Chapter 4
CHAPTER 4
MATERIALS AND METHODS

MATERIALS

4.1. CHILLIES:

Fresh Red Chillies of two varieties, namely Jwala and Pusa Sada Bahar were obtained from fruits and vegetables market near, I.A.R.I. PUSA, New Delhi.

4.1.1. PRE-TREATMENTS GIVEN:

Following Pre-treatments were given:

(A) Punching
(B) Destalking + Punching

Mechanisms applied for the aforesaid pre-treatments are being described in forgoing pages.

4.1.1.A. Punching –

Chilli punching machine (Plate 1), which was used for the punching of chillies, was developed in the Division of Agricultural Engineering, I.A.R.I., New Delhi. The Machine specifications are as follows:

- Number of needles: 1024
- Number of Rows: 32
- Machine Size: 0.406 X 0.406 X 0.200 m
- Batch size: 0.25 Kg
- Tray Size: 0.40 X 0.40 X 0.01 m
- Diameter of needle: 1 mm
- Length of Needle: 1mm

The machine works on the principle that when a set of needles with pointed ends is allowed to pierce into chillies, holes (1 mm. diameter) are created on the surface of the chillies which enhances their drying rate. The schematic diagram of the machine is given in the Figure 4.1.
Figure 4.1: Schematic Diagram of Chilli Punching Machine Used for the Experiment
ENLARGED SECTIONAL SIDE VIEW: AA'

Figure 4.2: Schematic Diagram of Chilli De-staking Machine

Note: All dimensions in mm
4.1.1.B. DESTALKING:

The chilli-destalking machine was (plate 2) used for the destalking of chillies. The working of the machine is based on the principle that when chillies stalks are slightly given force with a plate, the stalks are removed. The machine has following specifications:

Number of chillies seats: 37
Dimension of the wooden base: 0.505 X 0.055 X 0.030 m
Dimension of the plate: 0.510 X 0.056 X 0.0015 m

The schematic diagram of the machine is given in the figure 4.2.

4.1.2. PREPARATION AND LOADING OF SAMPLES FOR EXPERIMENTATION:

Both varieties of Chillies, ie, Jwala and Pusa Sada Bahar were first pre-treated and prepared in the following manner:

(i) Four samples of each variety weighed upto 1 Kg, using weighing balance upto 1 gm accuracy.
(ii) Punching of samples was done with the help of the punching machine.
(iii) Destalking of the samples was done with the help of the destalking machine.
(iv) A separate batch of four destalked samples of both variety, each of 1 Kg, was further punched to test the combined effect of destalking + punching of pre-treatments on the drying of chillies of both varieties.

After pre-treatments, all the prepared samples were manually loaded in four different solar dryer viz. solar cabinet dryer, greenhouse solar dryer, open floor sun drying. Each dryer contained three samples of different pre-treatments, along with one untreated samples, for simultaneous drying.

For fluidized bed (mechanical) drying, only one sample was manually loaded at one time till the completion of drying of one sample as this dryer has the capacity to dry only one type of samples at one time as it has one drying chamber. After the drying of the one sample, other samples were loaded up for drying.
4.1.3. QUALITY EVALUATION TESTS FOR CHILLIES

4.1.3.A. PUNGENCY TESTS:

The capsaicin content of chillies was estimated by calorimetric method with some modification, as reported by Quaglettli (1971).

4 gms of the chilli powder was extracted with acetone till a colourless acetone solution was obtained. The volume was then made upto 100 ml with acetone. The extract was kept for 3 hours at the room temperature. After 3 hours, 5 ml of acetone extract was taken in a baker and was heated on water bath till full dry. To this, 5 ml of 0.1 NaOH solution was added, along with 3 ml of 3% phosphomolybdic acid solution and was kept at room temperature for 1 hour. Finally, optical density values were measured at 650 m: with the help of spectrophotometer. Different values of optical density were obtained for different chilli samples. The sample which shows the highest mean optical density is considered to have the highest capsaicin content.

4.1.3.B. COLOUR TEST

The colour of dried chillies were determined according to the colour of Munsel Colour Chart.

4.1.3.C. HEDONIC EVALUATION (SPECIMEN EVALUATION CARD FOR NUMERICAL SCORING FOR COLOUR QUALITY.)

Dried chilli samples were given to a set of panellists for evaluation of appearance (colour) parameter. They were requested to evaluate the colour parameter on 10 point Hedonic scale and the mean score was obtained for different samples (Appendix D).

4.1.3.D. DETERMINATION OF THE MOISTURE CONTENT

CHILLIES:

Moisture content of chillies was determined by taking three random samples of 5 gm each from the lot and subjecting them to hot air oven at 131°C for 2 hrs and then the final weight of the samples was determined. (Rangana, 1997, pp. 4-5).
4.2. GRAPES

Fresh grapes (Thompson Seedless) were obtained from the fruits and vegetables market near I.A.R.I. Pusa, New Delhi.

4.2.1. PREPARATION OF GRAPE SAMPLES FOR DRYING:

Thompson seedless grapes obtained from the market, were washed manually in clean water before giving any specific pre-treatments. Following pre-treatments were given to each sample:

A. Ethyl Oleate treatment
B. Milk treatment
C. Sulphur fume treatment

The weight of each pre-treated and untreated sample was 1 Kg.

A brief description of above-mentioned pre-treatments is being in the following pages.

4.2.1.A. ETHYL OLEATE TREATMENT:

This treatment is given to develop smooth micro-structures on the external surface of grapes, to make the process of evaporation of the moisture more faster. The enter method of ethyl oleate pre-treatment adopted here is taken from the raisin producing industry in Sangoli Flow chart in the figure 4.3., explains the various steps involved in the raising making the through ethyl oleate treatment for the shade drying. Similar procedure of pre-treatment was followed for the preparation of grape samples for different methods of drying undertaken in this study.

4.2.1.B. BOILED MILK TREATMENT:

5 Kg Milk was boiled at 100°C using electric heaters and samples of 1 Kg were dipped for 15 minutes. This pre-treatments is given to smoothen the external surface of the grapes.
Fresh Grapes

Washing with Clean Water (1-2 min)

Draining

Dipping in solution for 5 minutes
1.8% Ethyl Oliate + 2.4% Potassium Carbonate)

Draining

Spreading in Shade drying structures for drying

After 3 – 4 days, spraying
(1.2% Ethyl Oliate + 1.8% Potassium Carbonate Solution)

After 6 days spray
(0.6% Ethyl Oliate + 8% Potassium Carbonate Solution)

Raisins with 18% m.c. are ready after 15 – 16 days

Grading/Sorting

Packing in boxes 1 Kg, 12.5 Kg & 15 Kg

FIGURE 4.3: METHOD OF MAKING "RAISINS" FROM FRESH GRAPES IN SANGLI DISTT. (MAHARASTRA)
4.2.1.C. SULPHUR FUME TREATMENT:

Sulphur fume treatment is given to increase the shelf life of raisins as it prevents spoilage from storage pests and diseases and gives attractive yellow colour. To provide the sulphur treatment, a sulphur box was developed at the Division of Agricultural Engineering I.A.R.I, New Delhi. A 0.90mx0.90 XI meter high wooden sulphur box was fabricated. The box has trays for sulphur fume treatment of fresh grapes (before during). The box is equipped with air tight wooden door. The burnt sulphur is kept on the floor of the box to produce SO$_2$ fumes for sulphur treatment. A batch of about 50Kg grapes can successfully treated in the box utilized for three to four hours. Sulphur box, utilized for giving the sulphur fume treatment is shown in the Figure 4.4.

![Figure 4.4: Sulphur Box](image)

4.2.2. LOADING OF TREATED/UNTREATED GRAPE SAMPLES FOR EXPERIMENTATION:

Samples of different pre-treatments were manually loaded among different solar dries i.e. solar cabinet dryer, solar portable rack (wire net) dryer, greenhouse solar dryer and for open floor seen drying. Each dryer contained, samples with three treatments, i.e., ethyl oleate treatment, sulphur
treatment, milk treatment, along with one untreated (control) sample. The weight of each sample was 1Kg.

For, fluidized bed (mechanical) drying, sample of only one treatment was manually loaded for drying as this dryer does not have the capacity to accommodate all samples in one time. After the completion of drying of one sample, another sample was loaded for drying.

4.2.3. PHYSICO-CHEMICAL ANALYSIS OF FRESH GRAPES (THOMPSON SEEDLESS) SAMPLES:

Fresh grape samples of Thompson seedless variety were analysed to determine the suitability of the grapes for the production of good quality raisins. Following parameters were taken into consideration:

i. Moisture Content
ii. Acidity
iii. Brix
iv. Sugars
   (a) Reducing sugars
   (b) Total sugars

As the same parameters were also taken for physico-chemical analysis of raisins produced. Methods applied for the analysis of fresh grapes samples and dried grapes (raisins) are enumerated in the section 4.2.5.

4.2.4. PHYSICO-CHEMICAL ANALYSIS OF RAISINS PRODUCED THROUGH DIFFERENT SOLAR DRIES AND FLUIDIZED BED (MECHANICAL) DRIER AFTER GIVING DIFFERENT TREATMENTS:

To compare the performance of different solar dries and fluidized bed (mechanical) drier in terms of, quality and consequent market acceptability of raisins produced. Physico-chemical analysis was done at the Food Technology Laboratory, Division of Horticulture, I.A.R.I, Pusa New Delhi for the following parameters:

A. Moisture content
B. Acidity
C. Reducing sugars
D. Total sugars
E. Sulphur dioxide (SO₂)
F. Non enzymatic Browning (N.E.B. at O.P. at 420 mm)

(D) Sensory Evaluation for -

(D₁) Colour
(D₂) Texture
(D₃) Taste

4.2.5. METHODS APPLIED FOR PHYSICO-CHEMICAL ANALYSIS OF FRESH SAMPLES OF GRAPES (THOMPSON SEEDLESS) AND DRIED GRAPES (RAISINS):

(i) MOISTURE DETERMINATION

Dry Oven Method (Rangana, 1997, pp. 4-5), method applied was similar to that of chillies.

(ii) ACIDITY DETERMINATION


(iii) SUGARS

Both reducing as well as total sugars for fresh grapes and raisins were analysed through Lane and Enynon method (Rangana, 1997, pp. 12-15).

(iv) SULPHUR-DI-OXIDE

As Sulphur-Di-Oxide was present only in those raisin which were given sulphur fumigation treatment. Sulphur-Di-Oxide valves (PPM) were analysed by following Modified Ripper Titration Methods. (Rangana, 1997, pp. 304).

(v) NON-ENZYMATIC BROWNING (N.E.B.)

The increase in absorbance of samples of raisins at 420 nm was taken as a measure of non-enzymatic browning. The colour was measured at 420 nm by spectrophotometer after preparing the clear extracts of raisins samples by following the method suggested by (Rangana, 1997, pp.).

(vi) SENSORY EVALUATION OF RAISINS PRODUCED:

Sensory evaluation of raisins produced through different types of solar driers and fluidized bed (mechanical) group of 10 panellists, following the rating and score proforma. (Appendix I) for colour, texture and taste.
4.2.6. COLOUR TEST FOR RAISIN PRODUCED

The colour of the raisins produced through different type of solar driers and fluidized bed (mechanical) drier, after giving them different treatments, were matched and compared as per the munsel colour chart.

4.2.7. METHODS OF DRYING UTILIZED

Following methods of solar drying were utilized to study the drying characteristics of both, chillies and grapes.

(i) Open Floor Sun Drying
(ii) Greenhouse Type Solar Drying
(iii) Solar Cabinet Drying (wire mesh)
(iv) Solar Portable Rack (wire net) Drying (For Grapes Only)
(v) Fluidized Bed (Mechanical) Drying

A brief description of aforesaid methods is being given in the following pages:

(i) OPEN FLOOR SUN DRYING

Open floor sun drying is still the most common method of solar drying, despite of its several drawbacks. Open floor sun drying is done in various ways by spreading the drying material on floors which may be cemented, asphalted floor, plastic sheets spread on the floor. For the present study, black colour plastic sheets having a floor area of 12.5 m² were chosen (plates 3 and 4). Samples of chillies (both varieties), and grapes were spreaded on plastic sheets during sunshine periods (from 9 A.M. to 5 P.M.). After sunshine hours, protection to drying material was provided by covering the material by bigger size plastic sheet, this procedure was continued till the final moisture contents of chillies and grapes were reached. The weight of each sample was 1 Kg (1000 gm) at beginning of drying process.

(ii) GREENHOUSE TYPE SOLAR DRYER

The system (Figure 4.5. and plates 5,6,7,8) can be used for drying large quantities of chillies and grapes spread over thin layers in a multi-racks kept inside the greenhouse. It is provided with an auxiliary air heating system and blower. A chimney is also provided at the roof-top level of the structure to assist in natural ventilation. Four racks of having five layers of each are
housed in the greenhouse. The size of each rack is 1.2 m X 1.8 m X 1.6 m. The greenhouse type air collector is of 6 X 4 m size resulting 10°C higher temperature than the outside temperature than the outside air temperature. The U.V. resistance plastic film is used as a glazing of the collector. The theoretical capacity of the system is about 2000 Kg of grapes to be dried during an average period of 8 days. It was observed that the relative humidity in the structure was considerably higher than required.

![Figure 4.5: Greenhouse Type Solar Dryer](image)

### (iii) SOLAR CABINET DRYER

Solar cabinet dryer, which was used for the drying of chillies and grapes, was initially developed at Central Institute of Agricultural Engineering, Bhopal, later on installed at Division of Agricultural Engineering, IARI, New-Delhi.

It consists of a metal box frame having three sets of wire-mesh trays. The roof top is slanting and contains of clear window glass of 3 mm thickness. A chimney with aspirator is provided to increase the natural convection of of air passing through chilli/grapes samples under drying. The dryer is painted with malt finished black place to absorb maximum solar radiation. The overall dimensions of the cabinet are 2.16 X 1.36 X 1.2 m. The total height with chimney is 2.4 meters. The drying capacity of system ranges between 30 to
50 Kg of fresh material per batch Figure 4.6 and plates 9,10,11 show the solar cabinet dryer with drying material.

Figure 4.6: SOLAR CABINET DRYER

(iv) Solar Portable Rack (Wire Net) Dryer:

A 1.2 m X 1.2 m X 0.60 m size solar portable (wire net) rack dryer (Figure 4.7 and plate 12) with natural ventilation was fabricated. The structure was mounted on angle iron frame of 1 m height. One solar portable (wire net) rack drying unit can accommodate 20 Kg of fresh grapes at one time. More such units can be fabricated depending upon the requirement (quantity of grapes to be dried). The main advantages of such units are:

- They are easy to fabricate.
- They can be moved easily during unfavourable weather conditions.
- They are durable.

Solar portable rack (wire net) drying units can be utilized by small go downs or entrepreneur.
FLUIDIZED BED (MECHANICAL) DRYER:

Fluidized bed (mechanical) dryer (plates 14, 15 and 16) was utilized for the mechanical drying of chillies and grapes. Samples of 1 K each for grapes were dried to the desired (final) moisture contents of 8-10%, db, and 15-18%, db, respectively. The bed temperature was maintained at 50°C for chillies and between 55°C - 60°C for grapes, along with a constant air flow rate of blower at 0.049 m³/sec for all the treatment and energy consumption was determined by attaching an energy meter to the dryer.

4.2.8. PARAMETERS MEASURED DURING EXPERIMENTATION OF CHILLIES AND GRAPES (THOMSON SEEDLESS) DRYING:

Following parameters were measured/observed during the experimentation of chillies (both varieties) and grapes (Thompson Seedless) drying:
1) Total sunshine hours in a day.

2) Temperature and relative humidity of air inside as well as outside the solar dryers.

3) Solar radiation inside solar as well as outside the solar dryers.

4) Air flow rate (through the chimney m\(^3\)/s) in the greenhouse solar dryer.

5) Weight reduction measurement of Chillies and Grapes samples after every two hours in solar dryers and after one hour in the fluidized bed (mechanical) drying.

4.2.9. PHYSICO-CHEMICAL PARAMETERS MEASURED FOR DRIED PRODUCTS:

4.2.9.A. FOR DRIED CHILLIES

1) Mean Optical Density with the help of spectrophotometer.
2) Moisture Content.
3) Colour Value as per Munsel Colour Chart.

4.2.9.B. FOR DRIED GRAPES (RAISINS):

1) Moisture Content
2) Acidity
3) Brix
4) Sugars
   (a) Reducing Sugars
   (b) Total Sugars
5) Non-Enzyamatic Browning (O.D. at 420nm)
6) Sensory evaluation for
   (a) Colour
   (b) Texture
   (c) Taste

4.2.9.C. FOR FRESH GRAPES:

1) Moisture Content
2) Acidity
3) Brix
4) Sugars
   (a) Reducing Sugars
   (b) Total Sugars
Plate 1: Chillies Punching Machine

Plate 2: Chillies De-stalking Machine
Plate 3: Open Floor Sun Drying of Chillies (Jwala and Pusa Sada Bahar) with Different Pre-treatments and Untreated Samples

Plate 4: Open Floor Sun Drying of Thompson Seedless Grapes with Different Pre-treatments and Untreated Samples
Plate 5: Greenhouse Type Solar Drier

Plate 6: Chillies (Jwala and Pusa Sada Bahar) Drying in Greenhouse Type Solar Drier
Plate 7: Thompson Seedless Grapes Drying in the Greenhouse Type Solar Drier.

Plate 8: Thompson Seedless Grapes with Ethyl-Oleate Pre-treatment in the Greenhouse Type Solar Drier
Plate 9: Solar Cabinet Drier
Plate 10: Chillies Drying (Jwala and Pusa Sada Bahar) in the Solar Cabinet Drier

Plate 11: Thompson Seedless Grapes Drying in the Solar Cabinet Drier
Plate 12: Portable Rack (Wire Net) Solar Drier (This drier was utilized for grapes only)
Plate 13: Chillies (Pusa Sada Bahar) Drying in the Fluidized Bed (Mechanical) Drier
Plate 14: Chillies (Jwala) Drying in the Fluidized Bed (Mechanical) Drier
Plate 15: Thompson Seedless Grapes Drying in the Fluidized Bed (Mechanical) Drier