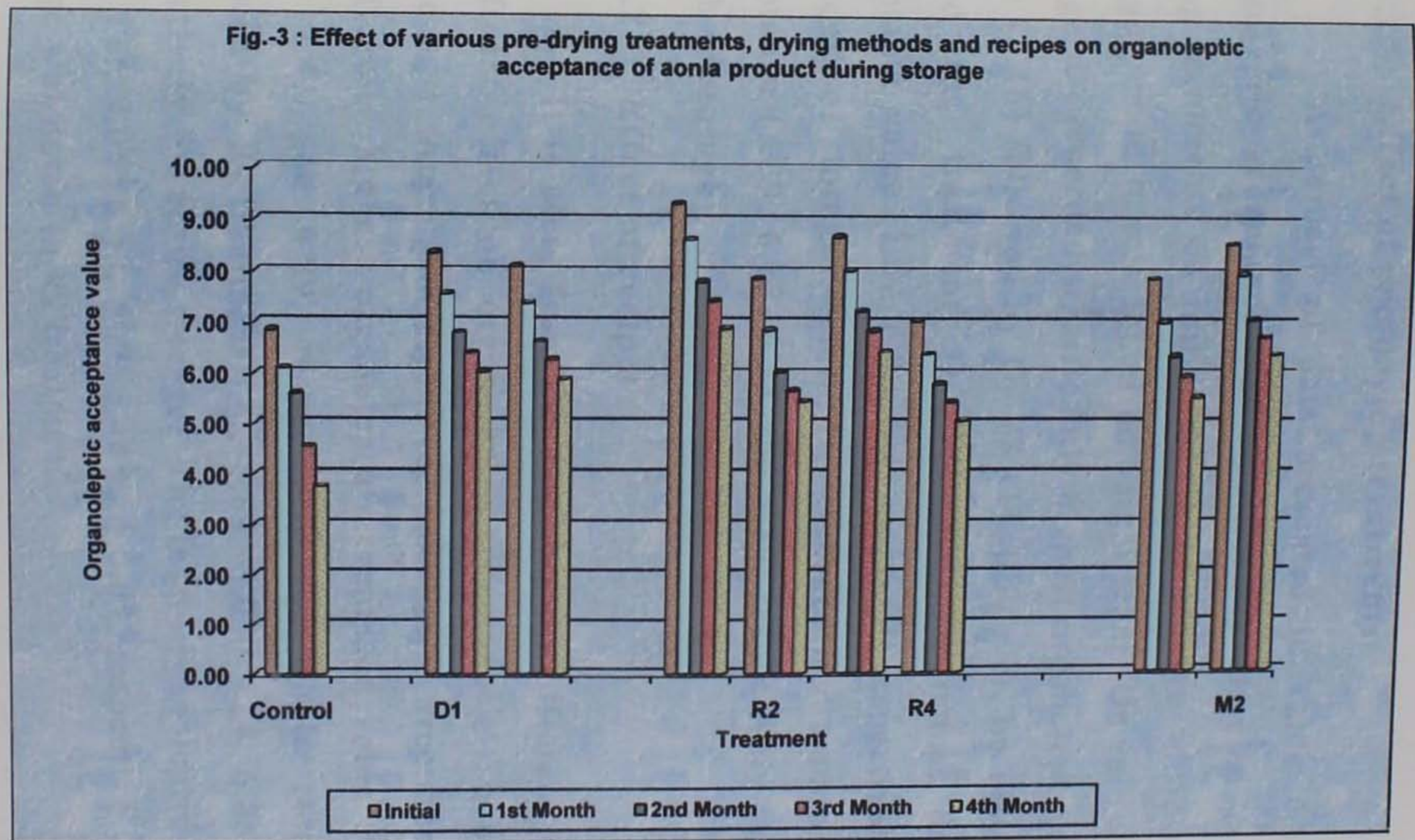
4.1.3 Organoleptic acceptance

The data regarding organoleptic acceptance as influenced by various pre-drying treatments, recipes and drying methods are presented in Table 4.3. The organoleptic acceptance

Table-4.3: Effect of various pre-drying treatments, drying methods and recipes on organoleptic acceptance of aonla product during storage

Treatments	Organoleptic acceptance				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	6.85	6.10	5.60	4.55	3.75
Pre-drying treatments					
D_1	8.36	7.57	6.80	6.41	6.03
D_2	8.11	7.39	6.63	6.28	5.89
S. Em ±	0.053	0.063	0.062	0.50	0.052
C. D. at 5 %	0.15	NS	NS	NS	NS
Recipes					
R_1	9.33	8.63	7.81	7.43	6.89
R_2	7.87	6.86	6.03	5.67	5.45
R_3	8.69	8.03	7.24	6.85	6.44
R_4	7.05	6.40	5.80	5.44	5.07
S. Em ±	0.076	0.089	0.088	0.071	0.073
C. D. at 5 %	0.22	0.26	0.25	0.20	0.21
Drying methods					
M_1	7.89	7.03	6.35	5.95	5.53
M_2	8.58	7.98	7.08	6.74	6.39
S. Em ±	0.053	0.063	0.062	0.50	0.052
C. D. at 5 %	0.15	0.18	0.18	0.14	0.15
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	Sig.	Sig.	Sig.	Sig.	Sig.
D x R x M	NS	NS	NS	NS	NS
C.V. %	3.18	4.12	4.54	3.85	4.24

Fig.-3 : Effect of various pre-drying treatments, drying methods and recipes on organoleptic acceptance of aonla product during storage



of aonla product decreased as the storage period increased. The organoleptic acceptance of aonla product was minimum in control treatment throughout the storage period.

4.1.3.1 Effect of pre-drying treatments

A perusal of data presented in Table 4.3 that the organoleptic acceptance was significantly affected due to pre-drying treatments on initial month of storage while on rest of storage period it was found non-significant. On initial month of storage, D_1 recorded significantly highest organoleptic acceptance value (8.36) followed by D_2 (8.11). However, on rest of storage period the treatment D_1 recorded maximum organoleptic acceptance value (7.57, 6.80, 6.41 and 6.03, respectively for 1st to 4th month of storage). While, D_2 recorded minimum organoleptic acceptance (7.39, 6.63, 6.28 and 5.89, respectively for 1st to 4th month of storage).

4.1.3.2 Effect of recipes

It is clear from the data that the different recipes had significant effect on organoleptic acceptance of aonla product (Table 4.3). Among different recipes, the R_1 treatment recorded significantly highest organoleptic acceptance value (9.33, 8.63, 7.81, 7.43 and 6.89, respectively for whole storageperiod) followed by R_3 treatment i.e., 8.69, 8.03, 7.24, 6.85 and 6.44, respectively for entire storage. The least organoleptic acceptance value i.e., 7.05, 6.40, 5.80 5.44 and 5.07, respectively for entire storage was noted in R_4 treatment.

4.1.3.3 Effect of drying methods

It is evident from Table 4.3 that the drying methods significantly affect the organoleptic acceptance of aonla product. The organoleptic acceptance of aonla product was significantly highest in M_2 treatment i.e., 8.58, 7.98, 7.08, 6.74 and 6.39, respectively for entire storage. The drying method M_1 treatment recorded least organoleptic acceptance value for entire storage period.

4.1.3.4 Interaction effect

The interaction effect of R x M for organoleptic acceptance of aonla product was found significant during entire storage (Table 4.3.1). The interactions D x M, D x R and D x R x M were found non-significant for organoleptic acceptance of aonla product.

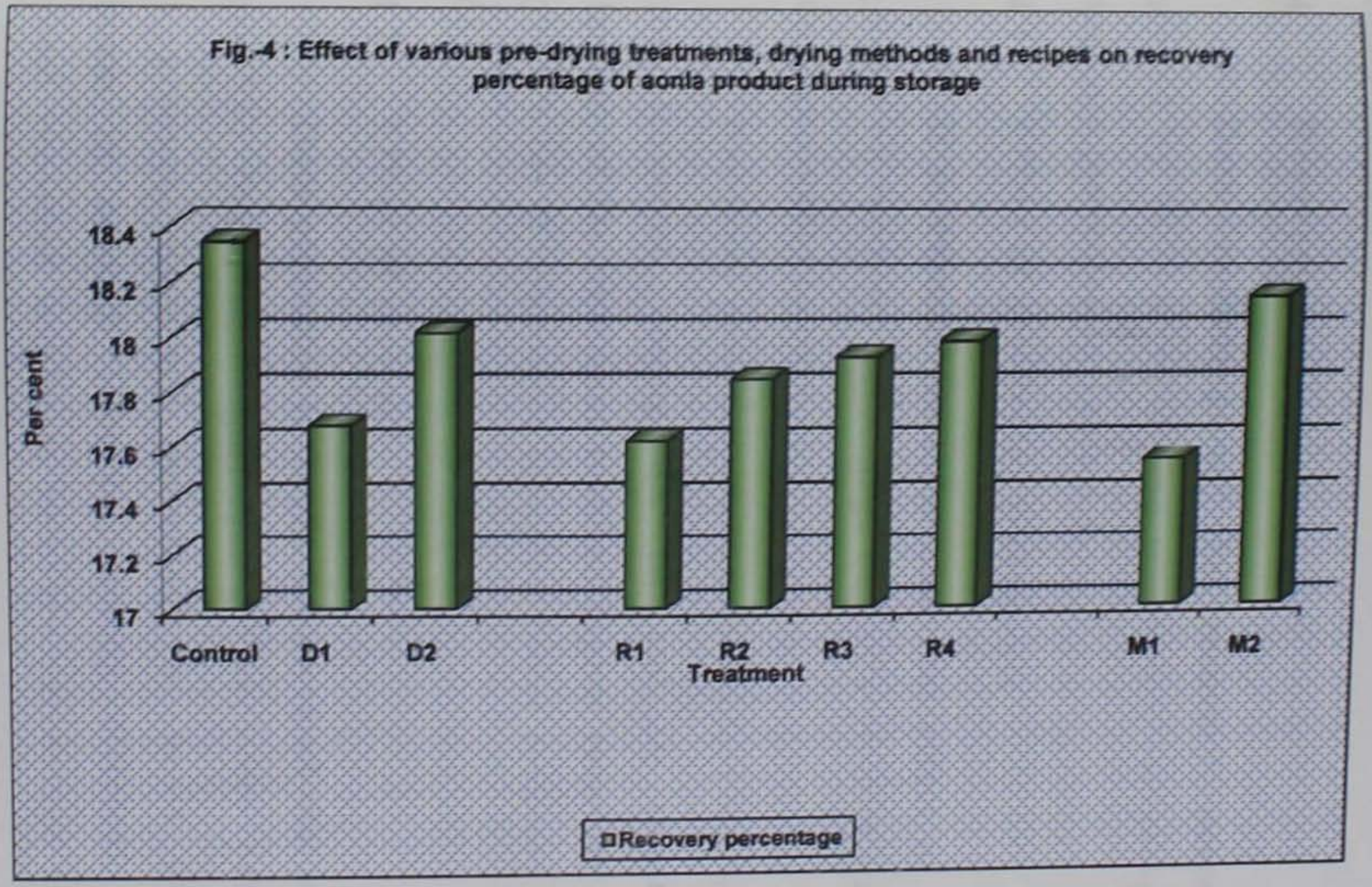
Table- 4.3.1: Combined effect of drying methods and recipes on organoleptic acceptance of aonla product during storage

Treatments	Organoleptic acceptance				
	Initial	1st Month	2nd Month	3rd Month	4th Month
R_1M_1	8.82	7.85	7.17	6.72	6.17
R_2M_1	7.54	6.53	5.74	5.34	4.94
R_3M_1	8.32	7.62	6.96	6.53	6.23
R_4M_1	6.88	6.12	5.52	5.21	4.78
R_1M_2	9.83	9.42	8.44	8.14	7.62
R_2M_2	8.20	7.20	6.31	5.99	5.95
R_3M_2	9.05	8.44	7.51	7.17	6.65
R_4M_2	7.23	6.68	6.08	5.67	5.36
S. Em ±	0.107	0.126	0.125	0.100	0.103
C. D. at 5 %	0.31	0.36	0.36	0.29	0.30

Table-4.4: Effect of various pre-drying treatments, drying methods and recipes on recovery percentage of aonla product

Treatments	Recovery percentage
Absolute control	18.35
Pre-drying treatments	
D_1	17.68
D_2	18.02
S. Em ±	0.131
C. D. at 5 %	NS
Recipes	
R_1	17.62
R_2	17.85
R_3	17.93
R_4	17.99
S. Em ±	0.185
C. D. at 5 %	NS
Drying methods	
M_1	17.55
M_2	18.15
S. Em ±	0.131
C. D. at 5 %	0.38
Interaction effect	
D x M	NS
D x R	NS
R x M	NS
D x R x M	NS
C.V. %	3.59

Fig.-4 : Effect of various pre-drying treatments, drying methods and recipes on recovery percentage of aonla product during storage



The treatment combination R_1M_2 treatment recorded significantly highest organoleptic acceptance value (9.83, 9.42, 8.44, 8.14 and 7.62, respectively for entire storage) followed by R_3M_2 treatment i.e., 9.05, 8.44, 7.51, 7.17 and 6.65, respectively for entire storage.

4.1.4 Recovery percentage

Data regarding to the recovery percentage as influenced by various pre-drying treatments, recipes and drying methods are presented in Table 4.4.

4.1.4.1 Effect of pre-drying treatments

It is evident from the data that effect of pre-drying treatments on recovery percentage of aonla product was found to be non significant (Table 4.4).

Recovery percentage of aonla product was maximum in control. However, among the D_1 and D_2 treatments, the application of D_2 treatment resulted higher recovery percentage (18.02).While, D_1 treatment recorded lower recovery percentage (17.68).

4.1.4.2 Effect of recipes

Data presented in Table 4.4 revealed that the different recipes had found non-significant for recovery percentage of aonla product. Recovery percentage of aonla product was maximum in control. However, among different recipes R_4 treatment recorded maximum recovery percentage (17.99). The

recipe R_1 treatment recorded minimum recovery percentage (17.62).

4.1.4.3 Effect of drying methods

It is apparent form data given in Table 4.4 that recovery percentage of aonla product was found significant due to drying methods. Control recorded highest recovery percentage of aonla product. However, between two drying methods M_1 and M_2, M_2 treatment resulted the significantly higher recovery percentage (18.15) followed by M_1 (17.55).

4.1.4.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for recovery percentage were found non-significant during entire storage period (Table 4.4).

4.2 Chemical parameters

4.2.1 Acidity

Data pertaining to acidity of aonla product as influenced by pre-drying treatments, recipes and drying methods are presented in Table 4.5. The value of acidity decreased considerably in all treatments with increase in storage period. The acidity content of aonla product was maximum in control treatment throughout the storage period.

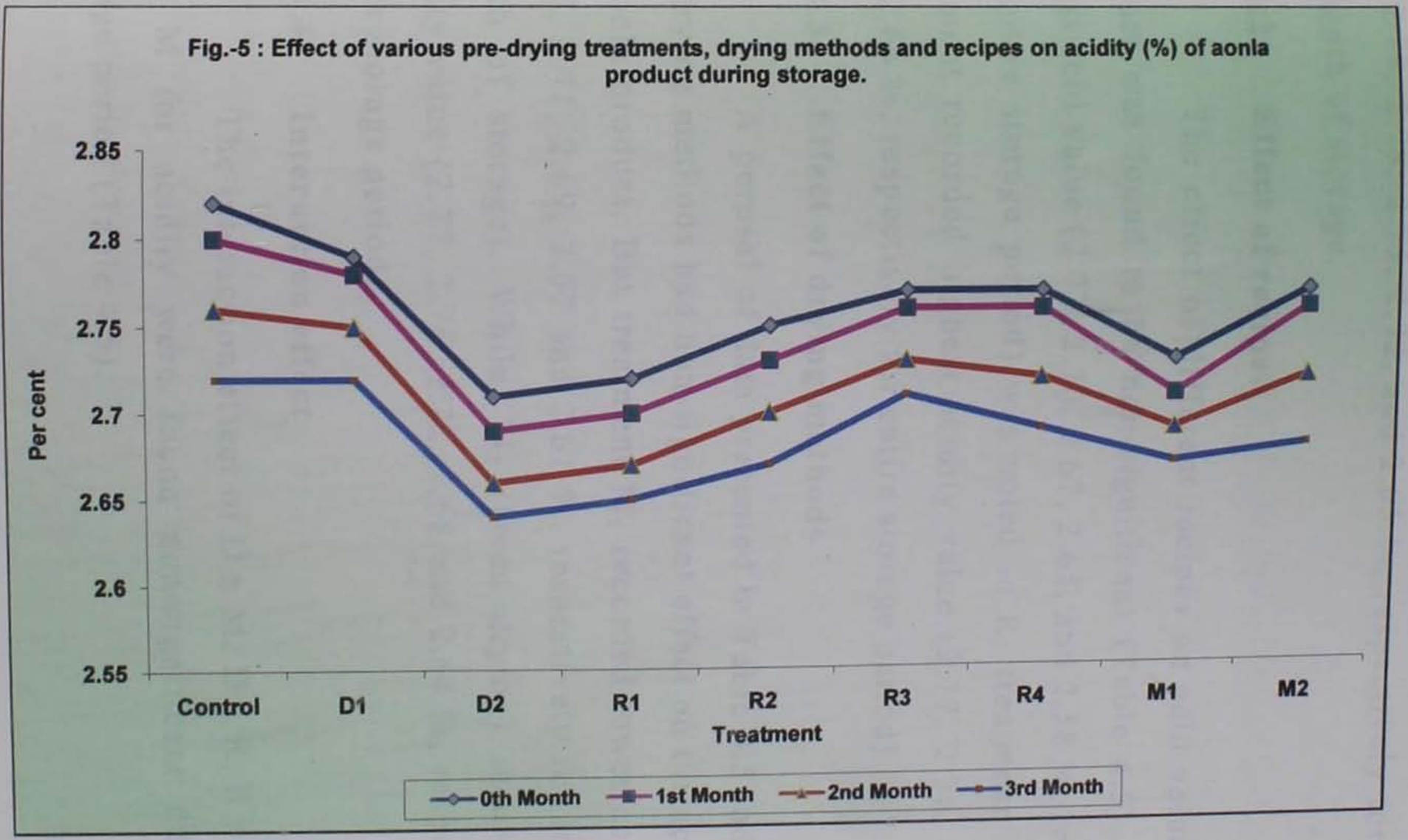
4.2.1.1 Effect of pre-drying treatments

It is evident from the data presented in Table 4.5 that the pre-drying treatments significantly affected the acidity value

Table- 4.5: Effect of various pre-drying treatments, drying methods and recipes on acidity (%) of aonla product during storage

Treatments	Acidity (%)				
	0th Month	1st Month	2nd Month	3rd Month	4th Month
Absolute control	2.82	2.80	2.76	2.72	2.66
Pre-drying treatments					
D_1	2.79	2.78	2.75	2.72	2.65
D_2	2.71	2.69	2.66	2.64	2.60
S. Em ±	0.013	0.016	0.019	0.022	0.017
C. D. at 5 %	0.04	0.05	0.05	0.06	0.05
Recipes					
R_1	2.72	2.70	2.67	2.65	2.58
R_2	2.75	2.73	2.70	2.67	2.62
R_3	2.77	2.76	2.73	2.71	2.66
R_4	2.77	2.76	2.72	2.69	2.64
S. Em ±	0.018	0.023	0.026	0.028	0.025
C. D. at 5 %	NS	NS	NS	NS	NS
Drying methods					
M_1	2.73	2.71	2.69	2.67	2.61
M_2	2.77	2.76	2.72	2.68	2.64
S. Em ±	0.013	0.016	0.019	0.022	0.017
C. D. at 5 %	NS	NS	NS	NS	NS
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	NS	NS	NS	NS	NS
D x R x M	NS	NS	NS	NS	NS
C.V. %	2.31	2.90	3.39	4.08	3.26

Fig.-5 : Effect of various pre-drying treatments, drying methods and recipes on acidity (%) of aonla product during storage.



of aonla product. Significantly lower acidity value (2.71, 2.69, 2.66, 2.64 and 2.60 %, respectively for initial to 4th month of storage) was recorded in D_2 treatment followed by D_1 treatment i.e., 2.79, 2.78, 2.75, 2.72, and 2.65 %, respectively for initial to 4th month of storage.

4.2.1.2 Effect of recipes

The effect of different recipes on acid value of aonla product was found to be non-significant (Table 4.5). However, lowest acid value (2.72, 2.70, 2.67, 2.65, and 2.58 %, respectively for entire storage period) was noted in R_1 treatment. While, R_3 treatment recorded highest acidity value (2.77, 2.76, 2.73, 2.71 and 2.66 %, respectively for entire storage period).

4.2.1.3 Effect of drying methods

A perusal of data presented in Table 4.5 indicated that the drying methods had non-significant effect on the acidity value of aonla product. But treatment M_1 recorded lower acidity value (2.73, 2.71, 2.69, 2.67 and 2.61 %, respectively for initial to 4th month of storage). While, M_2 (Oven drying) recorded higher acidity value (2.77, 2.76, 2.72, 2.68 and 2.64 %, respectively for entire storage period).

4.2.1.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for acidity were found non-significant during entire storage period (Table 4.5).

4.2.2 Ascorbic acid content (mg/100 g)

The data regarding to the ascorbic acid content (mg/100 g) as influenced by various pre-drying treatments, recipes and drying methods are presented in Table 4.6. The ascorbic acid content of aonla product decreased as the storage period increased. The ascorbic acid content of aonla product was minimum in control treatment throughout the storage period.

4.2.2.1 Effect of pre-drying treatments

Effect of pre-drying treatments on ascorbic acid content of aonla product was found to be significant (Table 4.6). Between two pre-drying treatments i.e. D_1 and D_2. The application of D_1 recorded lower ascorbic acid content (272.90, 248.34, 201.53, 152.11 and 121.21 mg/100g, respectively entire storage period) followed by D_2 treatment (285.53, 267.53, 224.18, 169.31 and 142.16 mg/100 g, respectively for initial month to 4th month of storage.

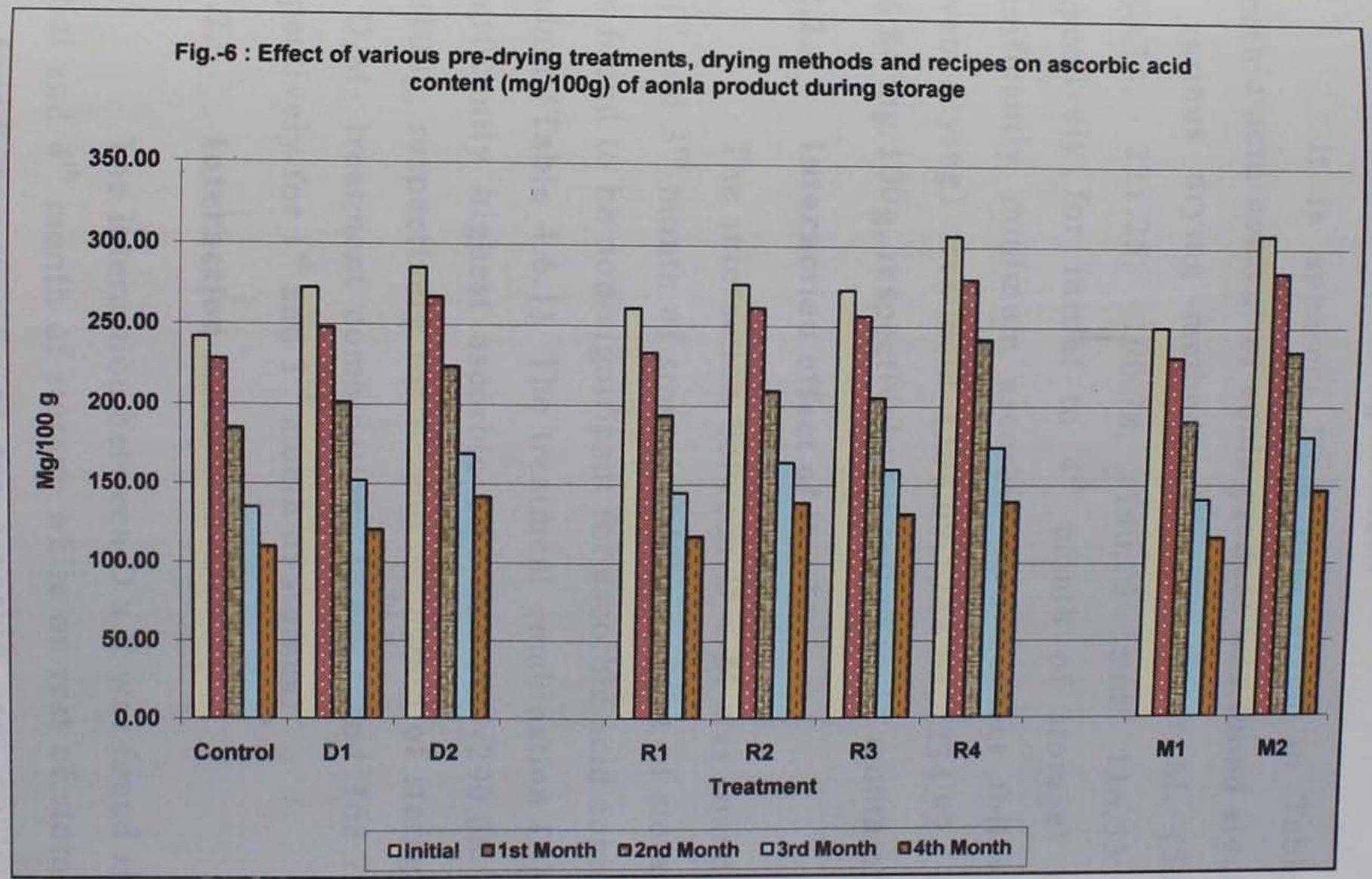
4.2.2.2 Effect of recipes

Data presented in Table 4.6 revealed that the different recipes had found significant effect on ascorbic acid content. Among different recipes, R_1 treatment recorded minimum ascorbic acid content (261.00, 233.35, 194.00, 144.70, and 117.27%, respectively for initial to 4th month of storage) which was followed by R_2 treatment (276.17, 261.45, 209.48, 164.20 and 138.75 mg/100g, respectively for initial to 4th month of storage). The recipe of treatment was R_4 recorded significantly

Table- 4.6: Effect of various pre-drying treatments, drying methods and recipes on ascorbic acid content (mg/100g) of aonla product during storage

Treatments	Ascorbic acid content (mg/100 g)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	242.10	228.51	185.23	135.26	110.12
Pre-drying treatments					
D_1	272.90	248.34	201.53	152.11	121.21
D_2	285.53	267.53	224.18	169.31	142.16
S. Em ±	2.077	1.897	1.953	1.908	1.183
C. D. at 5 %	5.98	5.46	5.62	5.50	3.43
Recipes					
R_1	261.00	233.35	194.00	144.70	117.27
R_2	276.17	261.45	209.48	164.20	138.75
R_3	272.78	256.95	205.50	159.94	131.38
R_4	306.92	279.99	242.42	173.99	139.35
S. Em ±	2.938	2.683	2.762	2.699	1.674
C. D. at 5 %	8.46	7.73	7.95	7.77	4.82
Drying methods					
M_1	250.34	231.25	190.78	140.73	116.53
M_2	308.09	284.63	234.92	180.68	146.84
S. Em ±	2.077	1.897	1.953	1.908	1.183
C. D. at 5 %	5.98	5.46	5.62	5.50	3.43
Interaction effect					
D x M	NS	Sig	NS	Sig	NS
D x R	Sig	NS	NS	NS	Sig
R x M	Sig	Sig	Sig	NS	Sig
D x R x M	Sig	NS	NS	Sig	NS
C.V. %	3.64	3.60	4.49	5.82	4.40

Fig.-6 : Effect of various pre-drying treatments, drying methods and recipes on ascorbic acid content (mg/100g) of aonla product during storage



maximum ascorbic acid content (306.92, 279.99, 242.42, 173.99 and 139.35 mg/100g, respectively for initial to 4th month of storage).

4.2.2.3 Effect of drying methods

It is apparent from data given in Table 4.6 that ascorbic acid content of aonla product was found significant due to various drying methods. The treatment M_1 (Sun drying) (250.34, 231.25, 190.78, 140.73 and 116.53 mg/100g, respectively for initial to 4th month of storage) resulted in significantly minimum ascorbic acid content followed by M_2 (Oven drying) treatment (308.09, 284.63, 234.92, 180.68 and 146.84 mg/100g, respectively for initial to 4th month of storage).

4.2.2.4 Interaction effect of D x M

The interaction between D x M was found significant at 1st and 3rd month of storage, while, on rest of storage period it was found to be non-significant for ascorbic acid content of aonla product (Table 4.6.1). The treatment combination D_2M_2 recorded significantly highest ascorbic acid content (290.08 and 192.58 mg/100g, respectively for 1st and 3rd month of storage) followed by D_1M_2 treatment combination (279.17 and 168.79 mg/100g, respectively for 1st and 3rd month of storage).

4.2.2.5 Interaction effect of D x R

The interaction between D x R was found significant at initial and 4th month of storage while on rest of storage period it was found non-significant for ascorbic acid content of aonla

product (Table–4.6.2). The treatment combination D_1R_1 recorded significantly lowest ascorbic acid content (243.70 and 109.25 mg/100g, respectively for 1st and 4th month of storage) followed by D_1R_2 treatment i.e., 268.45 and 120.60 mg/100g, respectively for 1st and 4th month of storage.

Table- 4.6.1: Combined effect of pre-drying treatments and drying methods on ascorbic acid content (mg/100g) of aonla product during storage

Treatments	Ascorbic acid (mg/100g)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
D_1M_1	243.29	217.52	178.53	135.43	107.27
D_1M_2	302.52	279.17	224.52	168.79	135.15
D_2M_1	257.38	244.98	203.03	146.04	125.79
D_2M_2	313.67	290.08	245.33	192.58	158.53
S. Em ±	2.938	2.683	2.762	2.699	1.674
C. D. at 5 %	NS	7.73	NS	7.77	NS

Table-4.6.2: Combined effect of pre-drying treatments and recipes on ascorbic acid content (%) of aonla product during storage

Treatments	Ascorbic acid (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
D_1R_1	243.70	220.35	180.42	137.53	109.25
D_1R_2	268.45	247.67	196.48	157.78	120.60
D_1R_3	277.10	249.72	197.08	151.88	122.98
D_1R_4	301.95	275.63	232.12	170.62	145.50
D_2R_1	278.30	246.35	207.58	151.87	125.28
D_2R_2	283.47	275.23	222.48	161.23	132.00
D_2R_3	268.87	264.18	213.92	168.00	142.15
D_2R_4	311.88	284.35	252.72	186.75	155.72
S. Em ±	4.155	3.794	3.905	3.816	2.367
C. D. at 5 %	11.97	NS	NS	NS	6.82

4.2.2.6 Interaction effect of R x M

The interaction between R x M was found significant from initial to 3rd month of storage while on 4th month of storage period it was found non-significant for ascorbic acid content of aonla product (Table – 4..6.3). The treatment combination R_1M_1 recorded significantly lowest ascorbic acid content (225.00, 206.20, 166.17 and 98.28 mg/100g, respectively for initial, 1st, 2nd and 4th month of storage) which was followed by R_3M_1 treatment combination i.e., 243.77, 224.12, 180.37 and 115.42 mg/100g, respectively for initial, 1st, 2nd and 4th month of storage. While, on 3rd month of storage it was found to non-significant.

Table- 4.6.3: Combined effect of drying methods and recipes on ascorbic acid content (%) of aonla product during storage

Treatment	Ascorbic acid (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
R_1M_1	225.00	206.20	166.17	126.72	98.28
R_2M_1	248.52	232.25	187.88	143.33	125.33
R_3M_1	243.77	224.12	180.37	138.30	115.42
R_4M_1	284.07	262.42	228.70	154.58	127.08
R_1M_2	297.00	260.50	221.83	162.68	136.25
R_2M_2	303.82	290.65	231.08	185.07	150.42
R_3M_2	301.78	289.78	230.63	181.58	147.33
R_4M_2	329.77	297.57	256.13	193.40	153.37
S. Em ±	4.155	3.794	3.905	3.816	2.367
C. D. at 5 %	11.97	10.93	11.25	NS	6.82

Table- 4.6.4: Combined effect of pre-drying treatments, drying methods and recipes on ascorbic acid content (mg/100 g) of aonla product during storage

Treatments	Ascorbic acid (mg/100 g)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
$D_1R_1M_1$	203.67	190.40	150.37	120.83	94.60
$D_1R_2M_1$	225.73	208.43	168.60	129.43	105.17
$D_1R_3M_1$	251.60	212.63	173.47	138.83	122.13
$D_1R_4M_1$	292.17	258.60	221.70	152.60	107.17
$D_1R_1M_2$	283.73	250.30	210.47	154.23	123.90
$D_1R_2M_2$	312.00	286.90	219.50	176.73	141.87
$D_1R_3M_2$	302.60	286.80	225.57	174.33	136.03
$D_1R_4M_2$	311.73	294.40	242.67	193.40	158.97
$D_2R_1M_1$	246.33	222.00	181.97	132.60	101.97
$D_2R_2M_1$	271.30	256.07	202.30	147.83	132.03
$D_2R_3M_1$	235.93	235.60	192.13	147.17	125.67
$D_2R_4M_1$	275.97	266.23	235.70	156.57	143.50
$D_2R_1M_2$	310.27	270.70	233.20	171.13	148.60
$D_2R_2M_2$	295.63	292.67	235.70	169.87	138.80
$D_2R_3M_2$	300.97	292.77	242.53	188.83	158.63
$D_2R_4M_2$	347.80	302.47	269.73	216.93	167.93
S. Em ±	5.876	5.366	5.523	5.397	3.347
C. D. at 5 %	16.92	NS	NS	15.55	NS

4.2.2.7 Interaction effect of D x R x M

The interaction between D x R x M were found to be significant at initial and 3rd month of storage while on rest of month of storage period it was found as non-significant for ascorbic acid content of aonla product (Table–4.6.4). The treatment combination $D_1R_1M_1$ recorded significantly lowest ascorbic acid content (203.67 and 120.83 mg/100g, respectively for initial and 3rd month of storage) which was followed by $D_1R_2M_1$ treatment i.e., 225.73 mg/100g for 0th month of storage while on 3rd month of storage it was at par with $D_1R_2M_1$ (129.43 mg/100g).

4.2.3 Total Soluble Solids

The data pertaining to total soluble solids (TSS) of aonla product as influenced by pre-drying treatments, recipes and drying methods are presented in Table 4.7. The TSS content increased considerably in all treatments with increase in storage period. The TSS content of aonla product was recorded maximum in control throughout the storage period.

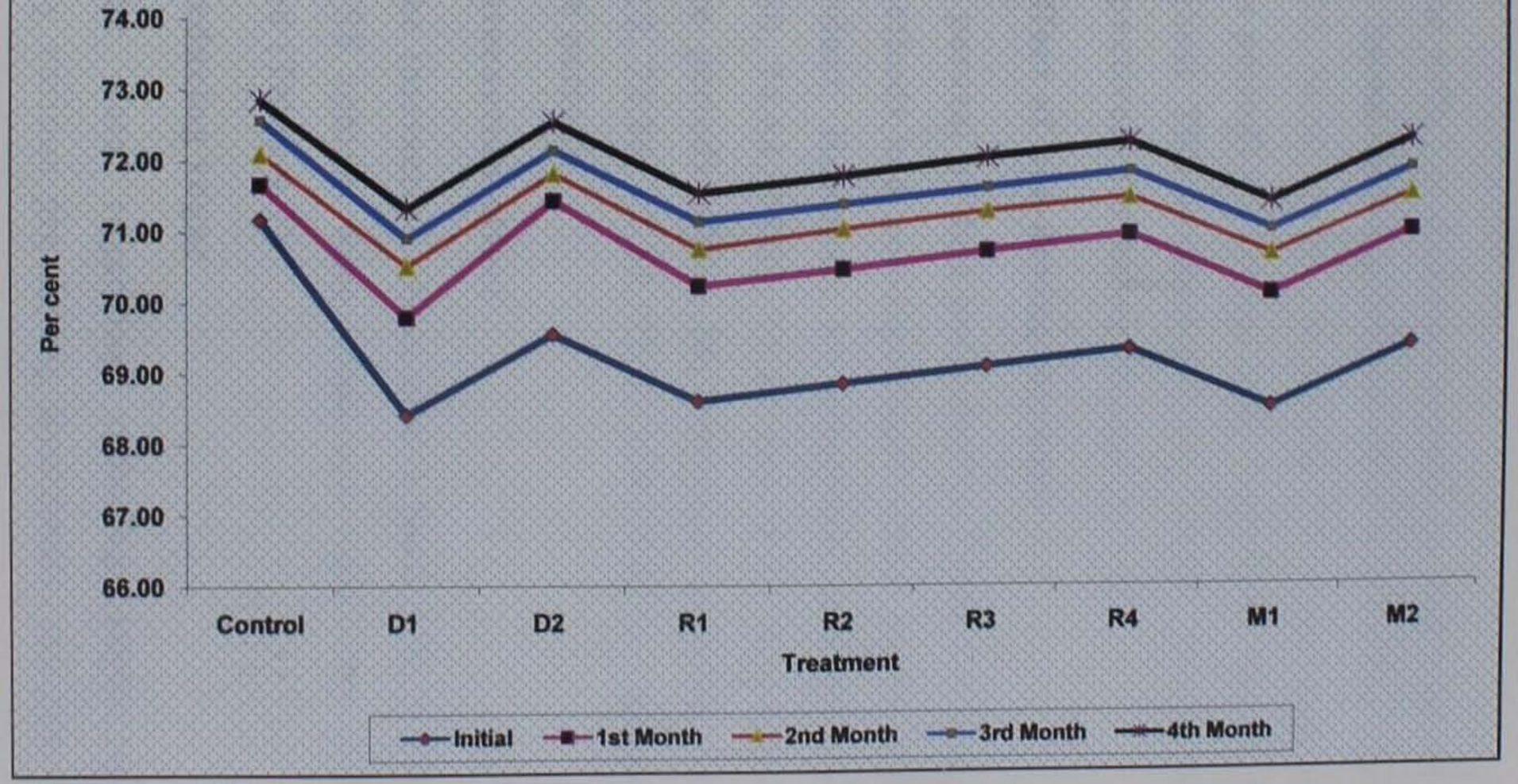
4.2.3.1 Effect of pre-drying treatments

It is evident from the data presented in Table 4.7 that the pre-drying treatments significantly affect the TSS content of aonla product. Significantly lowest TSS content (74.45, 74.68, 74.85, 75.07 and 75.29 %, respectively for entire storage period) was recorded in D_1) treatment, while, D_2 treatment i.e., 75.28,

Table- 4.7: Effect of various pre-drying treatments, drying methods and recipes on Total Soluble Solids (%) of aonla product during storage

Treatments	Total Soluble Solids (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	76.23	76.32	77.15	77.62	77.91
Pre-drying treatments					
D_1	74.45	74.68	74.85	75.07	75.29
D_2	75.28	75.52	75.69	76.04	76.26
S. Em ±	0.255	0.262	0.283	0.308	0.325
C. D. at 5 %	0.74	0.76	0.82	0.89	0.93
Recipes					
R_1	74.27	74.50	74.67	74.96	75.18
R_2	74.68	74.91	75.08	75.37	75.58
R_3	75.10	75.34	75.51	75.79	76.01
R_4	75.41	75.65	75.82	76.10	76.32
S. Em ±	0.361	0.371	0.401	0.435	0.460
C. D. at 5 %	NS	NS	NS	NS	NS
Drying methods					
M_1	74.60	74.84	75.01	75.30	75.52
M_2	75.12	75.86	75.53	75.81	76.03
S. Em ±	0.255	0.262	0.283	0.308	0.325
C. D. at 5 %	NS	NS	NS	NS	NS
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	NS	NS	NS	NS	NS
D x R x M	NS	NS	NS	NS	NS
C.V. %	1.67	1.71	1.85	1.99	2.10

Fig.-7 : Effect of various pre-drying treatments, drying methods and recipes on Total Soluble Solids (%) of aonla product during storage



75.52, 75.69, 76.04 and 76.26 %, respectively for entire storage period recorded higher TSS content of aonla product.

4.2.3.2 Effect of recipes

The effect of different recipes on TSS content of aonla product was found non-significant (Table 4.7).The lowest TSS content (74.27, 74.50, 74.67, 74.96 and 75.18 %, respectively for entire storage period) was noted in R_1 treatment. The R_4 treatment recorded highest TSS content (75.41, 75.65, 75.82, 76.10 and 76.32 %, respectively for entire storage period).

4.2.3.3 Effect of pre-drying methods

A perusal of data presented in Table 4.7 indicated that the drying methods had non-significant effect on the TSS content of aonla product. However, M_1 treatment recorded lower TSS content (74.60, 74.84, 75.01, 75.30 and 75.52 %, respectively for entire storage period) while, M_2 treatment recorded higher TSS content (75.12, 75.86, 75.53, 75.81 and 76.03 %, respectively for entire storage period).

4.2.3.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for TSS content were found non-significant during entire storage period (Table 4.7).

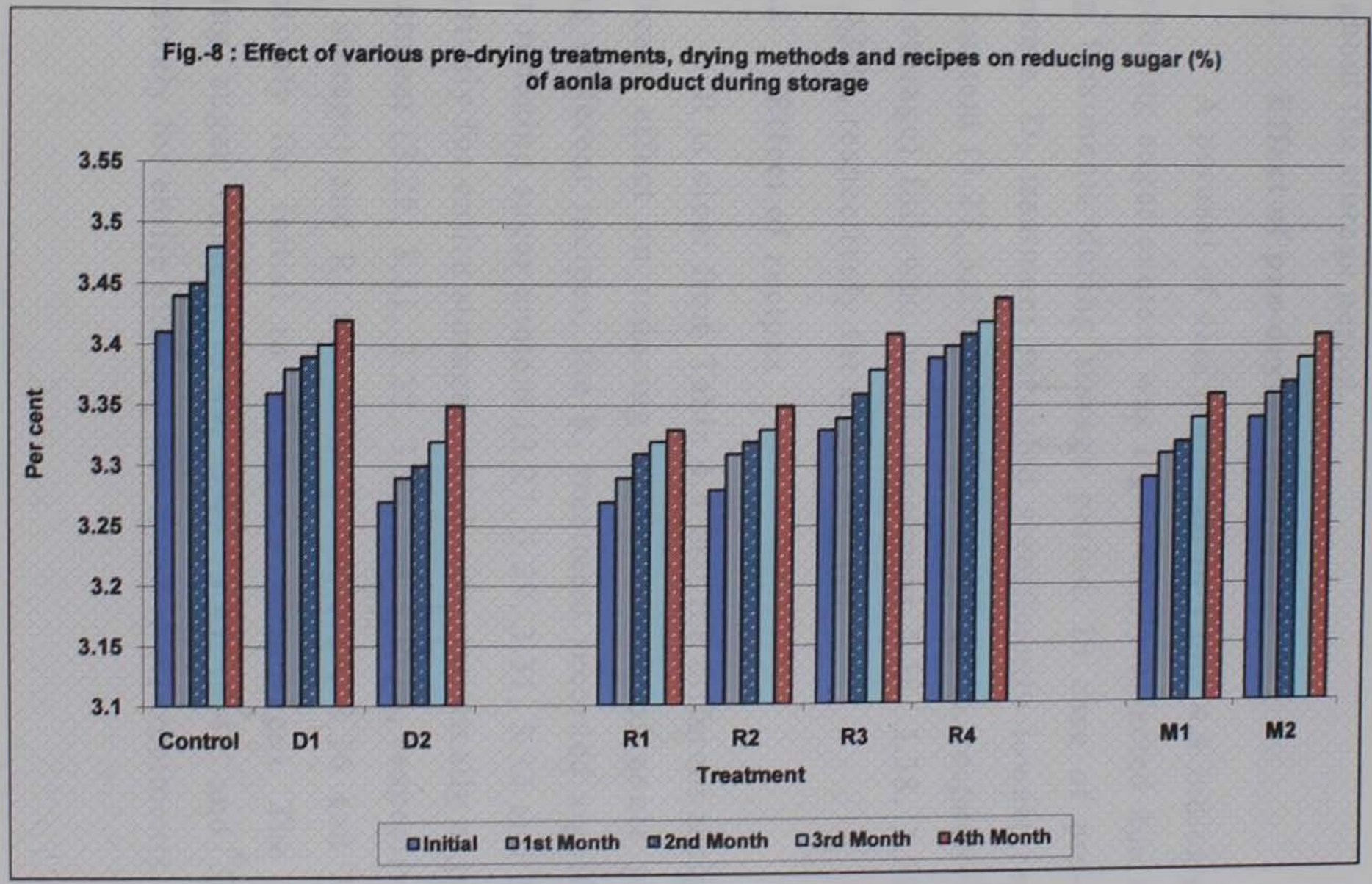
4.2.4 Reducing sugar

The data regarding reducing sugar content as influenced by various pre drying treatments, recipes and drying

Table-4.8: Effect of various pre-drying treatments, drying methods and recipes on reducing sugar (%) of aonla product during storage

Treatments	Reducing sugar (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	3.41	3.44	3.45	3.48	3.53
Pre-drying treatments					
D_1	3.36	3.38	3.39	3.40	3.42
D_2	3.27	3.29	3.30	3.32	3.35
S. Em ±	0.019	0.018	0.019	0.017	0.019
C. D. at 5 %	0.05	0.05	0.05	0.04	0.05
Recipes					
R_1	3.27	3.29	3.31	3.32	3.33
R_2	3.28	3.31	3.32	3.33	3.35
R_3	3.33	3.34	3.36	3.38	3.41
R_4	3.39	3.40	3.41	3.42	3.44
S. Em ±	0.026	0.026	0.026	0.025	0.027
C. D. at 5 %	0.08	0.07	0.08	0.07	0.07
Drying methods					
M_1	3.29	3.31	3.32	3.34	3.36
M_2	3.34	3.36	3.37	3.39	3.41
S. Em ±	0.019	0.018	0.017	0.017	0.019
C. D. at 5 %	NS	NS	NS	NS	NS
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	NS	NS	NS	NS	NS
D x R x M	NS	NS	NS	NS	NS
C.V. %	2.74	2.68	2.73	2.52	2.72

Fig.-8 : Effect of various pre-drying treatments, drying methods and recipes on reducing sugar (%) of aonla product during storage



methods are presented in Table 4.8. The reducing sugar content of aonla product increase with increased storage period. The reducing sugar content of aonla product was maximum in control throughout the storage period.

4.2.4.1 Effect of pre-drying treatments

A perusal of data presented in Table 4.8 indicated that the reducing sugar content was significantly affected due to pre-drying treatments during storage period. In case of pre-drying treatments, D_2 treatment recorded significantly lowest reducing sugar content (3.27, 3.29, 3.30, 3.32 and 3.35 %, respectively for entire storage) followed by D_1 treatment 3.36, 3.38, 3.39, 3.40 and 3.42 %, respectively for entire storage.

4.2.4.2 Effect of recipes

It is clear from Table 4.8 that the different recipes had significant effect on reducing sugar content of aonla product. Among different recipes, the R_1 treatment recorded significantly lowest reducing sugar content (3.27, 3.29, 3.31, 3.32 and 3.33 %, respectively for entire storage) which was statistically at par with R_2 treatment (3.28, 3.31, 3.32, 3.33 and 3.35 %, respectively for entire storage) and R_3 treatment (3.33, 3.34, 3.36 and 3.38 %, respectively for initial to 3rd month of storage). The highest reducing sugar content (3.39, 3.40, 3.41, 3.42 and 3.44 %, respectively for entire storage) was noted in R_4 treatments.

4.2.4.3 Effect of drying methods

It is evident from Table 4.8 that the drying methods had found non-significant for reducing sugar content of aonla product. However, between two drying methods M_1 treatment and M_2 treatment recorded least reducing sugar content (3.29, 3.31, 3.32, 3.34 and 3.36 %, respectively for entire storage) while M_2 (3.34, 3.36, 3.37, 3.39 and 3.41 %, respectively for entire storage) recorded highest reducing sugar content.

4.2.4.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for reducing sugar content of aonla product were found non-significant during entire storage period (Table 4.8).

4.2.5 Non-reducing sugar

Data regarding to the non-reducing sugar content as influenced by various pre-drying treatments, recipes and drying methods are presented in Table 4.9. The non-reducing sugar content of aonla product increased as the storage period increased. The non-reducing sugar content of aonla product was maximum in control throughout the storage period.

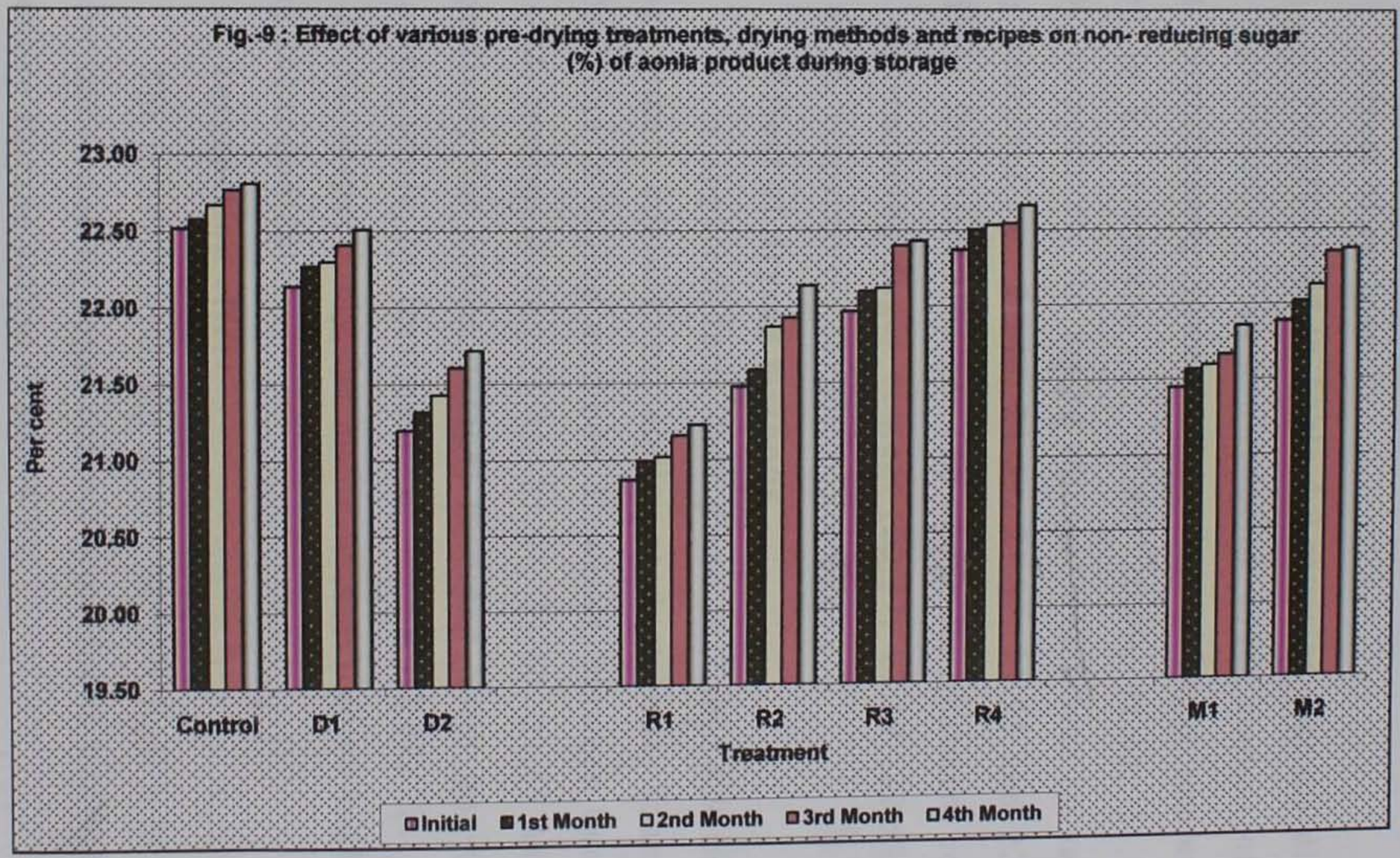
4.2.5.1 Effect of pre-drying treatments

Effect of pre-drying treatments on non-reducing sugar content of aonla product was found to be significant (Table 4.9). However, among the D_1 and D_2 treatments, the application of D_2 treatment resulted lower non-reducing sugar content (21.20, 21.32, 21.43, 21.61 and 21.72 %, respectively for entire storage).

Table- 4.9: Effect of various pre-drying treatments, drying methods and recipes on non- reducing sugar (%) of aonla product during storage

Treatments	Non- Reducing sugar (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	22.52	22.58	22.67	22.77	22.81
Pre-drying treatments					
D_1	22.14	22.27	22.30	22.41	22.51
D_2	21.20	21.32	21.43	21.61	21.72
S. Em ±	0.220	0.226	0.233	0.185	0.184
C. D. at 5 %	0.64	0.65	0.67	0.53	0.53
Recipes					
R_1	20.87	20.99	21.02	21.16	21.23
R_2	21.48	21.59	21.87	21.93	22.14
R_3	21.97	22.10	22.12	22.40	22.43
R_4	22.37	22.50	22.53	22.54	22.66
S. Em ±	0.312	0.319	0.329	0.262	0.260
C. D. at 5 %	0.90	0.92	0.95	0.75	0.74
Drying methods					
M_1	21.45	21.57	21.60	21.67	21.86
M_2	21.89	22.02	22.13	22.35	22.37
S. Em ±	0.220	0.226	0.233	0.185	0.184
C. D. at 5 %	NS	NS	NS	NS	NS
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	NS	NS	NS	NS	NS
D x R x M	NS	NS	NS	NS	NS
C.V. %	4.95	5.09	5.32	4.18	4.16

Fig.-9 : Effect of various pre-drying treatments, drying methods and recipes on non- reducing sugar (%) of aonla product during storage



While, D_1 treatment recorded higher non-reducing sugar content (22.14, 22.27, 22.30, 22.41 and 22.51%, respectively for entire storage).

4.2.5.2 Effect of recipes

Data presented in Table 4.9 revealed that the different recipes significantly affect non-reducing sugar content of aonla product. Significantly lowest non-reducing sugar content was recorded in R_1 treatment i.e., 20.87, 20.99, 21.02, 21.16 and 21.23 %, respectively for entire storage, which was on same bar with R_2 treatment i.e., 21.48, 21.59, 21.87, 21.93 and 22.14 %, respectively for entire storage. The recipe R_4 treatment recorded highest non-reducing sugar content (22.37, 22.50, 22.53, 22.54 and 22.66 %, respectively for entire storage).

4.2.5.3 Effect of drying methods

It is apparent form data given in Table 4.9 that non-reducing sugar content of aonla product was found non-significant due to drying methods. However, between two drying methods M_1 treatment i.e., 21.45, 21.57, 21.60, 21.67 and 21.86 %, respectively for entire storage) recorded lower non-reducing sugar content while, M_2 treatment i.e., 21.89, 22.02, 22.13, 22.35 and 22.37 %, respectively for entire storage) noted higher non-reducing sugar content.

4.2.5.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for non-reducing sugar content were found non-significant during entire storage period (Table 4.9).

4.2.6 Total sugar

The data on total sugar as influenced by various pre-drying treatments, recipes and drying methods are furnished in Table 4.10. It is clear from table that the total sugar of aonla product gradually increased with increase in storage period. The total sugar content of aonla product was maximum in control throughout the storage period.

4.2.6.1 Effect of pre-drying treatment

From Table 4.10, it is evident that the total sugar was significantly affected by various pre-drying treatments. Maximum total sugar content was recorded in control. Between two pre-drying treatments, D_2 treatment recorded significantly lowest total sugar content i.e., 24.48, 24.61, 24.73, 24.93 and 25.07 %, respectively for entire storage period followed by D_1 treatment i.e., 25.51, 25.65, 25.69, 25.81 and 25.93 %, respectively for entire storage period.

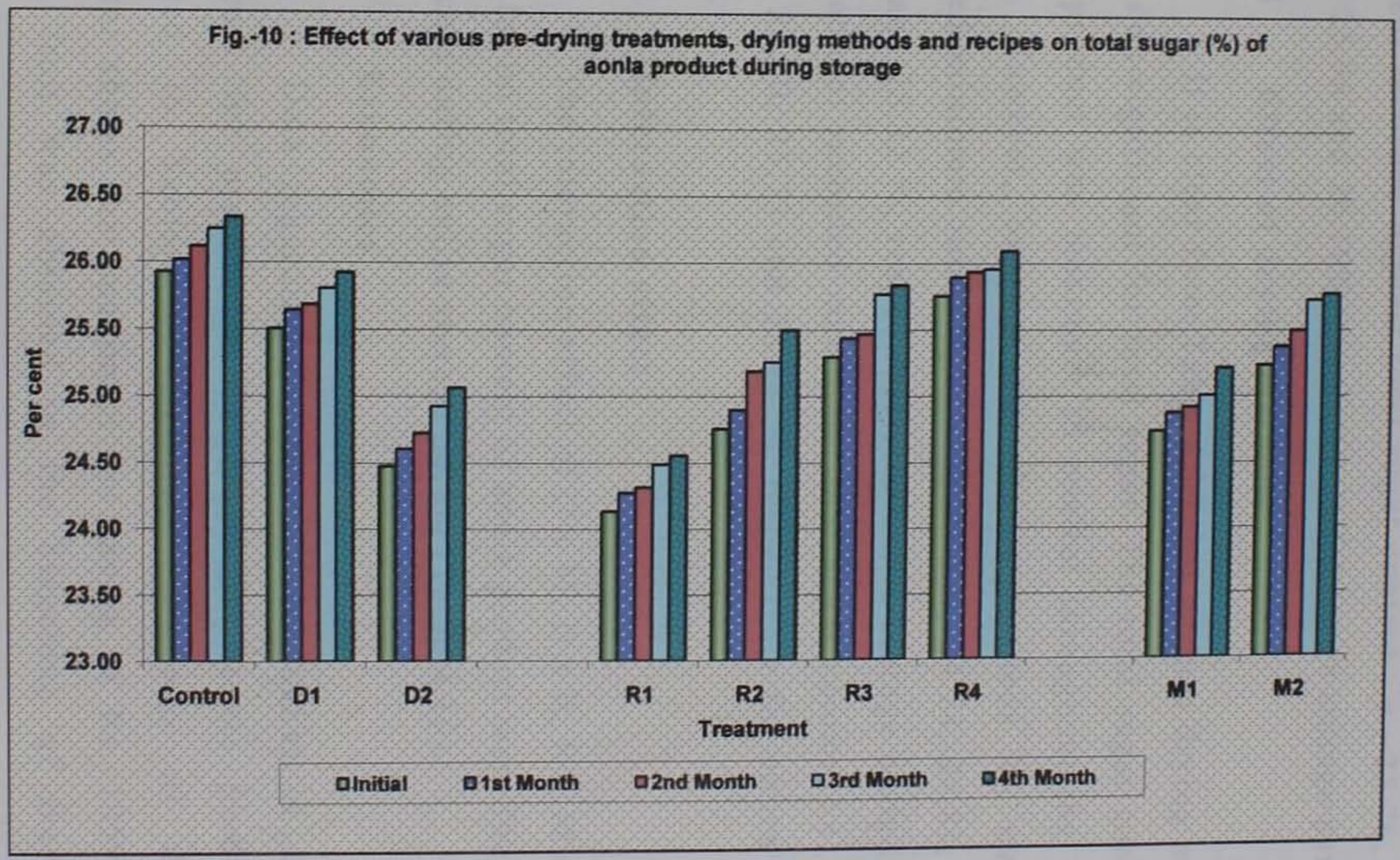
4.2.6.2 Effect of recipes

It is evident from Table 4.10 that the different recipes had significant effect on total sugar content of aonla product during storage. Total sugar content of aonla product was maximum in control throughout the storage period. However, among the different recipes, R_1 treatment noted significantly lowest total sugar content i.e., 24.14, 24.28, 24.32, 24.49 and 24.56 %, respectively for entire storage period which was statistically at par with R_2 treatment and the values are 24.76,

Table-4.10: Effect of various pre-drying treatments, drying methods and recipes on total sugar (%) of aonla product during storage

Treatments	Total sugar (%)				
	Initial	1st Month	2nd Month	3rd Month	4th Month
Absolute control	25.93	26.02	26.12	26.25	26.34
Pre-drying treatments					
D_1	25.51	25.65	25.69	25.81	25.93
D_2	24.48	24.61	24.73	24.93	25.07
S. Em ±	0.229	0.216	0.232	0.181	0.268
C. D. at 5 %	0.66	0.62	0.67	0.52	0.77
Recipes					
R_1	24.14	24.28	24.32	24.49	24.56
R_2	24.76	24.90	25.19	25.26	25.50
R_3	25.30	25.44	25.47	25.77	25.84
R_4	25.76	25.90	25.94	25.96	26.10
S. Em ±	0.324	0.306	0.329	0.353	0.379
C. D. at 5 %	0.93	0.88	0.95	0.74	0.1.09
Drying methods					
M_1	24.74	24.88	24.92	25.01	25.22
M_2	25.24	25.38	25.50	25.73	25.78
S. Em ±	0.229	0.216	0.232	0.181	0.268
C. D. at 5 %	NS	NS	NS	NS	0.77
Interaction effect					
D x M	NS	NS	NS	NS	NS
D x R	NS	NS	NS	NS	NS
R x M	NS	NS	NS	NS	NS
D x R x M	NS	NS	NS	NS	NS
C.V. %	4.47	4.23	4.54	3.55	5.18

Fig.-10 : Effect of various pre-drying treatments, drying methods and recipes on total sugar (%) of aonla product during storage



24.90 and 25.26 %, respectively for initial, 1st and 3rd month of storage and on 2nd and 4th month of storage it was followed by R_3 treatment i.e., 25.47 and 25.84 %, respectively. The recipe R_4 treatment recorded highest total sugar content i.e., 25.76, 25.90, 25.94, 25.96 and 26.10%, respectively for entire storage period.

4.2.6.3 Effect of drying methods

It is clear from Table 4.10 that various drying methods found non-significant for total sugar. The total sugar content of aonla product was maximum in control throughout the storage period. However, between two drying methods M_1 treatment recorded minimum total sugar content i.e., 24.74, 24.88, 24.92, 25.01 and 25.22 %, respectively for entire storage period. While M_2 treatment recorded maximum total sugar content i.e., 25.24, 25.38, 25.50, 25.73 and 25.78 %, respectively for entire storage period.

4.2.6.4 Interaction effect

The interaction effect of D x M, D x R, R x M and D x R x M for on total sugar content of aonla product were found non-significant during entire storage period (Table 4.10).

4.3 Economics

Data regarding the relative economics of different treatments for preparation of dehydrated aonla product are presented in Table-4.11. Relative economics of different treatment shows that maximum net saving of Rs. 1059.00 per quintal fruit was obtained in the blanching of fruits with

sulphitation (KMS @ 1000 mg/lit), fruit pieces with common salt 3 per cent and Sun drying ($D_2R_1M_1$) treatment. This treatment was closely followed by blanching of fruits with sulphitation (KMS @ 1000 mg/1) fruit pieces with black salt 3 per cent and oven drying ($D_2R_2M_2$) i.e., Rs. 1049.90. The highest benefit cost ratio (2.18) was recorded in the same treatment i.e., blanching of fruits with sulphitation (KMS @ 1000 mg/1), fruit pieces with common salt 3 per cent and Sun drying ($D_2R_1M_1$).

Table-4.11 Economics feasibility of various treatments for preparation of dehydrated aonla product

Treatments	Treatment cost	Quantity product	Price of the product	Net benefit	BCR
CONTROL	850.00	11.60	928.00	78.00	1.09
$D_1R_1M_1$	891.00	11.72	1816.60	925.60	2.04
M_2	955.00	12.30	1906.50	951.50	2.00
R_2M_1	895.00	12.29	1904.95	1009.95	2.13
M_2	959.00	12.32	1909.60	950.60	1.99
R_3M_1	1387.00	12.31	1908.05	521.05	1.38
M_2	1468.00	12.56	1946.80	478.80	1.33
R_4M_1	1423.00	12.70	1968.50	545.50	1.38
M_2	1487.00	13.30	2061.50	574.50	1.39
$D_2R_1M_1$	894.00	12.60	1953.00	1059.00	**2.18**
M_2	958.00	12.87	1994.85	1036.85	2.08
R_2M_1	898.00	12.40	1922.00	1024.00	**2.14**
M_2	962.00	12.98	2011.90	1049.90	2.09
R_3M_1	1407.00	12.49	1935.95	528.95	1.38
M_2	1471.00	13.12	2033.60	562.60	1.38
R4M1	1426.00	12.60	1953.00	527.00	1.37
M2	1490.00	13.14	2036.70	546.70	1.37

Control	850
D_1	17
D_2	20
R_1	15
R_2	19
R_3	528
R_4	547
M_1	9
M_2	73

Aonla product prices	**155 Rs/Kg**
Control price	**80 Rs/**
Purchase price of aonla	**700 Rs/Qt**

V. DISCUSSION

Brief discussion on the results of the present study entitled "Influence of Pre–drying treatments and drying methods on different recipes of aonla (*Emblica officinalis* Gaertn.) Product preparation." Presented In this chapter with appropriate reasons and possible explanation. The discussion has been divided under different sub heading.

5.1 Physical characteristics and

5.2 Chemical characteristics.

5.1 Physical characteristics

5.1.1 Colour

Colour of the product is an important qualitative parameter because it attracts the eyes of consumer and thus influences the market price. In the present study, various pre-drying treatments, recipes and drying methods significantly affected the colour of dehydrated product during entire storage period. Further, the colour value of dehydrated product decreased with the advancement of storage period, however, the rate of reduction in colour value was significantly influenced by various treatments.

In case of pre-drying treatments both blanching and blanching with sulphitation resulted higher colour value as compared to control (Table-4.1). Further, the rate of deterioration in colour of the product was at reduced rate as a result of

blanching and blanching with sulphitation treatment as compared to control. It might be due to the fact that SO_2 released by KMS prevented oxidative browning during storage. The retention of fruit colour due to different pre-drying treatments over control was also reported by Verma and Gupta (1996) in aonla cv. 'Banarasi'. Sethi (1986) also reported less non enzymatic browning in blanched aonla fruit as compared to unblanched fruit after drying. Blanching of fruits showed less browning due to inactivating of polyphenol oxidase that caused browning during storage. Srivastava and Kumar (1994) reported that sulphur dioxide fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus improves their colour. The present results are in confirmation with findings of Dandamrongrak *et al.* (2003) who reported that banana product obtained by pre-drying treatment with blanching was most preferred in terms of colour compared to control.

Similarly, different drying methods also influence the colour of the aonla product. The maximum colour value was obtained in oven drying as compared to sun drying (Table-4.1). This shows that the product dried in oven resulted in minimum loss of colour as compared to the product dried under sun. Sun dried products have maximum loss of colour due to the effect of direct sunlight. Suhardjo *et al.* (2000) also reported that drying methods influenced the colour of mango chips with best quality chips produced after drying in an electric drier as compared to sun drying. Similarly, Palodkar *et al.* (2003) also reported that

cabinet drying resulted better colour of dehydrated aonla as compared to sun drying.

Application of different recipe treatments significantly affected the colour of the product during storage. The maximum colour value was obtained in 3 per cent common salt treatment as compared to other recipes (Table 4.1). Though, no reference is available which could directly support the present findings on colour of the dehydrated aonla product as affected by different recipe treatments. A possible reason for this might be that different recipes i.e. common salt, black salt and ginger juice imparts different colour to the product. As being common salt white in colour, therefore, it imparts light colour to the product compared to black salt which imparts dark colour. In the present investigation colour imparted by common salt is most preferred compared to other recipes, as it seems to be more pleasure and attractive to the eyes.

Among the various treatments combination attempted in the present investigation the colour value of the product was significantly influenced by combined application of drying method and recipe treatments (Table-4.1.1). It is further evident from the data that these interaction treatment exhibited better retention of colour of dehydrated aonla product during storage. From various drying methods and recipe treatment combinations, the maximum colour value was observed in R_1M_2 treatment combination. This might be due to complementary effects in improving colour of the product.

5.1.2 Taste

Taste is the sensation caused in the tongue by things placed on it with the help of taste buds. It has four dimensional phenomenons like sweet, salty, sour and bitter. It is one of the most important parameter deciding the consumer's preference for the product. In the present investigation various recipe and drying method treatments significantly affected the taste of dehydrated aonla product over control. As far as the pre-drying treatment concerned, the application of blanching and blanching with sulphitation treatment exhibited higher taste value of the product over control during entire period of storage. However, the difference between the treatments was found to be non-significant during entire storage period (Table 4.2). Blanching is essential to inactivate the enzymes that would cause discolouration and ultimately change the taste, flavour and aroma. Sulphited product was also highly acceptable over control due to better aroma and taste. The results are in confirmation with the findings of Dabhade and Khedkar (1980 b) in mango powder. To support the present results, Kaur and Bindra (1985) also stated that pre-drying treatments like sulphuring and oiling improved the quality of raisins prepared from the 'Thompson Seedless' and 'Perlette' grapes.

The different recipe treatments significantly improved the taste of the product (Table 4.2). The maximum taste was recorded with 3 per cent common salt compared to control. As aonla is not a common dietary item, therefore, treatment with

different recipe improves the taste of the product the results colloborate with the findings of Mehta and Tomar (1982) who observed that mango slices treated with 1per cent KMS and 5 per cent common salt gave the best dehydrated product.

Similarly, different drying methods also significantly influenced the taste of the aonla product (Table 4.2). In the present experiment, oven drying exhibited the maximum taste value of the dehydrated aonla product and it remains highest during entire storage period of the product. The higher taste value at oven drying methods may be because this method dried the fruit under sanitary and controlled conditions. The present findings are supported by the findings of Suhardjo *et al.* (2000) who reported that drying methods influenced the taste and quality of mango chips, with the best quality chips produced after drying in an electric drier at 80^0 C over sun drying.

Whereas, the interaction of recipe and drying method treatments significantly influenced the taste of dehydrated aonla product (Table 4.2.1) during the storage of the product. The maximum taste value was recorded at R_1M_2 treatment combination and it remained highest during entire period of storage. The significant results of these interactions may be due to the additive effects of these treatments. The combined application of pre drying treatments, recipes and drying methods was found to be non-significant in the present investigation (Table 4.2).

5.1.3 Organoleptic acceptance

Organoleptic acceptance decides the consumer's preference of the product. It includes the overall acceptance of the product with respect to colour, flavour, taste and appearance. It determines the final acceptance of the product by consumer. In the present study all the treatments exhibited significantly higher organoleptic acceptance of the product over control.

As far as the individual effect of pre-drying treatments is concerned, the maximum initial organoleptic acceptance score was obtained in blanching followed by blanching with sulphitation as compared to control (Table 4.3). The present finding is supported by Sharma *et al.* (1989). They obtained apricots of excellent organoleptic quality when dried after sulphiting and lye treatment. Gadakh *et al.* (1999) reported that overall acceptability of untreated ber fruits was low compared to destined fruits with blanching and sulphuring pretreatment. Blanching is essential to inactivate the enzymes that would cause discolouration and ultimately change the flavour and aroma. Sulphited product was also highly acceptable by the panel of judges over control due to better aroma and taste. The results are in confirmation with the findings of Verma and Gupta (1996). However, the rate of decrease in organoleptic score was significantly low at both blanching and blanching with sulphitation i.e. D_1 (blanching of fruits) and D_2 (blanching of fruits with sulphitation KMS @ 1000 mg/lit.) treatment as compared to control, but difference between the treatments i.e.D_1

and D_2 was found to be non-significant which indicate that both the treatments were equally effective for retention of organoleptic score of the dehydrated product during storage. The present findings are also supported by Tripathi *et al.* (1988).

The different recipe treatments were found to be significant for organoleptic acceptance of the dehydrated aonla product initially as well as during entire period of storage. The maximum organoleptic acceptance was obtained with fruit pieces with 3 per cent common salt (R_1) (Table 4.3). The possible explanation of this may be due to be the better colour, taste, aroma, appearance and flavour of the product has in common salt. Finally, it depends upon the consumer's preference of different recipes. These results are in agreement with the earlier findings of Damame *et al.* (2002) in aonla *supari*.

Different drying method treatments also significantly affected the initial organoleptic acceptance of dehydrated aonla product as well as during the storage (Table 4.3). In the present investigation between two drying methods, the highest organoleptic acceptance was obtained at oven drying treatment followed by sun drying. It might be due to the reason that the product dried quickly in oven as compared to sun drying. Due to longer exposure to sunlight maximum loss of colour occurred and the product developed off flavour and gets infested with dirt and dust. Under oven drying the product is uniformly dried and avoided from over heating.

The interaction between the recipes and drying methods significantly affected the organoleptic acceptance of dehydrated aonla product during the entire period of storage (Table 4.3.1). This might be due to mutual complementary effect of these treatments. Further, in the present study the interaction effect of pre-drying treatments with drying methods (Table 4.19) and interaction effect of pre-drying treatments, recipes and drying methods was found to be non significant (Table-4.3).

5.1.4 Recovery percentage

Recovery percentage is an important parameter of dehydrated products. The results of present study indicates that the absolute control give significant higher recovery as compare to the all treatments, i.e., blanching, recipes and method of drying. It is evident from the results that the application of various pre-drying treatments. i.e., blanching, sulphitation, significantly reduced the recovery over control. Whereas, the difference between the blanching and sulphitation was found to be non significant. The present findings are in conformed with research trails in cabbage (Kaur and singh, 1998)

It is evident from the present study that application of various pre-drying treatment i.e. blanching and blanching with sulphitation had reduced the recovery percentage over control which indicate that sulphitation had an affect on the recovery percentage of dehydrated product. The lower recovery percentage at blanching and blanching with sulphitation treatment might be due to more water losses which increased by thin nature of cell

wall. The present findings are in confirmation with the recorded observation of Dabhade and Khedkar (1980 a) in mango.

Similarly, the application of different recipe treatment also showed a non-significant effect on recovery percentage of dehydrated aonla product (Table 4.4). However, the effect of different drying methods was found to be significant where, the maximum recovery percentage was obtained at oven drying (M_2). The possible explanation for higher recovery at oven drying may be due to uniform drying in oven as compared to other drying methods. The present findings are further supported by the results of Pragati *et al.* (2000).

It is further evident from the data that various interactions of pre-drying treatment, drying method and recipe had non significant effect on recovery percentage of dehydrated aonla product.(Table 4.4)

5.1.5 Storability

In present investigation no microbial growth and activity was noticed on dehydrated aonla product stored in plastic containers at ambient temperature up to four months. It might be due to the loss of moisture while drying and dehydration and preservative action of sulphitation. Jayaraman *et al.* (1974) also reported that the intermediate moisture food of guava and pineapple packed in polythene pouch and stored at ambient temperature was microbically safe after six months. Kaur and Bindra (1985) also found that sulphur dioxide fumigation for lye

treated berries was very effective to retard the growth of spoilage organism and respiratory browning of raisins. However, in the present study, the maximum storability of the dehydrated aonla product was recorded at blanching with sulphitation + fruit pieces with 3 per cent common salt + oven drying ($D_2R_1M_2$) treatment on the basis of minimum physico-chemical deterioration and highest organoleptic acceptance and taste of the product as discussed earlier in this chapter.

5.2 Chemical characteristics

5.2.1 Acidity

Acidity is an important quality parameter of the product. The data presented in Table 4.5 reveals that pre-drying treatments i.e. blanching and blanching with sulphitation significantly affected the acidity of dehydrated aonla product. The highest acidity was recorded at control while, minimum acidity at blanching with sulphitation treatment. The acidity of dehydrated aonla product decreased with the advancement of storage period. However, the rate of reduction in acidity was significantly influenced by the pre-drying treatment. These results are in confirmation with findings of Mehta and Tomar (1982) and Sethi (1986) in aonla.

Low acid content of dehydrated aonla product in pre-drying treatment might be due to greater leaching losses of acid content during blanching and sulphitation treatment which ultimately resulted into lower acidity percentage of dehydrated

product. The findings of the present investigation are in confirmation with the work of Dabhade and Khedkar (1980a) who reported heavy leaching losses of acids during blanching and sulphitation in raw mango pieces. In the present study, the individual effect of different recipe and drying method treatments as well as various interactions treatments on acidity of dehydrated aonla product was found to be non-significant during entire period of storage (Table 4.5).

5.2.2 Ascorbic acid

Among the various chemical characteristics, ascorbic acid (vitamin 'C') is very important qualitative parameter of aonla fruits. Retention of ascorbic acid content in the product is therefore at most important. In the present study, ascorbic acid content in the dehydrated aonla product was significantly affected by pre-drying treatments, recipes, drying methods and their combinations (Table 4.6).

The ascorbic acid content of dehydrated aonla product decreased with the advancement of storage period in all the treatments including control. However, various pre-drying treatments, recipe and drying methods attempted in the present study helped in reducing the loss of ascorbic acid during storage. The reduction in ascorbic acid during storage is probably due to the process of oxidation of ascorbic acid forming dehydrating ascorbic acid by enzyme ascorbinase (Das and Desh, 1967).

The maximum retention of ascorbic acid content was obtained with blanching as compared to sulphitation treatment and control (Table 4.6). Thus, blanching and sulphitation treatments reduced the ascorbic acid losses to greater extent. Sulphur treatment reduced the destruction of ascorbic acid. This might be attributed to inactivation of oxidase enzyme responsible for degradation of ascorbic acid content due to blanching and inhibition of oxidative changes of ascorbic acid by SO_2 released by KMS. Beneficial effect of blanching and sulphitation on ascorbic acid content of dried product was also observed by Dabhade and Khedkar (1980 b) in mango powder and Sethi (1986) and Singh *et al.* (2006) in dehydrated aonla product. Srivastava and Kumar (1994) also reported that vitamins in sulphured fruits were preserved but not in unsulphured ones.

The different recipe treatment had significant effect on retention of ascorbic acid content of dehydrated aonla product in the present experiment. Among the various treatment attempted, the minimum ascorbic acid content was recorded with fruit pieces with 3 per cent black salt treatment and it remained lowest during entire period of storage. The possible explanation for the better retention of ascorbic acid due to common and black salt with ginger juice treatment over control might be due to inhibition of oxidative changes of ascorbic acid by salt and ginger juice.

Drying methods significantly affected the ascorbic acid content of dehydrated aonla product. Maximum ascorbic acid content was obtained with oven drying (M_2) and minimum of at

sun drying (M_1). The present finding is supported by Singh *et al.* (2006), Pragati *et al.* (2000), Gadakh *et al.* (1999) in ber and Dabhade and Khedkar (1980 d) in *amchur*. Ascorbic acid is over sensitive to oxidation hence, more losses in ascorbic acid during sun drying might be due to heat, light and oxidation.

Combined effect of pre-drying treatments and recipes on ascorbic acid content of dehydrated aonla product was found to be significant on initial and 4th month of storage (Table 4.6.2). Likewise, the interaction effect of recipes and drying method treatments had significantly influenced the ascorbic acid content of the product on initial, 1st, 2nd and 4th month of storage (Table 4.6.3). The interaction effect of pre-drying treatments and drying method treatments was found to be significant on 1st and 3rd month of storage (Table 4.6.1). However, the combined application of all the three factors i.e. pre-drying treatments, recipes and drying methods was found to be significant on initial stage and 3rd month of storage (Table 4.6.4). The effectiveness of combined application might be because of mutual complementary effect of these factors.

5.2.3 Total Soluble Solids

The TSS content of aonla product was significantly affected by various pre-drying treatments while various drying methods and recipes were found non-significant during entire storage period (Table-4.7). The TSS content of dehydrated aonla product increased with the advancement of storage period in all the treatments including control.

The maximum TSS content was obtained with sulphitation treatment and control as compared to blanching (Table 4.7). Thus, sulphitation treatments increased the TSS content to a greater extent. Pre-drying treatments significantly affected the TSS content of dehydrated aonla product. Maximum TSS content was obtained with D_2 (blanching of fruits with sulphitation (KMS @ 1000 mg/l)) and minimum of at D_1 (blanching of fruits) during the entire storage period. This might be due to more sugar conversion in D_2 as compared to D_1. Similarly, increasing trend in TSS content was earlier reported by Tripathi *et al.* (1988).

The effect of different drying methods and recipes on TSS content of dehydrated aonla product was found to be non-significant in the present study. Similarly, all the interaction of pre-drying treatments, recipes and drying methods showed a non-significant effect on TSS content of dehydrated aonla product during entire period of storage.

5.2.4 Sugars

The data on effect of various treatments viz., pre-drying treatment, recipes, drying methods and their combinations on reducing sugar, non-reducing sugar and total sugar content of dehydrated aonla product are presented in Table-4.8, 4.9 and 4.10. The data recorded in present investigation indicates that untreated control fruit pieces exhibited higher reducing, non-reducing and total sugar content after dehydration and it remain highest during entire period of storage as compared to all the

treatments. However, among the various pre-drying treatments, the maximum reducing sugar, non-reducing sugar and total sugar was recorded in pre-drying treatment. The maximum reducing sugar, non-reducing sugar and total sugar content were recorded in blanching of fruits (D_1) treatment which were significantly higher than blanching of fruits with sulphitation (D_2). The data further revealed that there was a gradual increase in reducing, non-reducing and total sugar content of product. However, increase in sugar content was found to be at slower rate in treated fruits than in untreated control. Maximum sugars in control are due to the fact that it prevented any type of sugar losses by blanching and sulphitation. The findings of present experiment are in line with the work of Sethi (1986), Dabhade and Khedkar (1980 a), Dabhade and Khedkar (1980 e) in mango.

In case of different recipe treatment the application of 3 per cent common salt treatment resulted the minimum reducing, non-reducing and total sugar content which was significantly lower than other treatment (Table 4.8, 4.9 and 4.10).

The effect of different drying methods on reducing sugar, non reducing sugar and total sugar content of dehydrated aonla product was found to be non-significant in the present study. Similarly, all the interaction of pre-drying treatments, recipes and drying methods showed a non-significant effect on reducing, non-reducing and total sugar content of dehydrated aonla product during entire period of storage.

VI. SUMMARY AND CONCLUSION

The present investigation was under taken at Department of Horticulture, N.M.College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) to study "Influence of pre-drying treatments and drying methods on different recipes of aonla (*Emblica officinalis* Gaertn.) Product preparation". The experiment was laid in Randomized Design with Factorial concept with seventeen treatments and one absolute control. During the investigation treatments effect were studies on some physical parameters viz., colour, taste, organoleptic acceptance, recovery percentage and storability and some chemical parameters viz., acidity, ascorbic acid, total soluble solids, reducing sugar, non-reducing sugar and total sugar from initial to 4th month of storage.

6.1 Effect of pre-drying treatments on dehydrated aonla product during storage

1. The significantly higher colour value of dehydrated aonla product (7.51, 6.77, 6.17, 5.53 and 4.96, respectively for initial to 4th month of storage) was recorded in D_2 (blanching of fruits with sulphitation KMS @ 1000 mg/l).

2. Significantly higher taste value of dehydrated aonla product (8.16, 7.26, 6.46, 6.00 and 5.42, respectively for entire storage period) was recorded in D_1 (blanching of fruits).

3. Organoleptic acceptance was found significant at initial month of storage there after it was found non-significant for entire storage period. However, maximum value of organoleptic acceptance was noted in D_1 (blanched fruits).

4. Among various chemical parameters reducing sugar, non-reducing sugar, total sugar and acidity were significantly lower in D_2 (blanching of fruits with sulphitation KMS @ 1000 mg/l). However, ascorbic acid content of aonla product was significantly higher in D_2 (blanching of fruits with sulphitation KMS @ 1000 mg/l). While, TSS content of aonla product was found non-significant with various pre-drying treatments.

6.2 Effect of recipes on dehydrated aonla product during storage

1. The various physical parameters viz., colour, taste and organoleptic acceptance of dehydrated aonla product during storage were significantly higher in R_1 (fruit pieces with common salt 3 %). Whereas, recovery percentage was significantly higher in R_4 (fruit pieces with black salt 3% and ginger juice 10%).

2. In case of chemical parameters viz., acidity, ascorbic acid content, TSS, reducing sugar, non-reducing sugar and total sugar of dehydrated aonla product during

storage were significantly lower in R_1 (fruit pieces with common salt 3 %).

6.3 Effect of drying methods on dehydrated aonla product during storage

1. The value of colour, taste, organoleptic acceptance, ascorbic acid content and recovery percentage of dehydrated aonla product during storage were significantly higher in M_2 (Oven drying).
2. The acidity, TSS, reducing sugar, non-reducing sugar and total sugar of dehydrated aonla product during storage were significantly lower in M_1 (Sun drying).

Conclusion

On the basis of results obtained in present investigation, it can be concluded that application of various pre-drying treatments, different recipes and drying methods had significant effect on dehydrated aonla product. Between two pre-drying treatments, it was found that the value of taste, organoleptic acceptance and recovery percentage can be significantly improved by D_1 (blanching of fruits) while D_2 (blanching of fruits with sulphitation KMS @ 1000 mg/l) treatment exhibited beneficial effect with respect to colour. In case of recipes, R_1 (fruit pieces with common salt 3 %) was found more preferable followed by R_3 (fruit pieces with common salt 3 % + ginger juice 10 %). In case of drying methods, M_2 (Oven drying) was found more effective for physico-chemical parameters of dehydrated aonla product during storage.

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Appendix- I: Nutrient composition of aonla fruit (Sant Ram, 1990)

Sr. No.	Constitute		Level
			Per cent
1.	Moisture	:	77.1 - 82.20
2.	Protein	:	0.50
3.	Fat	:	0.10
4.	Minerals	:	0.50 - 0.70
5.	Fibre	:	1.9 - 3.40
6.	Carbohydrate	:	14.10 - 21.89
7.	Calcium	:	0.012 - 0.05
8.	Phosphorus	:	0.026 - 0.02
			mg/100g
9.	Iron	:	1.20
10.	Nicotinic acid	:	0.20
11.	Vitamin 'C'	:	200 - 1814
12.	Carotene	:	0.01
13.	Thiamine	:	0.03
14.	Riboflavin	:	0.05
15.	Niacin	:	0.18
16.	Tryptophan	:	3.00
17.	Methionine	:	2.00
18.	Lysine	:	17.00
			Cal.
19.	Calorific Value	:	59.00

Appendix – II: Meteorological data recorded during the course of investigation (weekly mean) year 2006-07

Month	Std. week	Temperature (^{0}C)			Relative humidity (%)		
		Max.	Min.	Ave.	Morning	Evening	Ave.
December	50	29.1	15.3	22.20	77	45	61.0
	51	31.2	18.4	24.80	66	38	52.0
	52	30.6	13.4	22.00	83	36	59.5
January	1	30.1	12.6	21.35	85	33	59.0
	2	30.2	14.5	22.35	80	33	56.5
	3	30.3	14.1	22.20	77	39	58.0
	4	26.7	9.6	18.15	81	26	53.5
February	5	31.7	16.5	24.10	77	36	56.5
	6	30.2	17.7	23.95	91	47	69.0
	7	28.1	16.8	22.45	87	38	62.5
	8	34.4	18.9	26.65	71	29	50.0
March	9	31.7	17.6	24.65	86	34	60.0
	10	34.1	16.7	25.40	71	24	47.5
	11	34.4	19.1	26.75	74	29	51.5
	12	35.0	19.1	27.05	84	30	57.0

ABBREVIATIONS

Anon.	=	Anonymous
Av.	=	Average
C.D.	=	Critical difference
cv.	=	Cultivarcvs.=Cultivars*et*
al.	=	*Et allii*, and others
RS	=	Reducing sugar
S.Em	=	Standard error of mean
TS	=	Total Sugar
TSS	=	Total Soluble Solids
Viz.,	=	Namely
Wt.	=	Weight
%	=	per cent°
C	=	Degree celcious (unit of heat)
nm	=	Neno meter

CERTIFICATE

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