STUDIES ON PRODUCTION OF 'RAISINS' FROM COMMERCIAL VARIETY 'THOMPSON SEEDLESS' GRAPES (*Vitis vinifera* L.)

By

K. S. KARNIC

DIVISION OF HORTICULTURE,
UNIVERSITY OF AGRICULTURAL SCIENCES
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K. S. KARNIC

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CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON PRODUCTION OF RAISINS FROM COMMERCIAL VARIETY THOMPSON SEEDLESS GRAPES (*Vitis vinifera* L.)" submitted by Mr. K.S. KARNIC, for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE) of the University of Agricultural Sciences, Bangalore, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

(A.G. HUDDAR)
Associate of Professor of Horticulture.

Bangalore,
August , 1985.

APPROVED BY

Chairman _____
(A.G. HUDDAR)

Members: _____
(U.V. SULLADMATH)

_____
(AMBA DAN)

_____
(ARUN M. SARPESHKAR)

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K.S. KARNIC

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INTRODUCTION

CHAPTER I

INTRODUCTION

Grapes, Vitis vinifera is one of the commercially important fruit crops of the world.

Around the world, grapes occupy an area of 10.1 million hectares (F.A.O., 1981). The Indian subcontinent has 10,000 hectares (F.A.O., 1981) of which 5895 hectares are in Karnataka (1982-83, Department of Horticulture).

Grape cultivation in India is concentrated in wet tropical and temperate zones of northern India and states like Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh.

The important varieties of grapes grown in India are Thompson Seedless, Anab-E-Shahi, Bangalore Blue, Gulabi and Cheena Sahebi. The average yield per hectare is about 20 tonnes in India, which is much higher compared to the yield in other parts of the world.

Karnataka is endowed with very favourable climatic conditions for cultivation of grapes. Out of 5895 ha under grapes in Karnataka, Bangalore district alone accounts for 69 per cent (3200 ha). Thompson Seedless occupies about 20 per cent of this area and the rest with Anab-E-Shahi, Bangalore Blue, Gulabi and other varieties.

The average yield of Thompson Seedless grapes is about 16 tonnes per hectare in Karnataka. The cost of

cultivation of this variety is comparatively much higher. Many a times, large quantities of seedless grapes accumulate in the market during peak season together with the other varieties. Since the price of the seedless varieties will be much higher than others due to higher cost of cultivation, it cannot compete with other varieties in respect of price and thus accumulate in the market forcing the cultivators to make distress sales, resulting in heavy financial loss.

Diversion of Thompson Seedless grapes for processing and raisin making would enable the cultivators to procure reasonable price for their produce and to avoid economic loss due to distress sales.

In India, several efforts have been made for making raisins from locally grown seedless grapes in different places (Thorat et al. 1963; Singh and Dhawan, 1973; Amba-Dan et al. 1977).

However, these efforts have not been successful due to lack of standardised processing procedures and facilities.

Since there is an abundant supply of Thompson Seedless grapes during the season, utilisation of the same for raisin making will cut down the drain on foreign exchange to a greater extent and will also be a source of assured income

for cultivators.

Several factors such as Agro-climatic conditions, variety, stage of maturity etc., influence the quality of raisins. Therefore, a study was undertaken with the main objective of standardisation of different processing procedures for obtaining quality raisins.

The following factors were studied to establish the optimum level of treatments required to get quality raisins:

1. The effect of stage of maturity on the quality of raisins.
2. The effect of lye treatment on the rate of drying and quality of raisins.
3. The effect of sulfur fumigation on the quality of raisins.
4. The effect of drying methods on the rate of drying and quality of raisins.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literature pertaining to various techniques and or pre-treatments in preparation of raisins is reviewed in this chapter.

2.1. Thompson Seedless as a suitable variety for making raisins

Cheema *et al.* (1954) have reported that cultivar Thompson Seedless was moderately rich in potassium, calcium, magnesium, phosphorus, sodium and found to contain 0.174 per cent N, 0.022 per cent P_2O_5 and 0.047 per cent K_2O as water soluble constituents. Singh and Dhawan (1973) stated that Thompson Seedless was an excellent variety as its berries were light golden, uniform oval, medium in size with T.S.S., of about 20 per cent.

2.2. Influence of maturity of grapes on the yield and quality aspects of raisins

2.2.1. On recovery of raisins

The Muscat of Alexandria exhibited a ratio of 4.8 for grapes of 18° Balling to 2.1 for grapes of 28° Balling, whereas Sultania (Thompson Seedless) was found to have a ratio ranging from 4.6 for grapes of 20° Balling to 3.6 for grapes of 24° Balling (Bioletti, 1915). In another study, Bioletti (1919) observed an average increase of 15.88 kg per tonne of fresh grapes for each added degree of sugar. Jacob (1942) reported that the increase in T.S.S. of raisin

grapes from 18° to 29° Balling in the fresh fruit was roughly 70 per cent and the increase in weight per unit volume over the same range of maturity was about 18 per cent.

2.2.2. On sugar content

There was an increase in sugar content of raisins as the maturity advanced from 18° to 24° Balling. At 18° Balling the sugar content of raisins was 69.5 per cent and 68.7 per cent respectively for dehydrated and sun-dried lots whereas at 24° Balling it was 72.8 per cent and 71.5 per cent respectively calculated as invert sugars and based on raisins of 15 per cent moisture content (Jacob, 1942).

2.2.3. On acid content

Jacob (1942) observed that the total titratable acidity of the raisins decreased markedly with increase in maturity of the fresh grapes in the early part of the ripening period. As the grapes become more mature, the rate of decrease in acidity of raisins became less.

2.2.4. On water insoluble solids of raisins

According to Jacob (1942), the water insoluble solids of the raisins made from grapes of 19° Balling was 7.0 per cent whereas in raisins made from grapes of 24° Balling was about 5.7 per cent. He observed inverse relationship between maturity of grapes and per cent insoluble solids.

2.3. Effect of drying methods on drying time and quality of raisins

Fruits have been preserved by drying since the dawn of history. Most of the raisins are produced by means of solar drying but use of dehydration began as a means of salvaging raisins when sun drying conditions were unfavourable as insurance against rain damage.

2.3.1. Sun drying

Grapes dried in sun had higher level of enzymic activity and darkened more rapidly in storage (Hussain et al. 1942). Jacob (1944) reported that emulsion treated grapes were rack dried in earlier stages and then exposed to sun during later stages of drying to change colour from green to yellow or light brown. Mark and Phaff (1949) observed no discoloration of raisin when treated grapes were exposed to sun for 3 hours a day and staked for the rest of the drying period protecting it from direct sunlight. He also reported that over exposure to sun was found to produce undesirable pink brown or amber colour. He observed the grapes exposed to sun for 3-4 days and staked had reddish brown colour.

As quoted by Grancarevic (1969)

Fischer (1959) reported that turning of fruits during drying shortens drying time from four days to one day without affecting quality. Grancarevic (1967-69) reported development of amber colour when emulsion sprayed

grapes were subjected for drying on racks under Australian conditions.

Greenish yellow coloured raisins were obtained when grapes were dried in shade houses in Afghanistan(Granacarevic, 1969). "Natural Sultanas" with bluish purple colour, distinctive flavour and bloom intact was successfully obtained by drying grapes on trays on ground under clear plastic cover (Granacarevic, 1969-71). Ponting and McBean (1920) stated that California grapes dried under sun resulted in chocolate brown coloured raisins. Heikal et al. (1972) have reported that grapes treated with lye and sulfur and sun dried had good colour with a storage period of 32 weeks without any change in colour and taste. Singh and Dhawan (1973) reported that protection of grapes from direct sunshine results in softer skin and prevents excessive darkening and loss of flavour. Winkler et al. (1974) observed that Thompson Seedless grapes dried on natural conditions without any treatment (in California, Iran, U.S.S.R.) would result in greyish black and greyish brown raisins with natural bloom largely intact, rather tough skinned with meaty and characteristic oxidised flavour, dry on the surface, no stickiness or oiliness and with little tendency to cake in storage. According to Granacarevic (1976) drying grapes treated with alkali under optimum conditions would result in golden yellow coloured raisins. He further stated that high humidity and rains

during drying results in brown type raisins.

Smith (1980) reported that grapes dried on roof tops required 4-6 days for drying and the resultant raisins were of red colour. Whereas grapes dried in shade houses required 2-3 months with an end product of golden green colour, fullness in berry and meaty.

2.3.2. Mechanical drying

Rapid loss of sugar was observed when raisins were heated to 84°C after becoming nearly dry.

At lower temperature, the effects were negligible unless raisins were allowed to over dry. Raisins finished at 70°C had exceptionally good colour and flavour. Bleached and mechanically dried Sultanas were not translucent as compared to sun dried ones. Drying for 16 hours at 73°C was found suitable for lye dipped seedless grapes.

Cruess and Christie (1921) quoted that Gadgil et al. (1919) reported rapid loss of sugar when raisin were heated to 185°F after becoming nearly dry. At lower temperature, the effects were negligible. Cruess et al. (1920) observed that rate of drying greatly increased with increase in temperature. Further, they observed that higher temperature had detrimental effects on colour and flavour, if raisins were not removed as soon as dried. Temperature of 73°C was found to be good for regular use. Further, they noticed that the colour and flavour of the

juice by soaking sun dried grapes in water was much inferior to juice obtained from mechanically dried grapes. Nichols and Christie (1930) stated that dehydration offers improvement in quality and yield by making it safe to defer picking until full maturity is reached and recommended a temperature not exceeding 73°C as safe for dipped Thompson Seedless grapes. Thorat et al. (1963) reported that the golden bleached raisins were most attractive in appearance and comparable to market samples of Kishmish raisins.

Drying of grapes above 70°C was unsuitable due to darkening of raisins and shrinking of skins. When dried at 68°C and 50°C respectively the product retained 14.75 per cent moisture, 78.9 per cent of sugars and 1.28 per cent of acid (Thorat et al. 1963).

Ponting and McBean (1970) noticed browning when dried above 76.5°C. But grapes dried below 76.5°C produced golden coloured raisins.

Amba Dan et al. (1977) reported that drying grapes at a temperature of 70-75°C was three times faster than at 50-55°C. But higher temperature rendered raisins unattractive with brown colour. Drying at 65-70°C initially and then lowering it to 50-55°C decreased drying time and also helped to retain fairly good colour in raisins. Gee (1980) reported that raisins obtained from

drying grapes at 45-50°C differed from sun dried raisins in having light brown colour, flavour and better sanitation.

2.4. Effect of lye treatment on drying time and quality of raisins

Certain fruits are dipped in alkali, both to remove the waxy coating termed "bloom" from the skin and to induce minute skin cracks called checks to facilitate faster drying.(Ponting and McBean, 1970).

2.4.1. Drying time

Cruess et al. (1920) have reported that Tokey grapes dipped in 0.5-0.6 per cent lye solution for 10-15 seconds were thoroughly dried in 16½ hours, while the undipped were not sufficiently dried even after 40 hours, thus doubling the time required for drying. They reported that dipped and sun dried grapes lost 65 per cent of their weight and were sufficiently dry at 20 days whereas undipped grapes took 33 days to dry. They also reported that Thompson Seedless required 0.5 per cent lye solution.

Chambers and Pongsawatmanit (1963) stated that rapid drying rate was obtained in a mixture of span 20 plus potassium carbonate. Granacarevic (1963) and Radler (1964) observed that treatment with cold emulsion of fatty acid derivatives before drying increased the rate of drying two folds or more, over that of undipped grapes over a range of 0-50

per cent weight loss. Dipping in 0.6 per cent hot lye for 10-20 seconds cut down the drying time of 12 hours to 5 hours in case of Kishmish variety (Thorat et al. 1963).

Sodium hydroxide 0.5 per cent with 0.5 per cent sodium carbonate gave satisfactory checking and enhanced drying rate (Heikal et al. 1973). Petrucci et al. (1974) stated that methyl oleate dip enhanced drying rate of grapes and fruits lost greater percentage of weight during initial 2-5 hours of mechanical drying. Amba Dan et al. (1977) have reported that dipping grapes in 0.5 per cent boiling caustic soda for six seconds was found to be very effective in checking and enhancing the rate of drying. Nichols and Christie (1930) reported that the yield of dipped grapes was less than that of raisins dehydrated without dipping due to loss of syrup in preparation and drying rather than from washing out of sugar in the dipping vat.

On the other hand, the yield of dipped sun dried raisins were consistently higher than those of undipped or natural raisins. The lower yields of undipped sun dried raisins appeared to result from respiration losses during slow drying or through fermentation.

They reported that the loss during dehydration was never serious, though most complete conservation of the solids in the fresh grapes was accomplished when they were

dehydrated without dipping.

2.5. Effect of sulfur dioxide on quality and storage of raisins and its retention as influenced by drying, lye treatment and concentration of sulfur

Sulfur dioxide/acid is added for preservation of colour and flavour during processing and subsequent storage. It is also used in prevention of enzymatic oxidative change and microbial deterioration and to inhibit non-enzymatic browning in dehydrated and dried fruits.

Cruess (1911) reported that sulfur dioxide has a selective antiseptic action. More sulfur dioxide is required to prevent fermentative activity and then to inhibit growth of micro-organisms (Bioletti and Cruess, 1912).

2.5.1. Quality

Cruess et al. (1920) reported that colour of the grapes dried in an evaporator was improved by short sulphuring and further they found that 30 minutes exposure to sulphur fumes was found to be sufficient for most white varieties. It was also noticed by them that sulphuring injured the flavour even when used for a very short length of time.

Richards (1930) noticed slight bleaching and observed reduction in darkening due to sulfuring. The bright

coloured raisins were obtained when grapes were sulfured for 2 hours (Hussein et al. 1942). Jacob (1944) reported that brightness of raisins was directly related to SO_2 concentration of fruits. Raisins with 11.5-14.0 per cent of moisture containing 2000 ppm SO_2 retained good colour. Mark and Phaff (1944) advocated exposure of berries to sulfur fumes for 2-4 hours to get yellowish white waxy coloured raisins. Higher penetration of SO_2 in the fruit before dehydration was found to be beneficial to obtain better colour and to maintain antimicrobial properties in raisins (Gooding and Derkworth, 1957). Thorat et al. (1963) observed that increase in SO_2 content would reduce browning and aid in retention of ascorbic acid. Checked bunches sulfured for three hours at 10 g/kg of grapes gave desired light brown colour (Amba Dan and Anand, 1972). Singh and Dhawan (1973) reported that exposure of berries to fumes for 3-4 hours at 2-4 g fulfur/kg of fruit gave good raisin by fixing the natural colour and preventing darkening by oxidation during drying. Jewell (1937) reported that slightly darkened dried apricots can almost be completely restored to their original colour by treating with sulfur dioxide.

Long et al. (1940) recommended that 2000 ppm SO_2 for apricot and peaches, 1000 ppm for pears, 800 ppm for golden bleached raisins and 800 ppm for apple, would suffice for retention of colour and flavour. Greer (1944) found that 250 ppm of SO_2 retarded the rate of darkening, ascorbic

acid loss and CO_2 production in orange concentrate. Sulfur dioxide increased resistance of fruit products to change in colour and flavour (Crusse et al. 1944a and 1944b).

Bhatia et al. (1962) reported higher retention of SO_2 in dehydrated banana over the sun dried product. They also reported that as the time of sulfuring increased, the dried product of banana retained higher concentrations of SO_2. Absorption and retention of SO_2 also increased as the maturity increased (Bhatia et al. 1962). Similar trend in retention of SO_2 has also been reported in respect of papaya, mango and pineapple by the same authors.

Bhatia and Amin (1962) have reported indirect relationship between browning and sulfuring time in case of dehydrated banana. They have also reported that slightly under-matured Pachabale banana had a tendency to turn less brown, probably due to less concentration of sugar. Further, they have observed higher retention of SO_2 in dried product tended to reduce browning in storage.

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

The present investigation pertaining to the influence of different stages of maturity and pre-treatments of grapes such as lye treatment, sulfur fumigation and drying methods on quality of raisins were carried out with a view to standardise the stage of maturity and pre-treatments in order to obtain commercial standard raisins.

Average maximum and minimum temperatures,, humidity and rainfall data during the period of drying were recorded and are presented in Appendix I.

Experimental details

3.1. Selection of vineyard

A typical Thompson Seedless vineyard "Akshaya Farm" at Seededahalli on Hesserghatta road was selected to procure fruits for this experiment. The vineyard was about 3½ to 4 year old, had moderate crop, maintained well by following recommended package of practices. The soil type of vineyard was sandy loam. Vines planted at 3.2 m x 1.75 m spacing and trained on pandal system had normal growth with uniform pruning, vines were not treated with any of the growth regulators.

3.2. Selection of samples and harvesting

Uniform branches were tagged during the first week of March 1981 so as to obtain evenly riped bunches for the

experiment and allowed to mature.

Fruit bunches having T.S.S. of 17-20 per cent which was the normal stage of commercial harvest in the area, were harvested out of the tagged bunches during the morning hours on March 20, 1981. This represented the 'First stage' of maturity. The material was brought to the post-graduate laboratory of the Division of Horticulture, G.K.V.K. Campus, University of Agricultural Sciences.

Some of the bunches were allowed for delayed harvest and fruits with 21-24 T.S.S., were harvested on April 3, 1981. This represented the 'Second stage' of maturity for the experiment. The material was brought to the laboratory for further treatments.

3.3. Preparation of samples

Dried, crushed or spoiled berries/bunches were removed. Clusters were separated with the help of scissors and berries were thoroughly mixed. Then the berries were thoroughly washed in running tap water and again damaged berries were removed from the lot. Then the entire lot was spread on trays uniformly and left for air drying.

Berries were divided into two lots. The first lot of berries was dipped in 0.5 per cent boiling lye solution (sodium hydroxide) for 5 seconds, using muslin cloth.

Separate solutions of same concentration were prepared for each sample to maintain uniform effect of the treatment. Immediately after lye treatment, samples were washed thoroughly in running tap water to remove any alkali adhering on the surface and then air dried.

Lye treated berries were further divided into four lots. One lot out of four was not subject to sulfur fumigation. The other three lots were subjected to sulfur fumigation at the rate of 5 grams, 10 grams and 15 grams each per kilogram of fruit for 3 hours in closed air tight chambers. Similarly, the non-lye treated lot was sub-divided into 4 equal parts, out of which 3 parts were subjected to sulfur fumigation at the rate of 5 grams, 10 grams and 15 grams each and the remaining part was not subjected to sulfur fumigation.

Then each part obtained as above was again divided into two, one for sun drying and another for oven drying.

3.4. Details of pre-treatment

3.4.1. Lye treatment

A solution of 0.5 per cent sodium hydroxide was prepared and made to boil. Samples designated for lye treatment were dipped in boiling lye solution for 5 seconds using muslin cloth. Separate solutions of same concentration i.e., 0.5 per cent were prepared for each treatment

unit to maintain uniform effect of treatment. Immediately thereafter samples were thoroughly washed to remove any alkali adhering on the surface.

3.4.2. Sulfur fumigation

Samples designated for sulfur fumigation were subjected to the treatment at the rate of 5, 10 and 15 grams per kg of fruits in close air tight chambers separately for 3 hours.

3.4.3. Drying

3.4.3.1. Sun drying

Samples designated for sun drying were evenly spread on zinc trays of 32 cm x 25 cm and exposed to sun on the roof top of G.K.V.K. Hostel for 8 hours a day from 8 AM to 4 PM till the required dryness is achieved.

3.4.3.2. Oven drying

Samples designated for artificial drying were spread uniformly on the trays of a 'Kilburn' oven and kept in the oven for drying at 70°C after stabilising the temperature. After 8 hours the temperature was recalibrated to 55°C and drying was continued for 10 hours as specified in the programme.

The sun and oven dried samples were weighed and packed in 400 gauge polyethylene bags.

3.5. Treatments and replications

The treatment combinations followed for sun drying and

oven drying were:

Sun drying (d_1)

1. Without lye treatment without sulfur fumigation (L_0S_0)
2. Without lye treatment with 5 grams sulfur fumigation per kg of berries (L_0S_1)
3. Without lye treatment with 10 grams of sulfur fumigation per kg of berries (L_0S_2)
4. Without lye treatment with 15 grams of sulfur fumigation per kg of berries (L_0S_3)
5. With lye treatment without sulfur fumigation (L_1S_0)
6. With lye treatment with 5 grams sulfur fumigation per kg of berries (L_1S_1)
7. With lye treatment with 10 grams sulfur fumigation per kg of berries (L_1S_2)
8. With lye treatment with 15 grams sulfur fumigation per kg of berries (L_1S_3)

Oven drying (d_2)

Similar treatment combinations were followed as mentioned under sun drying.

Replications: Three

Drying method .. Main plot

Lye treatment .. Sub plot

Sulfur fumigation .. sub-sub-plot

Design: Split split plot

3.6. Observations recorded

3.6.1. For fresh fruits

3.6.1.1. Moisture: Moisture in fresh grapes was determined by A.O.A.C. Method. Five replications of 50 grams fresh grapes were taken and berries were cut into half. They were spread on petri dishes and dried at 70°C until no change in weight on consequent weighings were found. The dry weight was deducted from fresh weight and converted to percentage of moisture present.

3.6.1.2. Acidity: Titratable acidity was estimated by A.O.A.C. Method.

Four replications of 250 grams each fresh grapes from well mixed lot were taken and juice was extracted by using a mixy (blender). This juice was utilised for estimation of acid.

A known aliquot was pipetted out and titrated against standard solution (0.1N) sodium hydroxide solution using phenolphthalein as indicator (A.O.A.C., 1960). The results obtained were converted in terms of equivalence of tartaric acid and expressed as a percentage.

3.6.1.3. Total soluble solids

T.S.S. of the juice was recorded using Erma (0.32 range) Refractometer after making the necessary temperature corrections.

3.6.1.4. Reducing and total sugars

The 'reducing' and total sugars were estimated by the A.O.A.C. Methods of Analysis (1960).

3.6.2. For raisins

For the purpose of analysis of raisins, the moisture present was adjusted to 15 per cent level.

3.6.2.1. Moisture

Moisture was estimated by A.O.A.C. Methods of Analysis (1960).

3.6.2.2. Sugars

Sugars were also estimated by A.O.A.C. Methods of Analysis (1960).

3.6.2.3. Acidity

Aliquot titratable acidity was estimated as in the case of fresh samples.

3.6.2.4. Sulfur di-oxide

Sulfur di-oxide in raisins was estimated by Monier

William's distillation method using iodine and a distillation time of 20 minutes (A.O.A.C. Methods of Analysis, 1960).

3.6.2.5. Rehydration

Five grams raisins were boiled for 20 minutes in 50 ml distilled water. Then the water was filtered and raisins were rolled on filter paper in order to remove adhered moisture and then weighed, and expressed as grams.

3.6.2.6. Non-enzymatic browning

Non-enzymatic browning in raisins was estimated by the method described by Handel, Bailey and Taylor (1950)

3.6.2.7. Organoleptic qualities of raisin

Organoleptic qualities such as colour, taste, odour, texture, appearance and overall acceptability of raisins were rated by adopting 0-9 scale by a panel of judges comprising teachers and post-graduate students.

(i) 0 for very bad
(ii) 1 for not acceptable
(iii) 2 for acceptable
(iv) 3 for fair
(v) 4 for moderately satisfactory
(vi) 5 for satisfactory
(vii) 6 for good
(viii) 7 for very good

(ix)8 for extremely good

(x) 9 for excellent

Characteristics

1. Colour	-	Golden yellow	- best
		Yellow	- good
		Light amber colour	- acceptable
		Dark amber colour	- not acceptable
2. Taste	-	Natural taste	- best
		Sweet	- good
		Sour and acid	- not acceptable
3. Odour	-	(a) Natural	- acceptable
		(b) Off odour	- not acceptable
4. Texture	-	(a) Meaty	- acceptable
		(b) Pasty	- not acceptable
5. Appearance	-	(a) Non sticky	- Acceptable
		(b) Sticky	- not acceptable
		(c) Shrinkage	

3.7. Statistical analysis

The experimental data were analysed by Fisher's analysis of variance. The level of significance employed in 'F' test was P = 0.05 and P = 0.01. Critical differences

EXPERIMENTAL RESULTS

CHAPTER IV

RESULTS

The results of the present study are presented as follows:

4. Analysis of fresh grapes

Before subjecting the grapes for different treatments the qualitative analysis for total soluble solids, sugar, acidity and moisture content was carried out.

The grapes having the total soluble solids ranging from 17-20°B were considered as a guiding factor for the first stage of maturity while grapes having 21-24°B were taken as at second stage of maturity.

The grapes at first stage of maturity had 73.6 per cent moisture, 16 per cent reducing sugar, 2.4 per cent non-reducing sugars, 0.82 per cent acidity, whereas the grapes of second stage maturity were found to have 63.4 per cent, 19.32 per cent, 1.6 per cent and 0.58 per cent, respectively (Table 1).

4.1. First stage maturity

Effect of lye treatment, sulfur fumigation and sun drying and their interaction on drying rate

Results are presented in Table 2 and Fig. 1 and 1a. Grapes without lye treatment and sulfur treatment took 13 days to dry as against 8 days in case of grapes treated

Table 1: Percentage of moisture, reducing and non-reducing sugars, acidity and total soluble solids in fresh Thompson Seedless grapes at two maturity stages

Contents	First stage	Second stage
Moisture (per cent)	73.6	63.40
Reducing sugar (per cent)	16.0	19.32
Non-reducing sugar (per cent)	2.4	1.60
Acidity (per cent)	0.83	0.58
T.S.S. (^{o}Brix)	17-20	21-24

Table 2: Effect of lye treatment, sulfur fumigation and sun drying on drying rate of (loss of weight) Thompson Seedless grapes
wt in grams.

Treatments	No. of days													
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	
						Weight in grams.								
$d_1L_0S_0$	460	430	392	365	330	295	260	230	195	170	150	135	118	
$d_1L_0S_1$	450	418	380	345	320	285	261	232	191	170	145	131	114	
$d_1L_0S_2$	445	415	374	345	305	285	255	220	180	164	142	130	112	
$d_1L_0S_3$	440	405	365	324	290	260	230	190	150	135	115			
Mean	448	417	377	344	311	281	251	218	179	159	138	132	114	
$d_1L_1S_0$	440	400	355	298	255	210	184	150	128	110				11.5 d
$d_1L_1S_1$	435	390	348	296	250	204	180	142	122	108				
$d_1L_1S_2$	428	385	332	294	250	200	175	140	110	104				
$d_1L_1S_3$	428	385	320	280	245	200	175	140	118	102				
Mean	432	390	338	292	250	203	178	143	119	105				
Grand Mean	440	403	357	318	280	242	214	180	149	132	138	132	114	

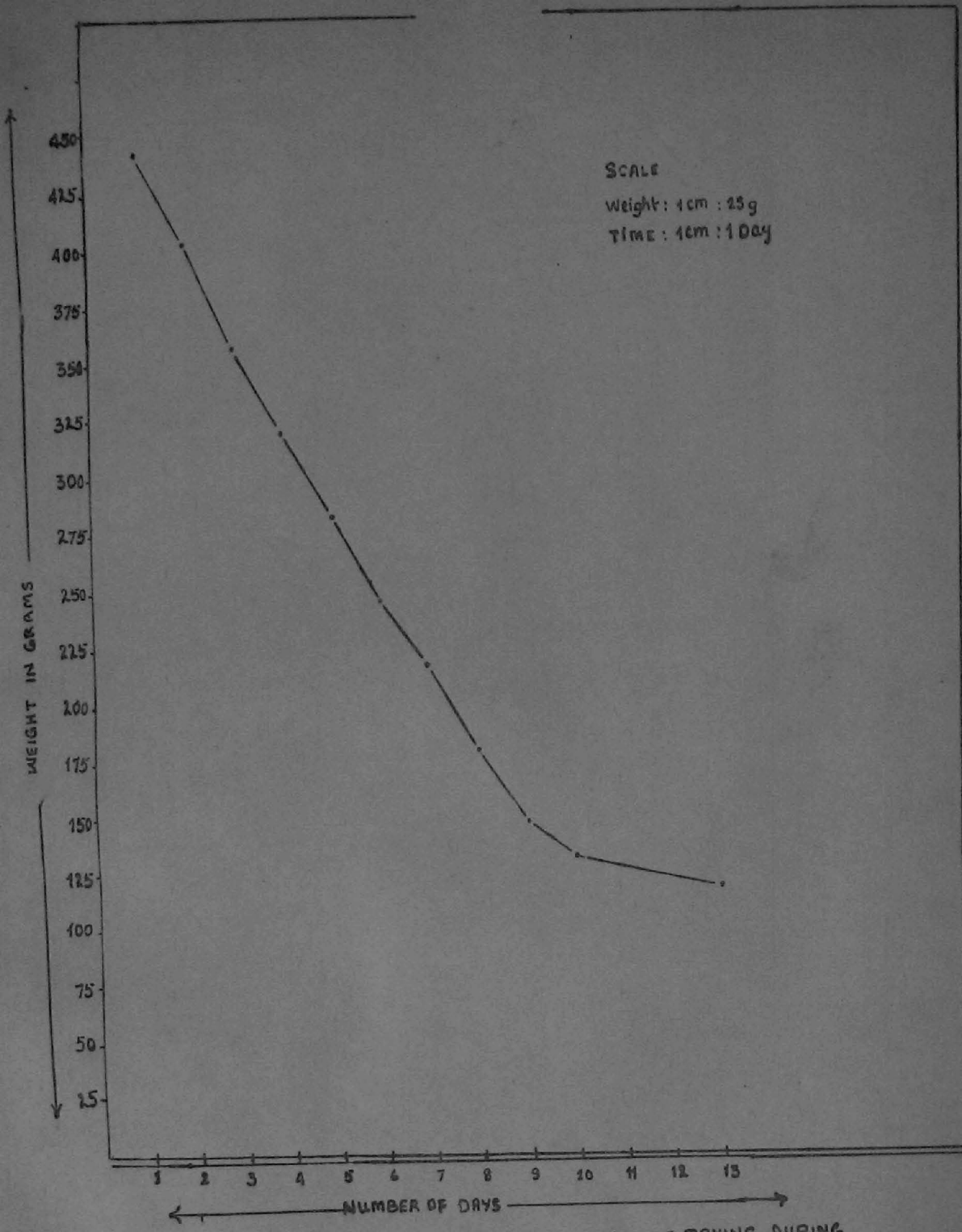


FIG 1 PATTERN OF WEIGHT LOSS DUE TO EFFECT OF DRYING DURING SUN DRYING OF THOMPSON SEEDLESS GRAPES

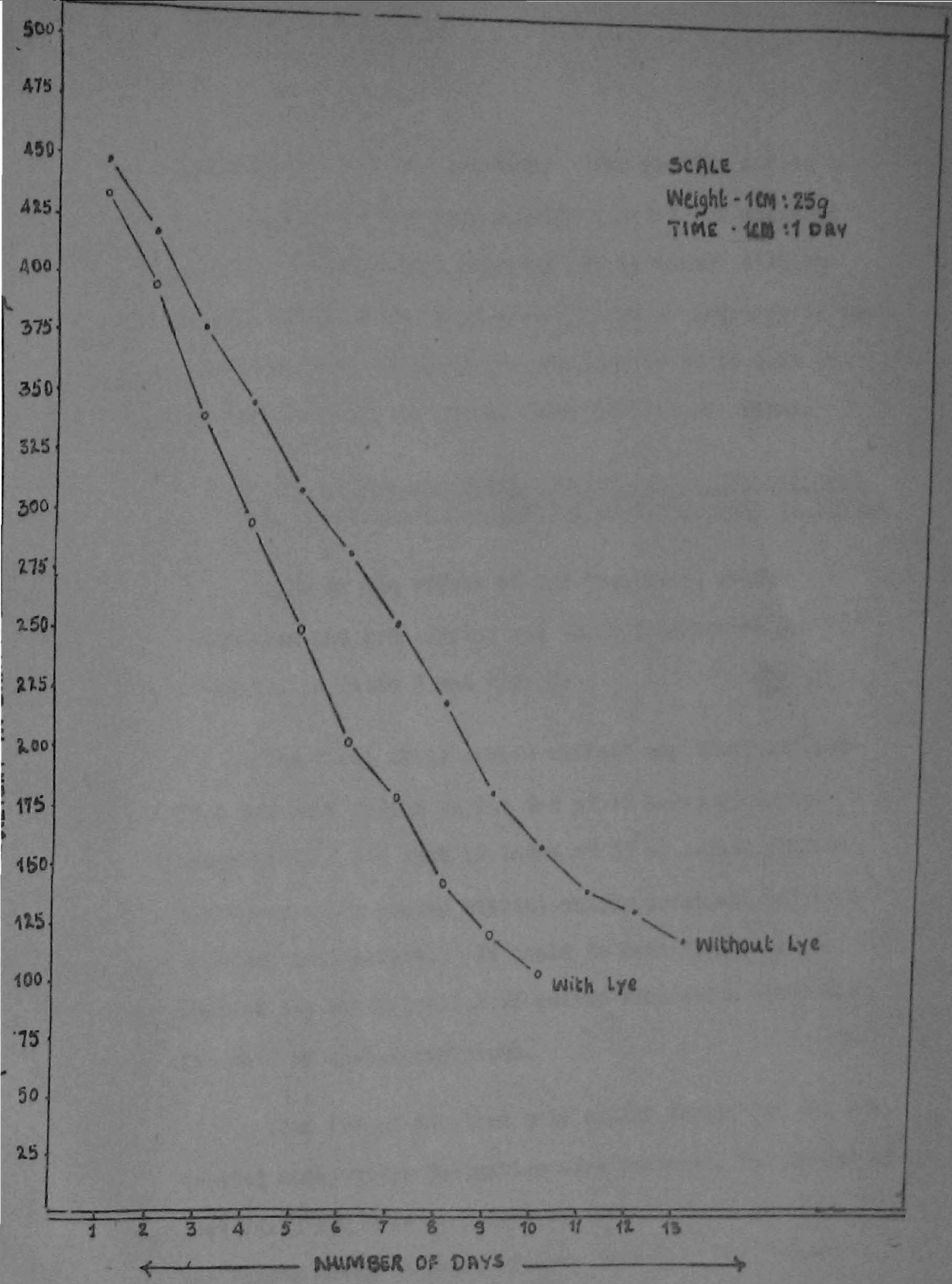


FIG 13 PATTERN OF WEIGHT LOSS DUE TO THE EFFECT OF LYE TREATMENT DURING SUN DRYING OF THOMPSON SEEDLESS GRAPES

with 0.5 per cent lye solution. The maximum period of 13 days was recorded from non-lye treated but sulfured grapes. Grapes which received lye treatment with or without sulfur fumigation took 10 days of exposure to sun for drying thus reducing the drying time by 23 days in sun drying method as against non-lye treated grapes.

4.2. Effect of lye treatment, sulfur fumigation and oven drying and their interaction on drying rate of grapes

Data on the effect of lye treatment, sulfur fumigation and oven drying and their interaction are presented in Table 3 and Fig. 2.

The first stage grapes without any treatment lost 70.0 per cent weight at the end of 18 hours of drying (8 hours at 70°C and rest 10 hours at 55°C) period whereas the lye treated grapes without sulfur treatment had lost 73.4 per cent weight. It could be seen from Table 3, that as the concentration of sulfur fumigation increased the rate of drying decreased.

When grapes received only sulfur fumigation and lye treated with sulfur fumigation were compared, the latter had lost 75.15 per cent of weight as against 71.95 per cent by the former after 18 hours of oven drying. Lye treated grapes lost 73.40 per cent weight as against 70 per cent in the case of non-lye treated. As regards the influence of

Table 3: Effect of oven drying of Thompson Seedless grapes on drying rate (first stage maturity)

Treatments	Drying time in hours			
	8 hours at 70°C		10 hours at 55°C	
	Per cent loss by weight	Per cent moisture content	Per cent loss by weight	Per cent moisture content
$d_2L_0S_0$	33.40	61.32	70.00	24.72
$d_2L_0S_1$	35.00	59.72	71.00	23.72
$d_2L_0S_2$	37.00	57.72	73.40	21.72
$d_2L_0S_3$	38.40	56.32	73.40	21.72
Mean	35.95	58.77	71.95	22.77
$d_2L_1S_0$	39.00	55.72	73.40	21.72
$d_2L_1S_1$	41.44	53.32	74.80	19.92
$d_2L_1S_2$	44.00	50.72	75.00	19.32
$d_2L_1S_3$	44.00	50.72	77.40	17.32
Mean	42.10	52.62	75.15	19.69
Grand mean	39.02	55.69	73.55	21.23

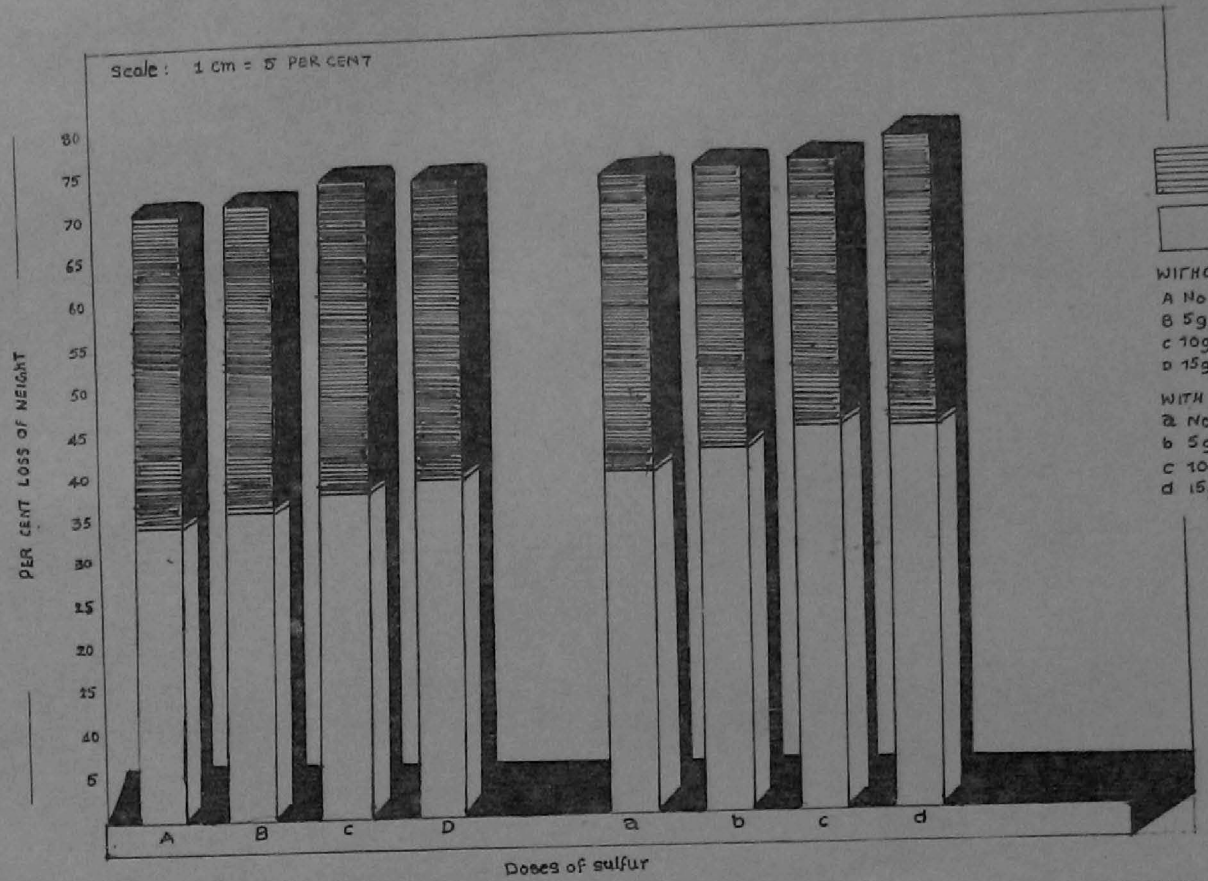


FIG. 2 EFFECT OF OVEN DRYING AND SULFUR FUMIGATION ON THE DRYING RATE OF THOMPSON SEEDLESS GRAPES

sulfur fumigation, a slight positive increase in weight loss was observed.

4.3. Effect of lye treatment, sulfur fumigation and drying methods and their interaction on total sulfur dioxide content in raisins

Results are presented in Tables 4a and 4b and Fig. 3.

It was observed that oven dried samples retained higher concentration of sulfur dioxide (270 ppm) than the sun dried samples 262 ppm. Lye treated samples had retained 291 ppm of sulfur dioxide as against 251 ppm of non-lye treated samples. It was noticed that as the concentration of sulfur fumigation increased, the retention of sulfur dioxide in raisins was also increased.

The minimum retention of sulfur dioxide was associated with the treatment combination of $d_1L_0S_1$(165 ppm) followed by $d_2L_0S_1$ (168 ppm) while the maximum was associated with $d_2L_1S_3$(391.16 ppm).

4.4. Effect of lye treatment, sulfur fumigation and their interaction on the acid content of raisins

The results are presented in Tables 5a and 5b and Fig. 4.

Oven dried raisins had significantly higher acidity (2.74 per cent) than the sun dried raisins (2.64 per cent). The samples which received lye treatment had lower acidity (L_1S_0) than non lye treated samples (L_0S_0).

Table 4a: Effect of lye treatment, sulfur fumigation and their interaction on the total sulfur dioxide content of raisins (first stage maturity)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S_1	165.65	168.56	167.10	206.03	208.4	207.21	187.15
S_2	214.65	224.65	219.65	280.96	282.43	281.69	250.67
S_3	328.40	345.61	337.00	380.80	391.16	385.98	361.49
Mean	236.23	246.27	241.25	289.26	293.99	291.62	266.43

Table 4b: Effect of lye treatment, sulfur fumigation, drying methods and their interaction on the total sulfur dioxide content (ppm) in raisins (first stage maturity)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S_1	165.65	206.03	185.84	168.56	208.4	188.48	187.16
S_2	241.65	280.96	247.80	224.65	282.43	253.54	250.67
S_3	328.40	380.80	354.60	345.61	391.16	368.38	361.49
Mean	236.23	289.26	262.74	246.27	293.99	270.13	266.44

GATEWAY

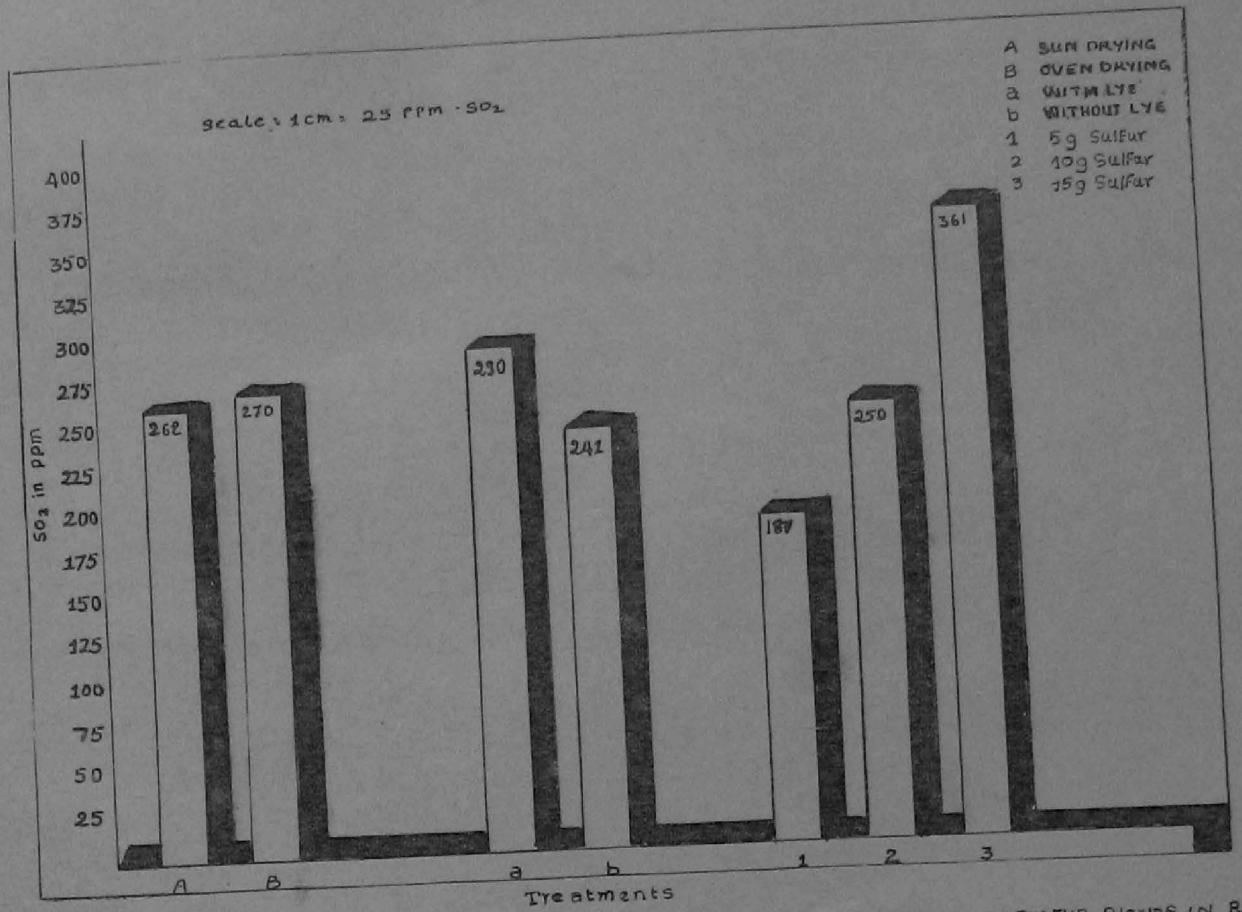


FIG. 3 EFFECT OF DRYING METHODS, LYE TREATMENT AND SULFUR FUMIGATION ON RETENTION OF SULFUR DIOXIDE IN RAISINS

Table 5a: Effect of lye treatment, sulfur fumigation, drying methods and their interaction on the acid content of raisins (per cent tartaric acid) (first stage mturity)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	2.24	2.25	2.245	2.63	2.27	2.45	2.348
S_1	2.53	2.65	2.590	2.73	2.77	2.75	2.670
S_2	2.38	2.96	2.670	2.83	2.85	2.84	2.755
S_3	3.00	3.10	3.050	2.92	2.92	2.92	2.985
Mean	2.54	2.74	2.640	2.78	2.70	2.72	2.685

Table 5b: Effect of lye treatment and sulfur fumigation, and their interaction on acid content of raisins (per cent tartaric acid)(first stage maturity)

Sulfur fumigation	With out lye treatment (L_0)			With lye treatment (L_1)		
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean
S_0	2.24	2.63	2.43	2.25	2.27	2.26
S_1	2.53	2.73	2.63	2.65	2.77	2.71
S_2	2.38	2.83	2.60	2.96	2.85	2.90
S_3	3.00	2.92	2.96	3.10	2.92	3.01
Mean	2.54	2.78	2.66	2.74	2.70	2.72

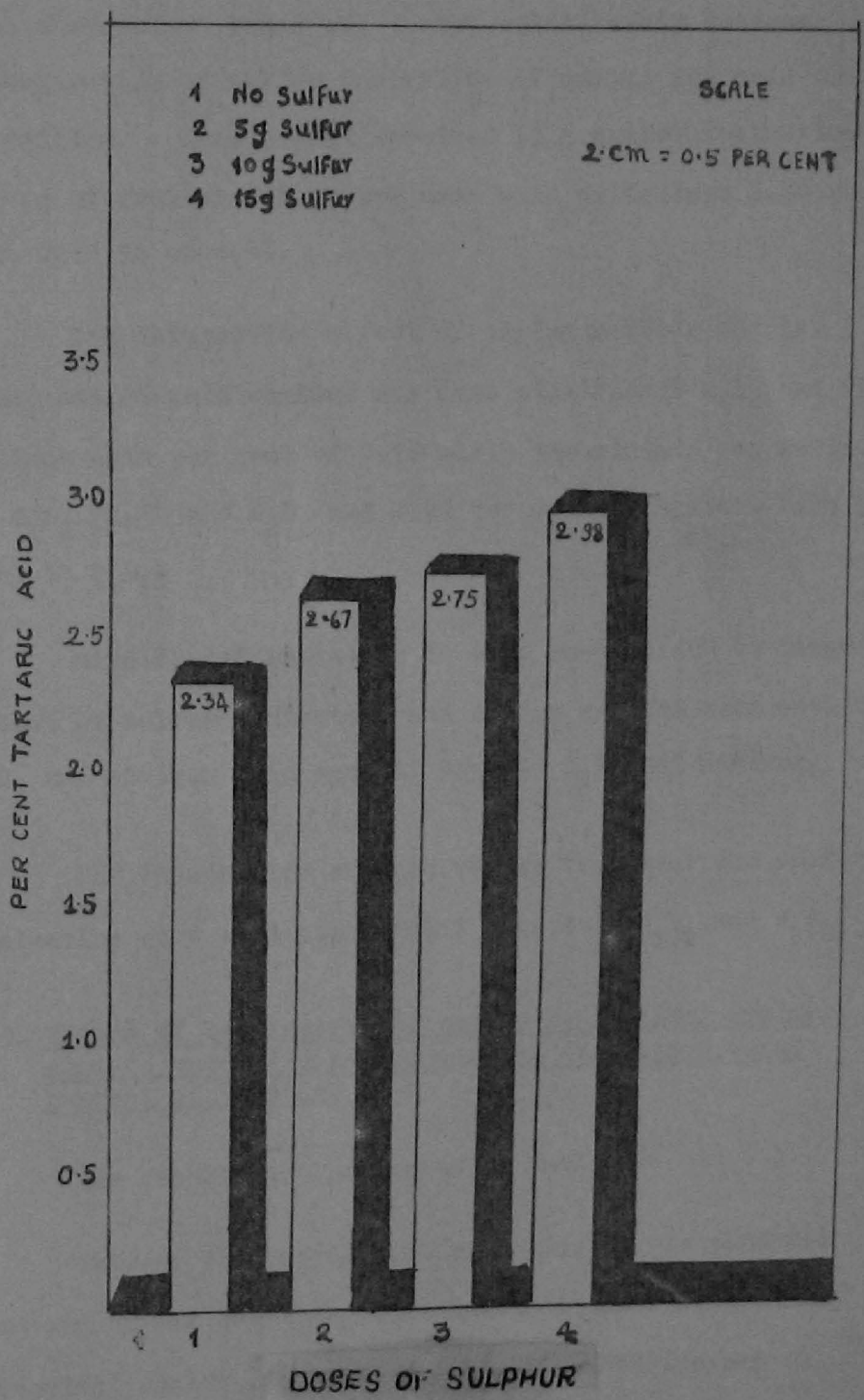


FIG. 4 EFFECT OF SULFUR FUMIGATION ON ACID CONTENT OF RAISINS

Significant variation in acid content due to different concentrations of sulfur treatment (Fig. 4) was also observed. There was direct relationship between concentration of sulfur fumigation of grapes and acid content of raisins. Grapes that received 15 g sulfur fumigation per kg of fruit had 2.92 per cent acid as against 2.34 per cent acid in control.

The interaction effect of drying methods and lye treatment on acid content was also significant d_2L_0 had the maximum acid per cent of 2.78 while the minimum was estimated in d_1L_0 (2.54)and d_2L_1 had 2.70 per cent as against 2.74 per cent in d_1L_1.

Significant variation in acid content due to interaction of sulfur fumigation and drying methods were noticed. d_1S_3 had maximum acid content whereas d_1S_0 had minimum.

The interaction effects of lye treatment and sulfur fumigation were also significant except in d_1S_1 and d_1S_2.

4.5. Effect of lye treatment, sulfur fumigation, drying methods and their interaction on 'reducing' sugar content of raisins.

The results are presented in Tables 6a and 6 b.

Between the two methods of drying it was observed that sun drying had a negative influence on retention of 'reducing' sugars in raisins, oven dried raisins had

Table 6a: Effect of lye treatment, sulfur fumigation, drying and their interaction on 'reducing' sugar content of raisins (first stage maturity)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	60.7	61.5	61.1	62.1	62.8	62.5	61.8
S_1	60.6	61.1	60.9	62.8	62.8	62.8	61.8
S_2	61.7	61.5	61.6	62.3	62.9	62.6	62.1
S_3	61.8	61.7	61.8	63.1	62.9	63.0	62.4
Mean	61.2	61.5	61.4	62.8	62.6	62.8	62.1

Source	SEm	CD	
Drying	0.214	CP 0.05	0.01
Sulfuring	0.144	6.366	0.533

Table 6b: Effect of lye treatment, sulfur fumigation and their interaction on reducing sugar content of raisins (first stage maturity)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying	Oven drying	Mean	Sun drying	Oven drying	Mean	
S_0	60.7	62.1	61.4	61.5	62.8	62.2	61.8
S_1	60.6	62.8	61.7	61.1	62.8	62.0	61.9
S_2	61.7	62.3	62.0	61.5	62.9	62.2	62.1
S_3	61.8	63.1	62.5	61.7	62.9	62.3	62.4
Mean	61.2	62.6	61.9	61.5	62.9	62.2	62.05

significantly higher percentage of 'reducing' sugars than the sun dried samples indicating that acceleration of drying would enable in lesser loss of 'reducing' sugar content of raisins. Effect of other treatments were not significant among themselves.

4.6. Effect of lye treatment, sulfur fumigation and drying methods and their interaction on N.E.B. of raisins

The results are presented in Tables 7a and 7b and Fig. 5.

Oven dried samples had less N.E.B. (0.072 O.D) as against sun dried samples (0.094 O.D). It is evident from the table, that as the concentration of sulfur fumigation increased, the O.D. (for N.E.B) decreased.

Samples received 15 grams of sulfur fumigation had only 0.054 O.D. as against 0.115 O.D. in case of non-sulfured samples.

Lye treated had less N.E.B. (O.D. of 0.077) as against samples without lye treatment (0.089 O.D).

Treatment combination of d_1S_3 and d_2S_3 had 0.061 and 0.047 O.D. whereas d_1S_2 and d_2S_2 had 0.075 and 0.066 O.D. Similarly, d_1S_1 and d_2S_1 had 0.100 and 0.084 O.D. respectively.

The minimum N.E.B. (O.D. 0.047) was associated with samples treated with lye solution and 15 grams of sulfur (L_1S_3), and the maximum was recorded in the samples (L_0S_0) (0.12), lye treated samples had 0.077 O.D. as against

Table 7a: Effect of lye treatment and sulfur fumigation and their interaction on N.E.B. in raisins (first stage maturity) (o.d. at 420 nm)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	0.130	0.110	0.120	0.120	0.898	0.109	0.114
S_1	0.110	0.091	0.100	0.094	0.075	0.084	0.092
S_2	0.091	0.060	0.075	0.076	0.056	0.066	0.070
S_3	0.074	0.048	0.061	0.061	0.061	0.047	0.047
Mean	0.101	0.028	0.089	0.087	0.065	0.077	0.0827

Table 7b. Effect of lye treatment, sulfur fumigation, drying methods and their interactions on non enzymatic browning of raisins (first stage maturity) (o.d. at 420 nm)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	0.130	0.120	0.125	0.110	0.098	0.104	0.115
S_1	0.110	0.094	0.102	0.091	0.075	0.083	0.095
S_2	0.091	0.076	0.083	0.065	0.056	0.060	0.072
S_3	0.074	0.061	0.067	0.048	0.034	0.041	0.054
Mean	0.101	0.087	0.094	0.078	0.065	0.072	0.0831

FIG. 5 EFFECT OF DRYING METHODS, LYE TREATMENT AND SULFUR FUMIGATION ON NON-ENZYMATIC BROWNING OF RAISINS

0.089 O.D. in respect of samples without lye treatment. The maximum O.D. of 0.13 was obtained in treatment combination of $L_0S_0D_2$.

4.7. Effect of lye treatment, sulfur fumigation and drying methods on 'rehydration' potential of raisins

The results are presented in Tables 8a and 8b.

Significant variation in rehydration potential of raisins was noticed between sun dried and oven dried samples. Raisins rehydrated for 20 minutes showed better rehydration potential with respect to oven dried samples than the sun dried.

Lye dipped samples had a better rehydration when compared to control.

The different dosage of sulfur fumigation exhibited significant influence on the rehydration potential of raisins. It was noticed that sulfuring had negative influence on rehydration potential of raisins. At the highest dosage of sulfur, lye treatment did not aid in any way to improve the rehydration potential of raisins.

Interaction effect between sun dried with or without lye treatment were significant themselves.

Oven dried raisins with lye treatment had gained 3.6 grams weight as against 3.47 grams weight increase in respect of raisins prepared under natural drying with lye treatment.

Table 8a: Effect of lye treatment, sulfur fumigation, drying methods and their interactions on 20 minutes rehydration of raisins

Weight in grams.

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	8.19	8.76	8.475	8.62	8.91	8.755	8.620
S_1	8.45	8.58	8.515	8.56	8.74	8.650	8.582
S_2	8.36	8.43	8.395	8.25	8.58	8.415	8.405
S_3	8.17	8.11	8.140	8.18	8.19	8.185	8.162
Mean	8.2925	8.47	8.38125	8.4025	8.605	8.50375	8.4425

Source	SEm	C.D. (P = 0.01)	C.D. (P = 0.05)
Drying	0.025	0.062	0.042
Lye treatment	0.025	0.062	0.042
Sulfuring	0.035	0.087	0.060
Drying x Lye dipping	0.035	0.087	0.060
Drying x Sulfuring	0.035	0.087	0.060
Lye x Sulfur	0.050	0.124	0.085
Drying x Lye x Sulfuring	0.070	0.170	0.120

Table 8b: Effect of lye treatment, sulfur fumigation and their interaction on 20 minutes rehydration of raisins

Weight in grams

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	8.19	8.62	8.405	8.76	8.91	8.835	8.62
S_1	8.45	8.56	8.505	8.58	8.74	8.660	8.58
S_2	8.36	8.25	8.305	8.43	8.58	8.505	8.40
S_3	8.17	8.18	8.175	8.11	8.19	8.15	8.16
Mean	8.2925	8.4025	8.347	8.47	8.605	8.537	8.44

The interaction of drying and sulfuring, negatively influenced the rehydration potential of raisins. It was found that sun dried without sulfuring had the best rehydration potential for 20 minutes period of rehydration (8.475) than the sulfured and sun dried and sulfured and oven dried.

However, irrespective of drying methods, sulfuring had inverse relationship between its concentration and rehydration potential.

Interaction between drying, lye treatment and sulfur fumigation were found to be inconsistent with respect to rehydration potential. However, samples which received lower concentration of sulfur fumigation were found to have better rehydration potential.

Second stage of maturity

4.8. Effect of lye treatment, sulfur fumigation and drying methods on drying rate

Data on the effect of lye treatment and sulfur fumigation under sun drying conditions are presented in Table 9 and Fig. 6 and 6a.

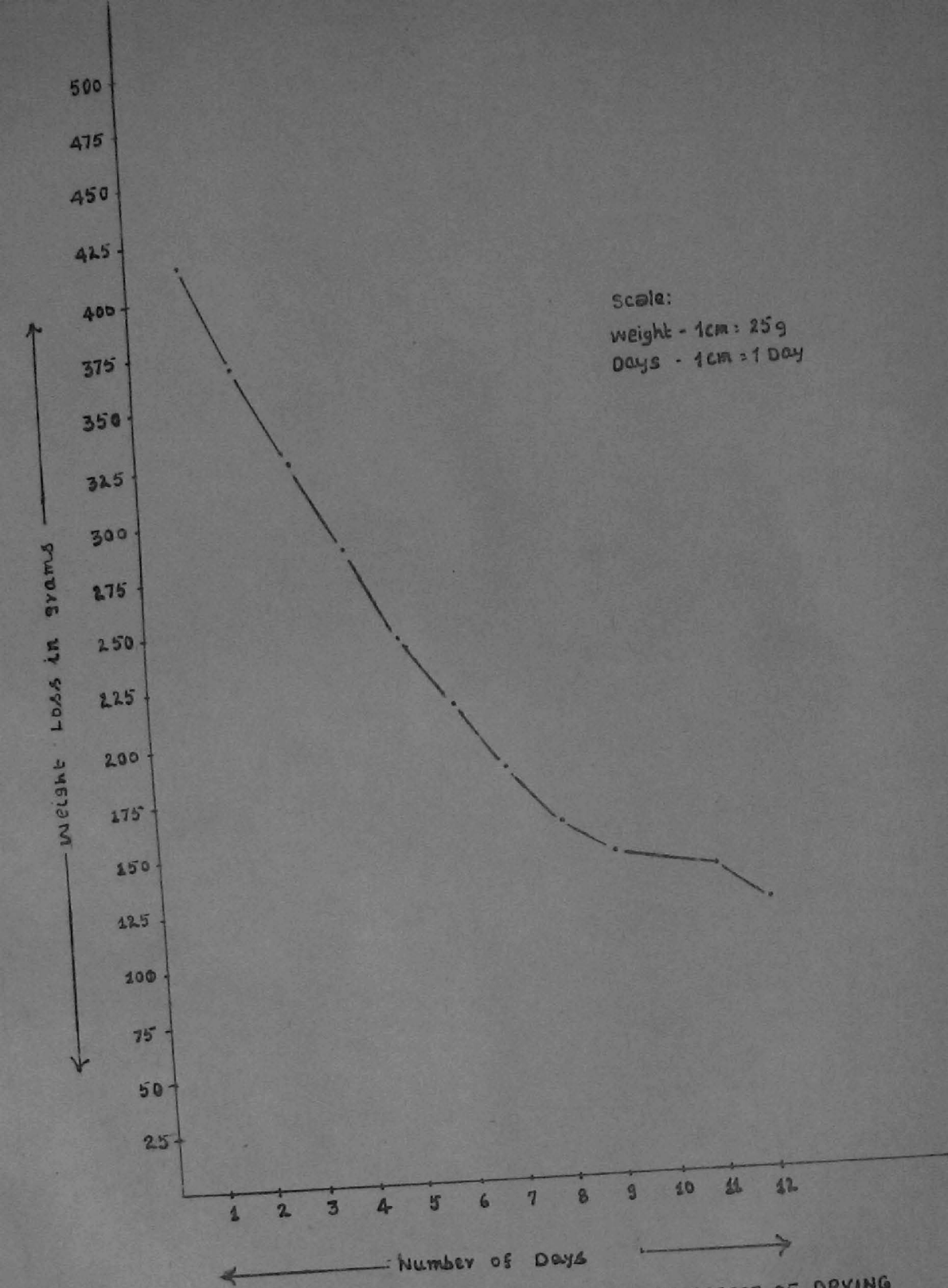
Grapes without lye treatment and sulfur fumigation took 12 days to dry as against grapes treated with 0.5 per cent lye solution (8 days).

The maximum period of 12 days was recorded from non lye treated but sulfured grapes. Grapes which received lye

Table 9: Effect of lye treatment, sulfur fumigation and sun drying on drying rate of (loss of weight) Thompson Seedless grapes

Weight in grams

Treatments	No. of days												
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	
$d_1L_0S_0$	440	395	360	332	298	270	230	222	198	170	145	130	
$d_1L_0S_1$	430	380	355	328	290	255	232	200	181	160	142	128	
$d_1L_0S_2$	430	378	350	322	285	250	230	196	177	155	140	125	
$d_1L_0S_3$	420	360	335	310	280	235	202	181	155	138	122	108	
Mean	430	378	350	323	288	252	226	199	177	155	137	122	
$d_1L_1S_0$	408	356	305	260	220	182	155	130	114				10.5 days
$d_1L_1S_1$	402	354	305	252	211	178	145	128	111				
$d_1L_1S_2$	398	350	296	245	200	175	140	121	109				
$d_1L_1S_3$	395	345	290	238	192	170	134	114	-				
Mean	400	351	299	248	205	176	143	123	111				
Grand Mean	415	364	324	285	246	214	184	161	144	155	137	122	



FIG

FIG 6 PATTERN OF WEIGHT LOSS DUE TO THE EFFECT OF DRYING DURING SUN DRYING OF THOMPSON SEEDLESS GRAPES

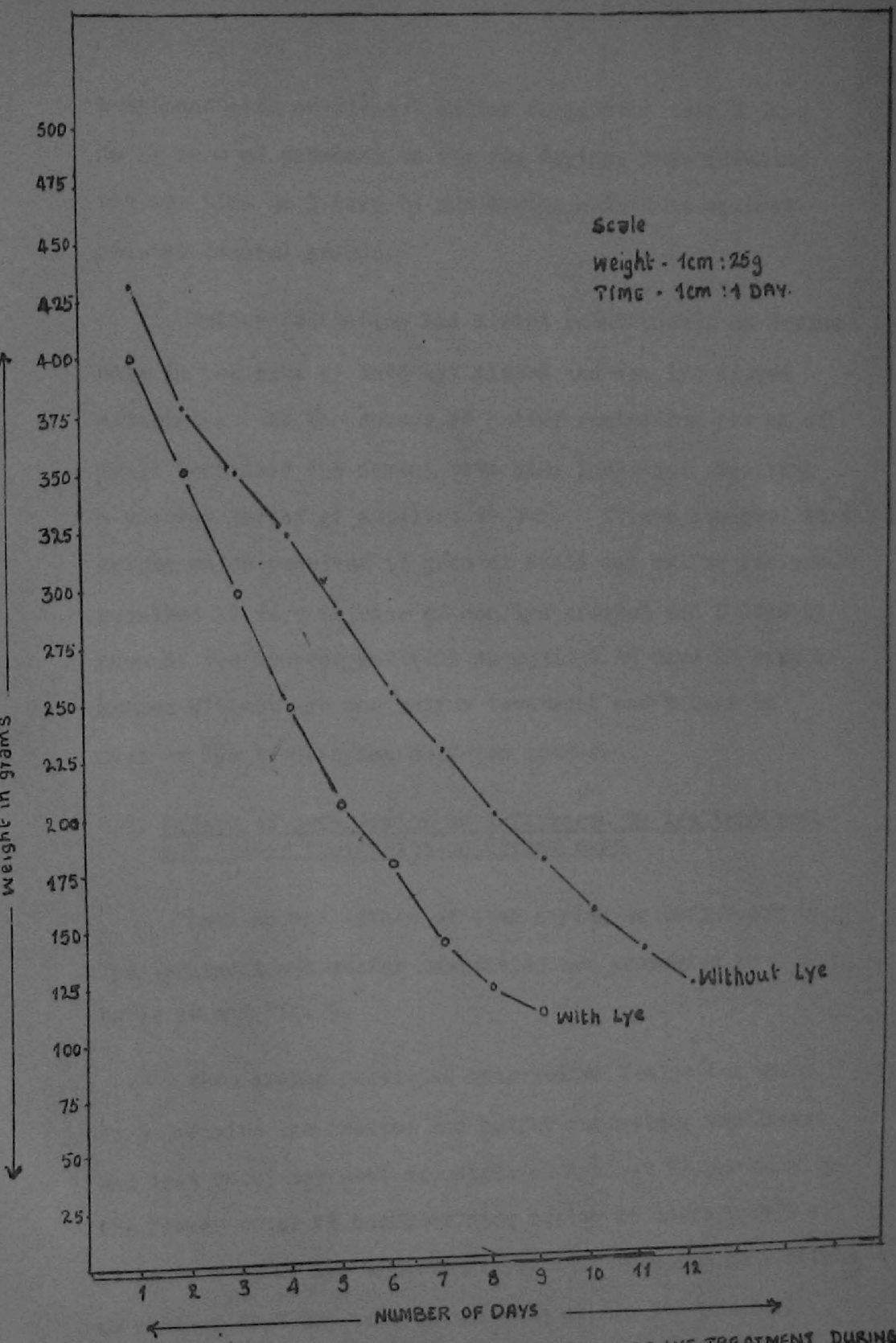


FIG 6a: PATTERN OF WEIGHT LOSS DUE TO EFFECT OF LYE TREATMENT DURING SUN DRYING OF THOMPSON SEEDLESS GRAPES

treatment with or without sulfur fumigation took 8 days to 12 days of exposure to sun for drying, thus reducing the dry time by 3 days in sun drying method as against non-lye treated grapes.

Sulfur fumigation had direct relationship on drying rate in the case of both lye dipped and non lye dipped materials. As the dosage of sulfur fumigation per kg of fruit increased the drying rate also increased requiring a shorter period of exposure to sun. It was observed that grapes which received 15 g/kg of fruit and sulfur fumigation required 10 days in case of non lye treated and 8 days in case of lye treated material as against 12 days in case of grapes without lye and sulfur treatment and 9 days in case of lye treated non sulfured grapes.

4.9. Effect of oven drying as influenced by lye treatment and sulfur fumigation on drying rate

Data on the effect of oven drying as influenced by lye treatment and sulfur fumigation are presented in Table 10 and Fig. 7.

When grapes receiving only sulfur fumigation were compared with lye treated and sulfur fumigated, the latter had lost 74.05 per cent of weight as against 72 per cent by the former after 18 hours of oven drying (8 hours @ 70°C + 10 hours @ 55°C) lye treated grapes lost 72.4 per cent weight as against 70.8 per cent in the case of non lye treated. As regards the influence of sulfur fumigation, a slight

Table 10: Effect of oven drying of Thompson Seedless grapes on drying rate (second stage of maturity)

Treatment	Drying time in hours			
	8 hours at 70°C		10 hours at 55°C	
	Per cent loss of weight	Per cent moisture c ontent	Per cent loss of weight	Per cent moisture content
$d_2L_0S_0$	35.4	40.95	70.8	18.51
$d_2L_0S_1$	37.4	39.60	71.4	18.13
$d_2L_0S_2$	38.4	39.05	72.0	17.75
$d_2L_0S_3$	40.0	38.04	73.8	16.61
Mean	37.8	39.41	72.0	17.75
$d_2L_1S_0$	37.8	39.43	72.4	17.49
$d_2L_1S_1$	40.0	38.04	73.4	16.86
$d_2L_1S_2$	40.4	37.78	74.4	16.23
$d_2L_1S_3$	43.8	35.63	76.0	15.21
Mean	40.5	37.72	74.05	16.44

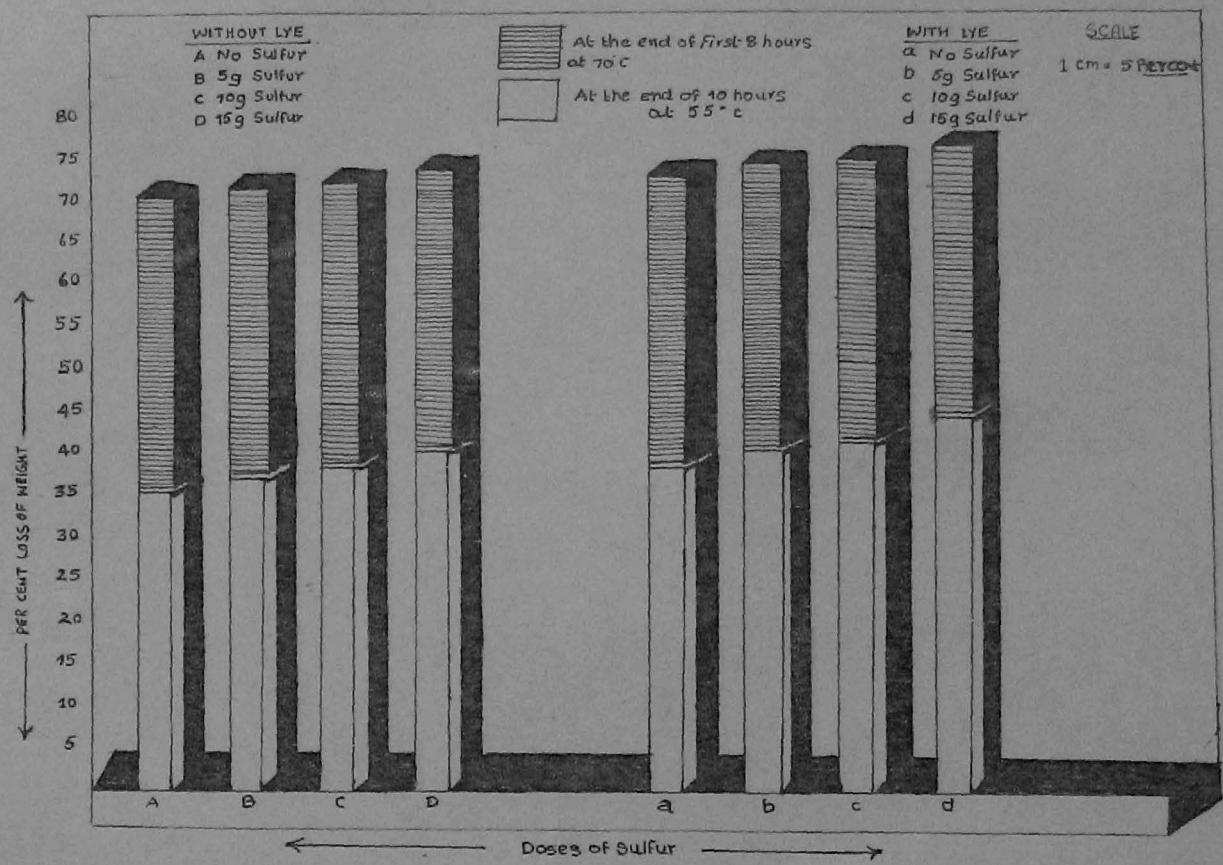


FIG. 7 EFFECT OF OVEN DRYING AND SULFUR FUMIGATION ON THE DRYING RATE OF THOMPSON SEEDLESS GRAPES

positive increase of weight loss was observed as the concentration of sulfur fumigation increased.

4.10. Effect of lye treatment, sulfur fumigation and drying methods and their interaction on total sulfur dioxide content in raisins

The results are presented in Tables 11a and 11 b and Fig. 8.

It was observed that oven dried samples retained higher concentration 392.5 ppm of sulfur dioxide as against sun dried samples which retained 364.9 ppm of SO_2.

It was noticed that the lye treated samples retained more of SO_2 than the non-lye treated samples.

It is evident from the table that as the concentration of sulfur fumigation increased, the retention of SO_2 in raisins also increased. The minimum retention was associated with the treatment combination of $d_1L_0S_1$ (209 ppm) while the maximum was associated with $d_2L_1S_3$ (601 ppm).

4.11. Effect of lye treatment sulfur fumigation drying methods and their interaction on the acid content of raisins

Results are presented in Tables 12a and 12b and Fig. 9.

Oven dried samples had higher acidity (2.06 per cent) than sun dried raisins (2.04 per cent) which was significant.

Table 11a: Effect of lye treatment, sulfur fumigation and drying methods and their interaction on the total sulfur dioxide (ppm) in raisins (second stage maturity)

Sulfur fumigation	Sun drying (d_1)			Oven dry (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	-	-	-	-	-	-	-
S_1	209.33	227.9	218.6	208.6	231.3	219.95	
S_2	265.20	371.6	318.4	341.6	380.2	360.90	
S_3	532.20	583.6	557.9	592.2	601.3	596.50	
Mean	335.57	394.4	364.9	380.8	404.2	392.50	378.74

Table 11b: Effect of lye treatment, sulfur fumigation and their interaction on the total sulfur dioxide content (ppm) in raisins (second stage maturity)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	0.00	0.00	0.00	0.0	0.0	0.00	0.00
S_1	209.33	208.60	208.96	227.9	231.3	229.6	219.28
S_2	265.20	341.60	303.40	371.6	380.2	375.9	339.65
S_3	532.20	592.20	562.20	583.6	601.3	592.45	577.325
Mean	335.57	380.8	358.18	394.4	404.2	399.31	378.74

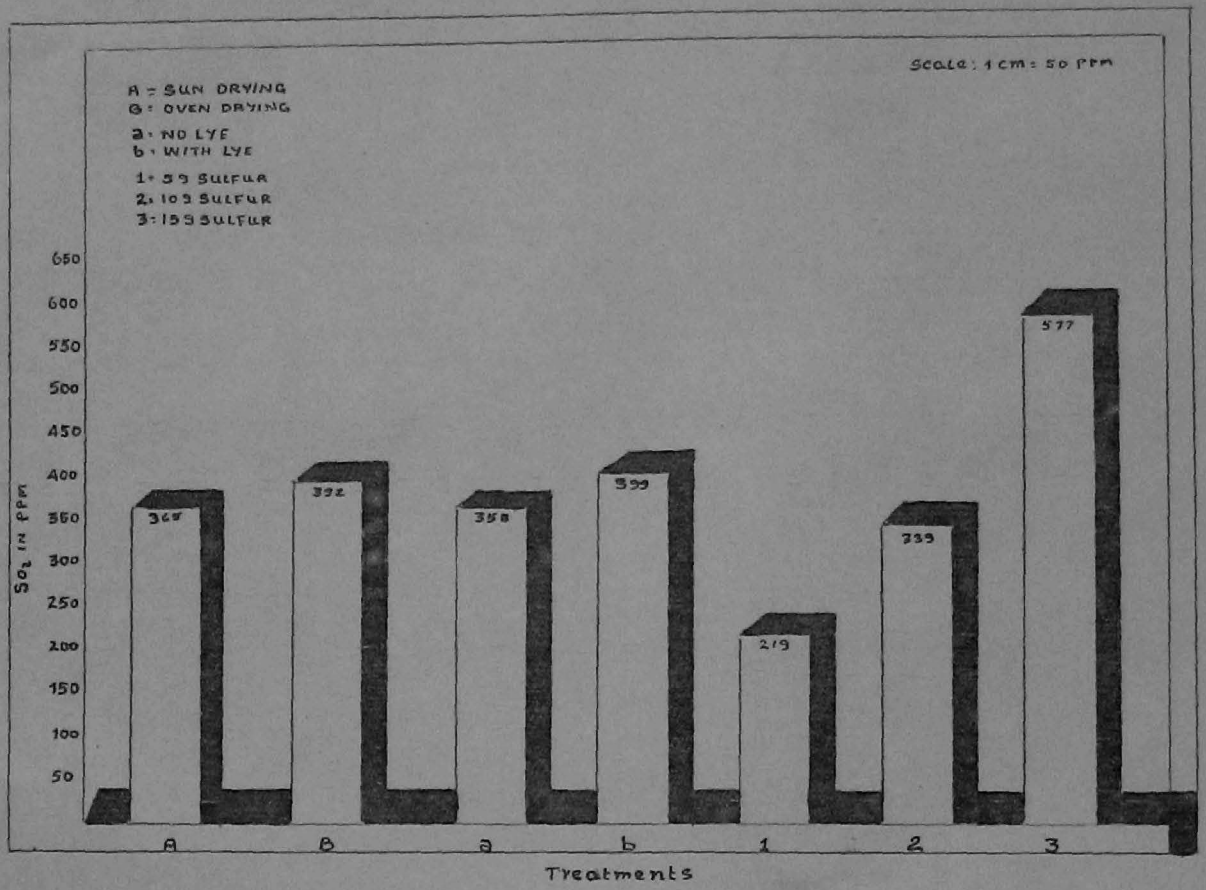


FIG 8 EFFECT OF DRYING METHODS, LYE TREATMENT AND SULFUR FUMIGATION ON RETENTION OF SULFUR DIOXIDE IN RAISINS

Table 12a: Effect of lye treatment, sulfur fumigation, drying methods and their interactions on the acid content of raisins (second state of maturity)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	1.85	1.83	1.84	1.78	1.78	1.78	1.81
S_1	1.90	1.91	1.905	1.88	2.01	1.945	1.925
S_2	2.23	2.41	2.185	1.96	2.21	2.085	2.135
S_3	2.26	2.26	2.26	2.35	2.51	2.43	2.345
Mean	2.06	2.06	2.047	1.99	2.12	2.06	2.05

Table 12b: Effect of lye treatment, sulfur fumigation and their interaction on the acid content of raisins (second stage of maturity)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	1.85	1.78	1.81	1.83	1.78	1.80	1.805
S_1	1.90	1.88	1.89	1.91	2.01	1.96	1.895
S_2	2.23	1.96	2.09	2.14	2.21	2.17	2.130
S_3	2.26	2.35	2.30	2.26	2.51	2.38	2.340
Mean	2.06	1.99	2.02	2.03	2.12	2.07	2.045

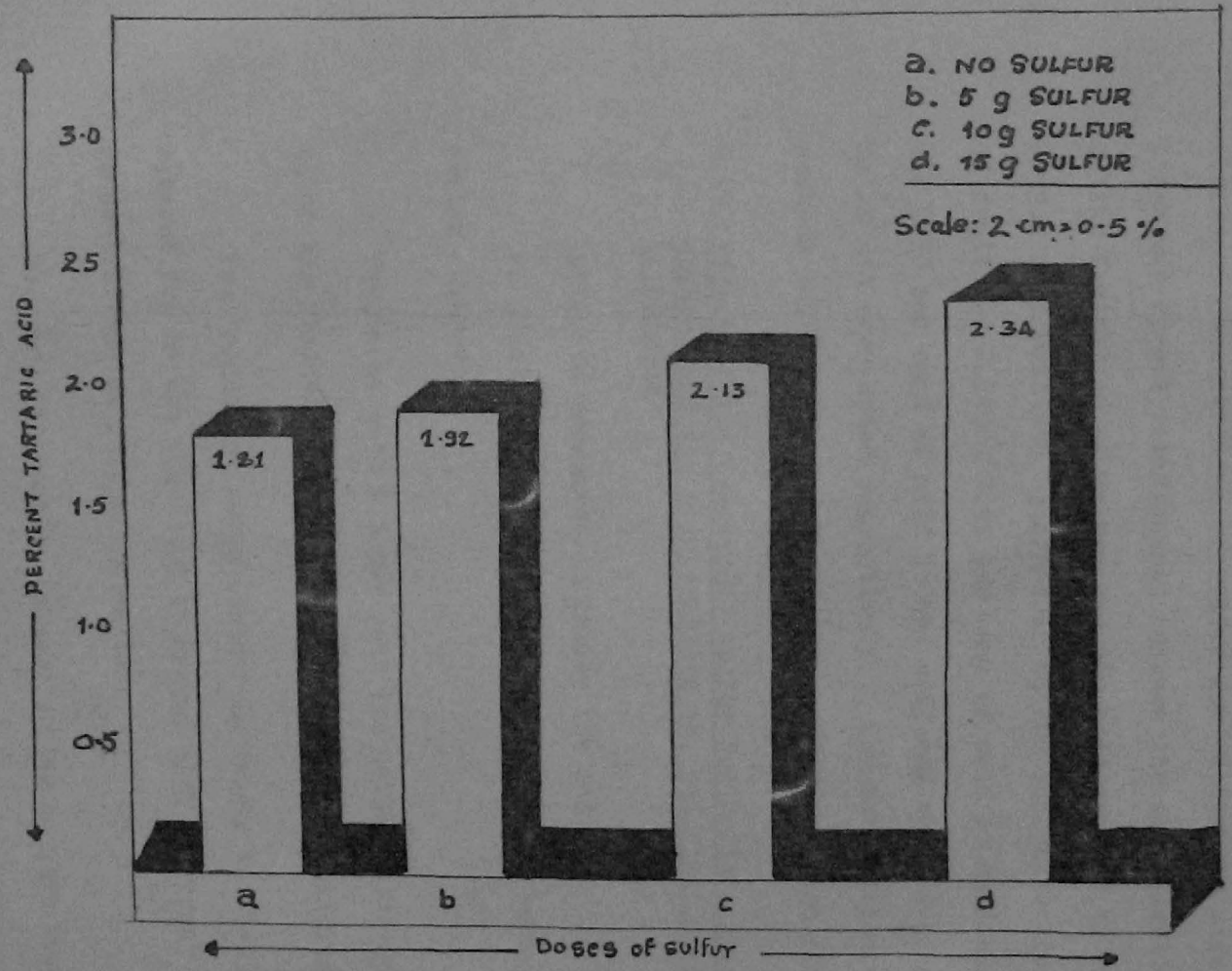


FIG. 9 EFFECT OF SULFUR FUMIGATION ON ACID CONTENT OF RAISINS

The samples which received lye treatment had lower percentage of acidity (L_1S_0) than the non lye treated ones (L_0S_0). Significant variation in acid content due to different concentration of sulfur fumigation was also observed. There was direct relationship between the concentration of sulfur fumigation of grapes and the acid content of raisins. Grapes that received 15 grams of sulfur fumigation per kg of fruit had 2.26 and 2.43 per cent of acid as against 1.84 and 1.78 per cent of acid in non sulfured samples of sun dried and oven dried respectively. The interaction of drying methods and lye treatment on acid content was also significant.

4.12. Effect of lye treatment, sulfur fumigation, drying methods and their interaction on 'reducing' sugar content of raisins

Data are presented in Tables 13a and 13b

No significant differences were observed between two drying methods.

Treatment with 0.5 per cent lye solution did not alter the 'reducing' sugar content of raisins significantly.

The 'reducing' sugar content in raisin was not much altered due to the treatment of grapes with different concentrations of sulfur fumigation.

However, interaction between drying and lye treatment, and lye treatment and sulfuring showed significant

Table 13a: Effect of lye treatment, sulfur fumigation, drying methods and their interaction on reducing sugar content of raisins (second stage maturity)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand Mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	65.8	65.6	65.7	64.7	66.03	65.36	66.030
S_1	67.6	66.4	67.0	67.4	67.5	67.45	67.225
S_2	66.8	65.8	66.3	66.5	67.4	66.95	66.490
S_3	67.8	66.3	67.05	66.23	67.1	66.66	66.855
Mean	67.0	66.02	66.51	66.2	67.0	66.60	66.510

Table 13b: Effect of lye treatment, sulfur fumigation and their interaction on reducing sugar content of raisins

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	65.8	64.7	65.25	65.6	66.03	65.81	65.53
S_1	67.6	67.4	67.50	66.4	67.50	66.95	67.23
S_2	66.8	66.5	66.65	65.8	67.4	66.60	66.63
S_3	66.8	66.23	66.01	66.3	67.1	66.70	66.85
Mean	67.0	66.2	66.6	66.02	67.0	66.51	66.55

differences. Sun drying and lye treatment had a negative influence on 'reducing' sugars i.e., samples treated with lye and sun dried had lower percentage of 'reducing' sugar (66.02 per cent) than the non treated samples (67.00 per cent). But, lye treated and oven dried raisins had significantly higher 'reducing' sugar content (67 per cent) than the non lye treated oven dried raisins (66.2 per cent).

The interaction between lye treatment and sulfur fumigation altered the 'reducing' sugar content or raisins significantly, though the relationship was not consistent.

No significant interaction effects were observed between drying, lye treatment and sulfur fumigation on 'reducing' sugar content of raisins.

4.13. Effect of lye treatment, sulfur fumigation and drying methods and their interaction on N.E.B. of raisins

Data are given in Tables 14a and 14b and Fig. 10

Oven dried samples had less N.E.B. (0.065 O.D) as against sun dried samples (0.078 O.D).

It is evident from Table 14b that as the concentration of sulfur fumigation increased, the O.D.(for N.E.B) decreased. Samples which received 15 grams sulfur fumigation had only 0.032 O.D. as against 0.099 O.D. in case of non sulfured samples.

Lye treated samples had less O.D. of 0.066 as against 0.076 O.D. in case of samples without lye treatment.

Table 14a: Effect of lye treatment, sulfur fumigation and their interaction on N.P.A. of raisins (second stage maturity) (e.g. d= 420 hm)

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	0.116	0.096	0.106	0.103	0.083	0.093	0.099
S_1	0.093	0.080	0.086	0.086	0.076	0.081	0.083
S_2	0.093	0.056	0.074	0.066	0.063	0.064	0.069
S_3	0.043	0.036	0.039	0.030	0.023	0.026	0.032
Mean	0.086	0.067	0.076	0.071	0.061	0.066	0.071

Table 14b: Effect of lye treatment, sulfur fumigation and drying methods and their interaction on enzymatic browning of raisins (second stage of maturity)
@ D at 420 nm)

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	0.116	0.103	0.109	0.096	0.083	0.089	0.099
S_1	0.093	0.086	0.089	0.080	0.076	0.078	0.083
S_2	0.093	0.066	0.079	0.056	0.063	0.059	0.069
S_3	0.043	0.030	0.036	0.036	0.023	0.036	0.032
Mean	0.086	0.071	0.078	0.067	0.061	0.065	0.071

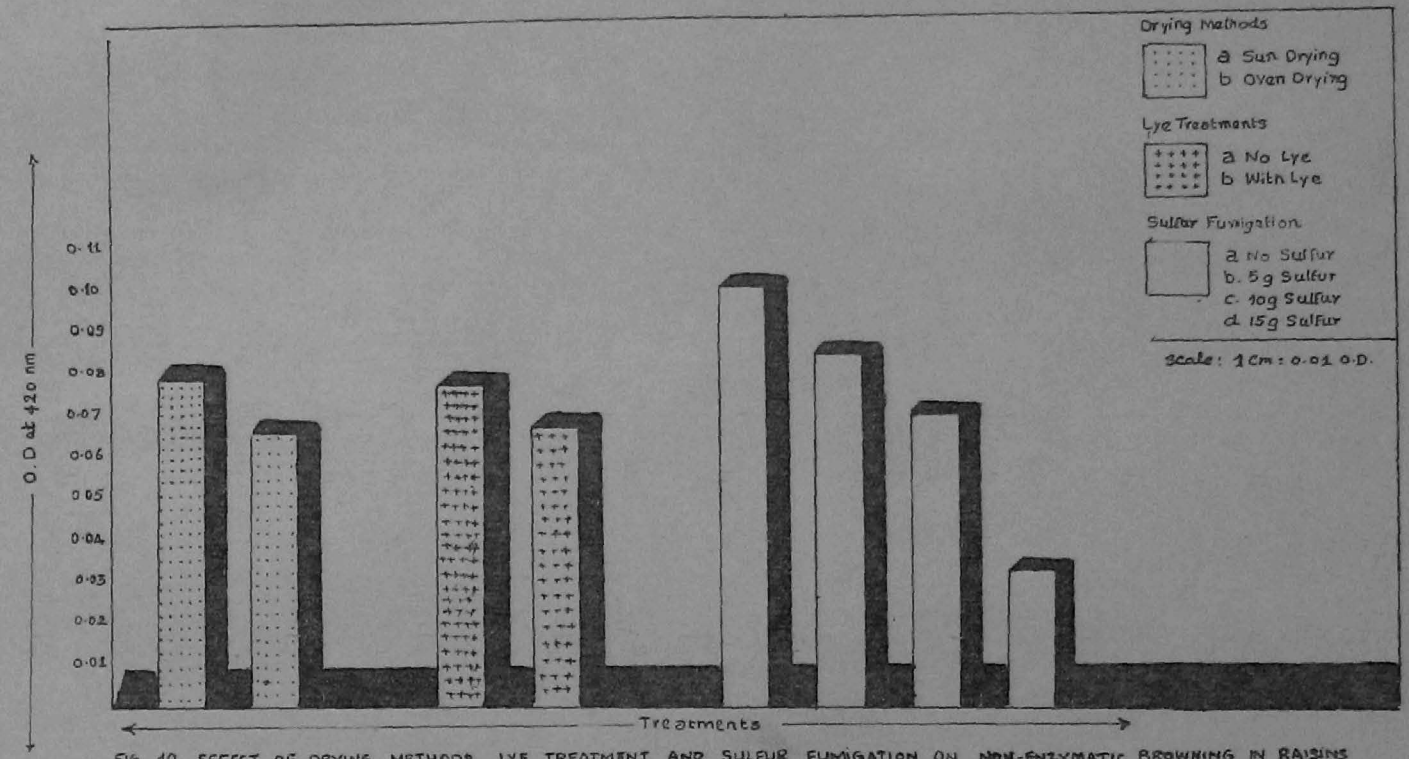


FIG 10 EFFECT OF DRYING METHODS LYE TREATMENT AND SULFUR FUMIGATION ON NON-ENZYMATIC BROWNING IN RAISINS

Treatment combinations d_1S_3 and d_2S_3 had 0.036 O.D. whereas d_1S_2 and d_2S_2 had 0.079 and 0.069 O.D. respectively. The minimum O.D. (0.026) in samples treated with lye solution and 15 grams of sulfur (L_1S_3) and the maximum (0.116) was associated with the samples without lye treatment and sulfur fumigation (L_0S_0).

Lye treated samples had 0.066 O.D. as against 0.076 O.D. in respect of samples without lye treatment. The maximum O.D. of 0.116 was obtained in treatment combination $L_0S_0d_1$ as against 0.023 O.D. in treatment combination $L_1S_3d_2$.

4.14. Effect of lye treatment, sulfur fumigation and drying methods and their interaction on rehydration of raisins

Data are presented in Tables 15a and 15b.

Significant variation was seen in the rehydration potential of raisins between sun dried and oven dried samples. The value for sun dried was higher when compared to the oven dried ones (9.11 and 8.74).

Lye treated samples had a better rehydration potential than the non lye treated samples. The values being 9.03 and 8.82 respectively.

The different dosage of sulfur fumigation exhibited significant influence on rehydration potential of raisins. Sulfur fumigation had no consistent influence on rehydration of raisins. However, the samples received higher concentration of sulfur fumigation exhibited lower rehydration when

Table 15a: Effect of lye treatment, sulfur fumigation and their interaction on 20 minutes rehydration of raisins (second stage maturity)

Weight in grams

Sulfur fumigation	Without lye treatment (L_0)			With lye treatment (L_1)			Grand mean
	Sun drying (d_1)	Oven drying (d_2)	Mean	Sun drying (d_1)	Oven drying (d_2)	Mean	
S_0	9.43	9.19	9.31	9.98	9.30	9.64	9.47
S_1	9.36	9.22	9.29	8.90	9.13	9.01	9.15
S_2	8.25	8.37	8.31	9.77	8.17	8.97	8.64
S_3	8.35	8.40	8.37	9.35	8.20	8.52	8.44
Mean	8.84	8.79	8.82	9.37	8.70	9.03	8.67

Table 15b: Effect of lye treatment, sulfur fumigation, drying methods and their interactions on 20 minutes rehydration of raisins (second stage maturity)

Weight in Grams.

Sulfur fumigation	Sun drying (d_1)			Oven drying (d_2)			Grand Mean
	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	Without lye treatment (L_0)	With lye treatment (L_1)	Mean	
S_0	9.43	9.98	9.70	9.19	9.30	9.24	9.47
S_1	9.36	8.90	9.13	9.22	9.13	9.17	9.15
S_2	8.25	9.77	9.01	8.37	8.17	8.27	8.64
S_3	8.35	8.85	8.60	8.40	8.20	8.30	8.44
Mean	8.85	9.37	9.11	8.79	8.70	8.745	8.925

compared to non sulfured ones.

The interaction effect on rehydration as influenced by drying method and lye treatment was found to be significant.

The lye treated and sun dried raisins had attained 9.37 g (L_1d_1) of weight as against lye treated oven dried samples (8.7 g)(L_1d_2).

L_1d_2 and L_0d_2 were on par between themselves in respect of rehydratability.

Significant variation in rehydration potential due to interaction of lye treatment, sulfur fumigation and drying methods was observed. The maximum rehydration potential was expressed by samples lye treated sun dried without sulfur fumigation ($L_1S_0d_1$). The minimum being associated with lye treated oven dried and 10 grams of sulfur fumigation ($L_1S_2d_2$).

4.15. Effect of lye treatment, sulfur fumigation and drying methods on organoleptic qualities of raisins

Data showing scores of different organoleptic attributes are given in Table 16.

Sun dried samples without any pre-treatment were dark coloured but had good taste and natural odour. Though the taste and odour were good, the appearance of raisins with

Table 16: Effect of lye treatment, sulfur fumigation, drying methods and their interaction on the organoleptic qualities of raisins of both first and second stage maturity

Treatments	Scores											
	Appearance		Colour		Taste		Odour		Texture		Overall acceptability	
	I stage	II stage	I stage	II stage	I stage	II stage	I stage	II stage	I stage	II stage	I Stage	II stage
$d_1L_0S_0$	1	1	1	1	3	6	5	5	4	4	1	1
$d_1L_0S_1$	2	2	3	3	3	5	3	5	4	4	2	2
$d_1L_0S_2$	3	5	5	7	3	3	2	2	4	4	4	3
$d_1L_0S_3$	5	7	6	8	2	1	2	1	4	4	3	3
Mean	2.75	3.75	3.75	4.75	2.75	3.75	3.0	3.25	4.0	4.0	2.5	2.25
$d_1L_1S_0$	1	1	1	1	3	5	3	6	3	4	1	1
$d_1L_1S_1$	2	2	4	5	4	6	5	6	5	5	3	4
$d_1L_1S_2$	5	6	6	7	4	5	4	5	5	5	5	6
$d_1L_1S_3$	6	7	7	7	4	5	3	2	5	5	4	5
Mean	3.5	4.0	4.5	5.0	3.75	5.22	3.75	4.75	4.50	4.75	3.25	4.00

continued..

Table 16 (contd.)

Treatments	Scores											
	Appearance		Colour		Taste		Odour		Texture		Overall acceptability	
	I stage	II stage	I stage	II stage	I stage	II stage	I stage	II stage	I stage	II stage	I stage	II stage
$d_2L_0S_0$ -	1	2	1	1	5	5	4	6	5	5	1	2
$d_2L_0S_1$	3	6	5	3	5	5	4	5	5	6	2	5
$d_2L_0S_2$	5	6	6	4	4	5	3	5	5	5	5	5
$d_2L_0S_3$	6	6	7	7	5	5	1	1	4	6	4	6
Mean	3.75	5.00	4.75	3.75	4.75	5.00	3.00	4.25	4.75	5.50	3.00	4.25
$d_2L_1S_0$	1	1	1	1	2	6	2	5	4	4	2	3
$d_2L_1S_1$	3	5	4	5	4	6	3	6	5	6	3	5
$d_2L_1S_2$	6	8	7	8	5	6	4	5	5	6	5	8
$d_2L_1S_3$	6	8	8	9	4	5	3	1	5	6	4	6
Mean	4.00	5.50	5.00	5.60	3.75	5.70	3.00	4.25	4.75	5.50	3.50	6.20

dark colour rendered them unacceptable in both stages of maturity.

Oven dried samples had good taste and fair odour with good texture. However, the appearance was poor due to dark colour and thus was scored unacceptable in both the stages of maturity.

It is evident from table that the lye treatment of grapes in both the stages of maturity had negative influence on colour and texture of raisins. However, when the samples of sun dried and oven dried were compared, it was found that oven dried samples had good taste, satisfactory odour and texture. Though the score for both sun dried and oven dried samples were same with regard to appearance and colour, oven dried raisins were found to be fairly acceptable due to its satisfactory odour, texture and taste.

Sulfur fumigation in general improved the appearance of raisins and this tendency progressed as the dosage of sulfur fumigation increased in case of both stages of maturity.

Fumigation with sulfur at different concentrations, exhibited improvement in appearance and colour without improving the taste and odour very much.

Grapes treated with higher concentration of sulfur and sun dried with or without lye treatment had very good

appearance and colour without damaging the texture. However, taste and odour in case of non lye treated material was found non acceptable due to off flavour of SO_2. In case of oven dried samples, lye treated samples had extremely good appearance, excellent colour, satisfactory taste and good texture but were unacceptable because of off flavour of SO_2 and ranked next to the moderate dosage of 10 grams of sulfur/kg of fruits. It is clear from the table that moderate dosage of 10 grams sulfur/kg of fruit rendered the raisins acceptable by record-ing maximum scores for all the attributes. The lowest dose of sulfur did not impart better colour and appearance, whereas the highest dose of sulfur imparted off odour to raisins.

It is evident from the table that scores for different attributes in respect of first stage of maturity were less compared to second stage maturity whichhad higher T.S.S. content, lower acidity and moisture.

DISCUSSION

CHAPTER V

DISCUSSION

The production of Thompson Seedless grapes is increasing year by year in the State of Karnataka in general and Bangalore and Kolar districts in particular.

The Government of India is importing raisins to meet the domestic demand by spending foreign exchange earning.

The growers of Thompson Seedless grapes are not getting good returns for their investment on the crop, due to glut in the market during the season. Thus, raisin preparation by using Thompson Seedless grapes has become inevitable in Bangalore, to help farmers in disposing of their produce for remunerative prices and as well as to cut down import cost and save foreign exchange.

Attempts at standardising drying procedures as well as necessary pre-treatments for preparation of raisins has not been reported so far with relevance to agro-climatic conditions of Karnataka using locally grown Thompson Seedless grapes. Thus an attempt in the direction of standardising certain procedures of raisin preparation in particular reference to Karnataka was made. The results obtained are discussed in the following paragraphs.

This study was conducted using two maturity stages, the first being, grapes having 17-20°B and the second being, grapes having 21-24°B.

Data on quality factors of fresh grapes at first and second stages of maturity are given in Table 1.

Drying rate

Grapes which received lye treatment and exposed to sun, dried faster than the non lye treatment samples. As the concentration of sulfur fumigation increased, grapes took a lesser period for drying. This tendency of faster drying due to lye treatment was observed for grapes irrespective of maturity of grapes used. This finding agrees with the findings of Cruess et al. (1920), Nichols and Christie (1930), Chambers et al. (1963), Thorat et al. (1963), Heikel et al. (1972), Amba Dan et al, (1977). It is observed that grapes without treatment took 12 days to dry as against 8 days in case of grapes treated with 0.5 per cent lye solution, for first and second stages of maturity respectively.

Grapes without any pre-treatment took 12-13 days to dry as against 9-10 days of drying when grapes were treated with 15 grams of sulfur/kg of fruits, in both the stages of maturity. These findings are in consonance with the results reported by Jacob (1944) who observed that 12 days of drying period was required under natural sun drying for sulfur bleached grapes as against 25 days for grapes without any sulfur treatment. The probable reasons for faster drying may be due to the plasmalising effect brought about by sulfur.

When the drying rate of two maturity stages were compared, second stage grapes dried faster than the first stage which may be due to higher T.S.S., and/or low moisture content in fresh grapes of second stage over first stage maturity grapes. Similar results were also reported by Neikal et al. (1972).

Sulfur fumigation and lye treatment in case of oven dried grapes affected drying rate as in sun drying. Raisins prepared out of first stage of maturity without any treatment reached 24.72 per cent moisture at the end of 18 hours of drying period as against 18.1 per cent moisture level in respect of second stage maturity grapes. It is evident from Table 3 and Table 10 that treating grapes with lye solution further enhanced drying rate in both maturity stages, Nichols and Christie (1930) have reported similar observations on Thompson Seedless grapes and that dipping shortens time for dehydration irrespective of original balling content. However, they reported contrasting results in their study on drying rate as influenced by balling degree. According to them grapes having 21°B required 25 hours as against 17 hours for grapes having 19 degree balling.

Oven dried samples retained higher concentration of SO_2 (392.5 ppm) than the sun dried samples (364.98) in case of second stage maturity. Similar pattern of retention of

SO_2 (262 ppm) was associated with sun dried samples as against 270 ppm in oven dried samples of first stage maturity raisins also.

Results were recorded in respect of raisins prepared at different stages of maturity by Long et al. (1940) showed retention of higher SO_2 in case of mechanical drying than in sun dried samples. He reported losses of SO_2 are minimised in rapid drying or dehydration, as heating the fruit mechanically and the drying fruit surface, apparently increase the fixation of SO_2 and makes its escape from fruit more difficult.

Samples received lye treatment had retained 399 ppm SO_2 as against 358 ppm of non lye treated samples of first stage maturity. A similar trend was also observed in respect of second stage maturity raising.

Thorat et al. (1963) reported higher absorption and retention of SO_2 when grapes were pricked and or lye dipped as compared to control. Further, they have reported as the time of sulfuring increased the absorption and rotention also increased in case of lye dipped and or pricked grapes of different varieties. The probable reason may be, higher absorption of SO_2 during fumigation, perhaps due to increase in surface area caused by *checking of* skin by lye treatment and conversion of SO_2 into sulfurus acid

which may rather slow down the escape of SO_2.

As the concentration of sulfur fumigation increased, retention of SO_2 in raisin has also increased irrespective of stage of maturity and method of drying, such a kind of result was obtained by Hussein et al. (1942).

Complimentary effects of oven drying, lye treatment and sulfur fumigation were noticed. The minimum retention was associated with treatment combination $d_1L_0S_1$ (166 ppm), whereas the maximum was seen in $d_2L_1S_3$ (391 ppm) in case of first stage raisins. Similarly, in second stage raisins $d_1L_0S_1$ had 209 ppm as against 601 ppm in case of $d_2L_1S_3$. This may perhaps be explained as due to the cumulative effects of different treatments already discussed in the preceding paragraphs.

No significant differences were observed between sun drying and oven drying of grapes in respect of reducing sugar content of raisins. However, a very slightly increased value was associated with oven dried raisins over sun dried raisins. Treatment with 0.5 per cent lye solution did not alter the 'reducing' sugar content of raisins appreciably over non lye treated ones.

No constant results in respect of sulfur fumigation on 'reducing' sugars of raisins were recorded. However, sulfured raisins recorded higher percentage of 'reducing' sugars than non sulfured ones.

No significant differences of drying methods, lye treatent and sulfuring were found.

Interaction effect of drying and lye treatment, lye treatment and sulfuring showed significant differences between each other. Sun drying and lye treatment interacted negatively i.e., samples treated with lye and sun dried had lower percentage of reducing sugar than the non-treated ones. But a positive influence of lye treatment and oven drying was evident.

When the variation in percentage of 'reducing' sugar between two stages of maturity were compared, the later had higher percentage (66.51) and the former had 62.0 per cent. The variation in 'reducing' sugar per cent between oven dried and sun dried samples of second stage maturity was almost equal. The effects of other treatments were similar to that of first stage maturity.

Heikel et al. (1972) found lesser percentage of sugar in case of sun dried raisins of 18 per cent T.S.S., (17.98) compared to dehydrated grapes (18.92). However, the difference in sugar percentages of sun dried and dehydrated grapes of 22°B was nil i.e., 18 per cent T.S.S., in both the cases. This confirms results obtained in the present study. Besides, Heikel et al. (1972) similar observations have been made by Jacob (1942). Further the same study strengthens the results obtained in this study with regard

to positive influence of lye treated and sun dried over non-lye treated grapes on sugar content of raisins. He also noticed no significant difference in sugar content due to interaction effects of drying, lye treatment and sulfur fumigation. He recorded 72.5 per cent sugar from golden bleached raisins and 72.3 per cent in sulfur bleached raisins.

Results obtained in the study as influenced by maturity is in consonance of the work of Jacob (1942 and 1944). He reported the sugar content of Thompson Seedless raisins increased with advancement of maturity of grapes upto 24^{0}B.

In both maturity stages, oven dried samples had significantly higher acid than sun dried. The samples which received lye treatment (L_1S_0) had lower percentage of acidity than the non lye treated ones (L_0S_0). Though overall mean values for lye treated samples had indicated higher percentage of acidity over non-lye treated, the higher acidity in respect of lye treated sulfured samples may be due to higher absorption of SO_2 consequent to effective checking and exposure of moist tissue.

A direct relationship between concentration of sulfur fumigation and acid content of raisin was observed. The interaction of drying and lye treatment, lye treatment and sulfur fumigation also varied significantly. Between two stages of maturity, the dried product of first stage

maturity had higher acid content thanthe second stage. This difference in acid content between two maturity stages as influenced by different treatments and drying methods were consistent.

Higher acid content in dehydrated grapes than the natural dried grapes has been reported by Jacob (1942). Similar findings to the present study in respect of lower acid content for sulfur bleached raisins have been obtained by Jacob (1942).

Interaction effect as obtained in this study are also in consonance with the studies of Jacob (1942). Results obtained in respect of acidity as influenced by maturity as well as pre-treatments such as sulfur fumigation and lye dipping are almost in confirmation with the findings of Jacob (1942, 1944), Nichols and Christie (1930) with respect to lye treatment and maturity.

Oven dried raisin of both the stages of maturity had minimum N.E.B. than the sun dried. The samples treated with 0.5 per cent lye solution had lower N.E.B., than the non-lye treated samples.

A direct relationship between concentration of sulfur fumigation and N.E.B., of raisins was observed.

The interaction of lye treatment and drying, lye treatment and sulfur fumigation had negative influence on

N.E.B., of raisins.

Between two stages of maturity, the dried product of first stage maturity had higher N.E.B., than the second stage.

Results obtained in the study as influenced by oven drying, lye treatment and sulfur fumigation are in consonance with the works of Hussein et al. (1942). He reported that the enzyme activity in the dehydrated product was approximately one fifth of that of the shade dried. This variation in oxidative activity may account for some of the differences in the storage qualities of the two types of raisins. He has also observed that immersion of grapes in hot lye reduced the enzymatic activity. They further stated that, enzymatic activity in the sulfur bleached raisins decreased with increase in length of sulfuring period. The highest coloured raisins were obtained when grapes were sulfured for 2 hours and the darkest when they were sulfured for 1 hour or less. Grapes sulfured at the highest concentration of SO_2 for a given period of time had less enzyme activity than those sulfured at lower concentration for the same period of time.

Hussein and Cruess (1940)(as quoted by Hussein et al. 1942) found that very high concentration of SO_2 was required to inactivate a grape enzyme preparation. Oxidase activity decreased gradually as the concentration of SO_2 increased from 0 to 5580 ppm, but was not entirely inhibited at any

concentration. Heikel et al. (1972) also observed that colour of raisins as determined by its optical density developed slowly during storage. This may be due to the inhibition of browning reaction which may occur in raisins by the sulfur dioxide present.

Amba Dan et al. (1977) stated that grapes treated with 0.5 per cent boiling caustic soda and 10 og sulfur/kg of fruit for 3 hours had the lowest N.E.D. (0.862) when compared to control (0.1192).

Thorat et al. (1963) reported that browning decreases with the increase in SO_2 content of the product.

Sun dried raisins of first stage maturity exhibited higher rehydration over oven dried samples.

In contrast, oven dried samples of second stage maturity exhibited higher rehydrability.

Lye treatment greatly influenced rehydration potential of raisins of both the maturity groups.

Lye treated samples of first stage maturity raisins attained a weight of 8.537 g as against 8.347 g of non-lye treated ones, when rehydrated for 20 minutes in boiling water.

A similar trend was also exhibited in second stage maturity raisins where the lye treated ones attained a

weight of 9.03 g as against 8.82 g of non-treated ones.

As the concentration of sulfur fumigation increased, there was decrease in rehydration of raisins in both maturity stages. In case of first stage the least weight (8.175 and 8.15) was associated with the raisins which received 15 g of sulfur fumigation, whereas the highest was associated with the non-sulfured ones (8.405 and 8.835 g) in case of first stage. Similar trend was observed in second stage of maturity also.

Significant difference was also noticed due to interaction effect of lye treatment, sulfur treatment and drying methods.

Higher rehydration associated with lye treated raisins over non-lye treated raisins probably due to checking affected by lye treatment which facilitates water to move into raisins faster.

Thorat et al. (1963) have observed similar trend and suggested that checking might have hastened the reconstitution.

In this study, it was observed that, as the concentration of sulfur increased, reduction in rehydration was noticed, which may be due to alteration of structure, and or texture of the raisins. This observation is strengthened because non-sulfured raisins had better rehydration than sulfured.

Second stage maturity raisins scored higher for different organo-leptic qualities than the first stage.

Higher content of sugars, high retention of SO_2, better effect of lye treatment, less acid content, minimum N.E.B., have contributedfor high score recorded by second stagematurity raisins.

Raisins that received lye treatment, optimum dose of sulfur and oven dried, scored highest in both the maturity stages when compared to naturally sun dried without any pre-treatment.

Similar results are obtained by Amba Dan et al. (1977) who found that chocking with 0.5 per cent boiling solution of caustic soda for 5 seconds, sulfuring with 10 g/kg of fruit for 3 hours and oven dried had lowest N.E.B. and highest SO_2 retention and scored as the best for organo-leptic qualities.

As regards colour influenced by sulfur fumigation, Mark and Phaff (1944), Thorat et al. (1963), Richards (1930), Hussein et al. (1942), Jacob (1944), Gooding (1957) have reported that optimum dose of sulfur fumigation would impart better colour by reducing enzymatic browning, retaining higher percentage of ascorbic acid as well act as an antimicrobial agent during storage.

As far as the advantages of mechanical drying over

sun drying are concerned, Thorat *et al.* (1963) reported that the Golden bleached raisins were most attractive in appearance. Nichols and Christie (1930) have also reported on the beneficial influence on quality of raisins by dehydration.

SUMMARY

CHAPTER VI

SUMMARY

Maturity

The time required for sun drying of matured grapes was only 10 days as against 11 days for less matured grapes.

Matured grapes retained a moisture level of 17.1 per cent when oven dried for 18 hours (8 hours @ 70°C + 10 hrs @ 55°C) whereas less matured ones had 21.32 per cent at the end of a similar drying period and condition.

The raisins of second stage maturity had 66.51 per cent of reducing sugars whereas 62 per cent was retained by the first stage raisins.

The acid content of first stage maturity raisins was much higher (2.68 per cent) than the second stage maturity (2.05 per cent).

Retention of SO_2 content was noticeably higher (392.5 ppm) in the second stage maturity raisins compared to 267.27 ppm SO_2 in first stage maturity raisins.

M.E.B., was less (0.71 O.D) in second stage as compared to first stage maturity raisins (0.82 O.D).

Lye treated samples dried in 8 days 3 days earlier than the control samples during sun drying of second stage

grapes and 2 days in case of first stage. Though there was a difference between two maturity stages with regard to time taken for drying of lye dipped samples, second stage maturity grapes required only 11 days as against 10 days in case of first stage grapes for sun drying.

Lye treated oven dried samples of second stage maturity retained 15.44 per cent against 17.55 per cent of moisture on its control samples whereas it was 19.69 and 22.77 respectively in the first stage samples.

Lye treatment

Dipping of grapes with 0.5 per cent hot lye solution for 5 seconds had a very significant effect on the drying of grapes in both maturity stages.

Lye treatment reduced the time required for sun drying. The treated samples required only 49 and 48 hours of exposure to sun for first and second stages of maturity whereas the control samples needed 60 and 56 hours of exposure to attain the same level of moisture content.

The trend was similar in oven drying. Lye treated samples had lost 75 and 74 per cent by weight in case of first and second stages of maturity grapes respectively and respective controls had lost only 71.95 and 72 per cent by weight at the end of the drying period.

Absorption and retention of SO_2 in lye dipped samples was greator than the non-lye treated ones in both the stages of maturity; 291 and 399 ppm of SO_2 was retained by the lye treated samples of first and second stages grapes and respective controls retained only 241 and 358 ppm respectively.

Percentage acid content of raisins of both stages was lower (1.80, 2.27) in lye treated samples compared to the non-lye treated samples (1.81 and 2.43 per cent). However, lye treated and sulfured samples had exhibited higher acid content over ju t lye dipped and as well as control which may be due to higher absorption of SO_2 in such samples perhaps due to the increase in surface area caused by checking of skin by lye treatment.

'Reducing' sugars were found to be higher in lye treated samples (62.13 and 66.51 per cent) in both first and second stages whereas it was lower (61.87 and 66.2 per cent) in control.

Raisins of lye treated grapes had lower N.E.B. (0.071 and 0.066 O.D) in both first and second stages whereas the respective control samples had higher N.E.B. (0.089 and 0.076 O.D) respectively.

Rehydration for 20 minutes in boiling water expressed the superiority of lye treated samples over non-lye treated ones in absorption of water in both the stages. The first

stage grapes exhibited an increase of 3.8 per cent in weight whereas the 4.2 per cent increase in weight was observed in second stage grapes than control.

Lye dipped samples ranked better (L_1 5.06) over non lye dipped (L_0 4.25) in respect of colour.

Sulfur fumigation

Irrespective of drying methods and stage of maturity sulfur fumigation had a direct relationship with regard to drying time and moisture loss. When grapes were subjected to 15 grams/kg of fruit, sulfur fumigation for 3 hours there was a reduction of 2 and 3 hours in case of sun drying for first and second stages respectively.

Similarly, the oven dried samples with 15 grams sulfuring had reduced moisture content of 3.7 and 3.0 per cent respectively for first and second stages grapes at the end of drying period, compared to control.

Sulfur fumigation showed no consistent influence on reducing sugar content of raisins. However, sulfured raisins recorded higher percentage than non-sulfured ones.

Increase in concentration of sulfur fumigation increased acid content of raisins. 2.3 per cent acid was recorded in raisins which received highest dose of sulfur fumigation (15 g/kg of fruit) as against 1.81 per cent in non-sulfured ones in case of second stage grapes.

A similar trend was observed in first stage grapes also.

Increase in concentration of sulfur fumigation increased retention of SO_2 content in raisins in both the stages. Second stage grapes fumigated at 15 g sulfur per kg of fruit retained 577 ppm of SO_2 as against none in the non treated ones. This was the case in first stage also.

The N.E.B., was reduced as the concentration of sulfur fumigation increased. In case of second stage grapes treated with 15 g sulfur, the O.D. was only 0.032 as against 0.099 in control. Typical trend was observed in first stage grapes as well. This indicates, retention of higher quantum of SO_2 in raisins would improve colour and in addition avoid early deterioration in quality during storage.

Rehydration of raisins decreased as the concentration of sulfur fumigation increased. Second stage maturity grapes receiving 15 g of sulfur fumigation had only 68.8 per cent rehydration when compared to 89.4 per cent in non sulfured raisins. First stage grapes exhibited similar trend.

The rating for 'colour' improved as the concentration of sulfur fumigation increased whereas it was the opposite for odour. Fifteen grams of sulfur fumigation recorded highest scoring (7.7) for colour and lowest for odour (1.2) in the case of second stage grapes, with similar rating in first stage also.

Interactions

Grapes of second stage maturity required only 48 hr to dry due to interaction effect of lye treatment, sulfuring and sun drying, as against 50 hr for lye treated sun dried and 58 hours for naturals. It was similar in respect of oven drying at both stages of maturity.

None of the interactions showed significant effect on 'reducing' sugar content of raisins of both the stages.

All treatment combinations had significant influence over acid content of raisins at both first and second stage maturity grapes. In second stage grapes the maximum acid content of 2.30 (L_1S_3) was recorded in raisins obtained from lye treated and 15 g sulfur fumigation and the minimum of 1.80 (L_1S_0) was found in lye treated but non-sulfured samples. Similar was the trend in first stage maturity grapes.

Optical density of 0.026 was recorded in raisins which were lye treated and sulfured with 15 g whereas the maximum O.D. of 0.106 was recorded with non lye and non sulfured raisins. There was definite complementary effect of lye treatment and sulfur concentration on N.E.B., in second stage grapes. Similar was the case in first stage grapes as well.

Rehydration of lye treated, 15 g sulfured raisins was the least compared to lye treated non sulfured ones in

case of second stage maturity grapes with similar trend in first stage also. Maximum rehydration is recorded in raisins of lye treated but non-sulfured and the least was associated with non lye treated, 10 g sulfured samples.

In case of second stage maturity, raisins obtained from grapes treated with lye solution and 10 g of sulfur fumigation and oven dried ranked best in organoleptic qualities. Second best was the raisins with similar treatment and sun dried. The least ranked was raisins obtained without any other treatments irrespective drying method. Similar was the case in first stage maturity grapes also.

However, out of the two stages, second stage maturity grapes were better than the first due to higher score obtained for all the attributes.

REFERENCES

REFERENCES

*Amba Dan and Anand, J.C., 1972. Make raisins when grapes are in plenty. Indian Hort., 17(3):5-6.

*Amba Dan, Pande, S.N. and Anand, J.C., 1977. Studies on raisin production from grapes (Vitis vinifera) grown under Delhi conditions. Indian J. Hort., 34(3):215-219.

*A.O.A.C., 1960. Methods of Analysis. Published by Assoc. Official Agri. Chem., Washington, D.C.

Bhatia.B.S., Amin H.D. & Giridheri lal 1962 studies on de-hydration of some tropical fruits I- Absorption and retention of SO2 during Sulfuring & Sulphiting II.

J. Food Science. 11. 63.

Pacific International Exposition, San Francisco, California Official Report, p. 307-314.

Bioletti, F.T., 1919. Dried wine grapes; Methods and returns. State Board of Viticultural Commissioners, Sacramento, Calif. Bull., 15:6-9.

Chambers, T.C. and Possingham, J.V., 1963. Studies on the fine structure of wax layer of Sultana grapes. Aust. J. Biol. Sci., 16:818.

*Choona, G.S., Bhatt, S.S. and Naik, K.C., 1954. Commercial Fruits of India. Published by Macmillan & Co. Ltd., Bombay.

Cruess, W.V., 1911. The effect of sulfurous acid on fermentation organisms. J. Indus. Eng. Chem., 4: 581-585.

Cruess, W.V., Balog, E.C., Friar, H.F. and Low, M., 1944a. Effect of sulfiting on dehydration temperature. Canner, 98(5):18.

Cruess, W.V., Balog, E.C., Friar, H.F. and Low, M., 1944b. Sulfuring to improve vegetables for dehydration. Food Packer, 25(1):51, 62.

*Cruess, W.V., Christie, A.W. and Flossfeier, F.C., 1920. The evaporation of grapes. Calif. Univ. Exp. Sta. Bull., 322:421-469.

*Cruess, W.V. and Christie, A.V., 1921. Dehydration of fruits. Calif. Agri. Exp. Sta. Bull., 339:53-54.

Exarchos, A.A., Mosidis, 1968. Changes in total SO_2 content of sulfured Sultanas during storage and influence of SO_2 losses in colour. Bull. Techno. Inst. Plan. Prod., 1968 (4).

Exarchos, A.A., Mesidis, and Kastouros, G.C., 1968. SO_2 absorbed by Sultana as influenced by the time of sulfuring. Bull. Techno. Inst. Fln. Prod., 1968 (4)

*F.A.O. Year Book of Area and Production, 1981. Vol. 35. Published by F.A.O. Rome.

Gee.M (1980) Some flavour and colour changes during low temperature de-hydration of grapes. J. Food Scie. 45 (1) 146-147.

Am. J. Enol. Vit., 14:230-234.

*Grancarevic, M., 1969. Drying and processing grapes in Afghanistan. Am. J. Enol. Vit., 20(3):198-202.

*Grancarevic, M., Lewis, W.J., 1976. Drying of grapes in Australia. Food Technol. Australia, 28(2):66-67, 69-71, 76.

Greer, L.P., 1944. New techniques produce better war time citrus concentrates. Food Indus., 16:626-627.

*Handel, C.K., Bailey, G.K. and Taylor, D.H., 1950. Measurement of non-enzymatic browning in dehydrated vegetables during storage. Food Technology, 4:344.

*Heikal, H., El-Hanawaty, Kamal, S.I. and Aboseid, M., 1972. Chemical and technological studies on dehydration of Egyptian grapes. Agri. Res. Rev., 50(4):171-183.

*Hussein, A.A., Mark, E.M. and Cruess, W.V., 1942. The effect of pre-treatment and subsequent drying on the activity of grape oxidase. Hilgardia, 14:347-357.

*Jacob, H.E., 1942. The relation of maturity of grapes to the yield, composition and quality of raisins. Hilgardia, 14(6):321-345.

*Jacob, H.E., 1944. Factors influencing the yield, composition and quality of raisins. Univ. Calif. Exp. Sta. Bull., 683.

Jewell, W.R., 1927. Sulfuring dried fruits. J. Dept. Agric. Victoria, 25:457-462.

*Leighton Smith, 1980. Viticulture in Afghanistan. World Crops, 32(3):78-84.

*Long, J.D., Mark, E.M. and Fisher, C.D., 1940. Investigations on the sulfuring of fruits for drying. Calif. Agri. Exp. Sta. Bull., 636.

Mark, E.M. and Phaff, H.J., 1949. Sun drying of fruits. Calif. Agri. Exp. Sta. Cir., 392.

Mark, E.M., Phaff, H.J. and Friar, H., 1943. Dehydration of cherries. Fruit Product J., 22(7):198-201, 214.

Mathew, A., 1928. M.S. Thesis, Library, University of California.

*Nichols, P.F. and Christie, A.W., 1930. Dehydration of grapes. Calif. Agri. Exp. Sta. Bull., 500:1-31.

*Petrucci, Canata, N., Bolin, H.R., Fuller, G. and Stafford, A.E., 1974. Use of oleic acid derivatives to accelerate drying of Thompson Seedless grapes. J. Am. Oil Chem. Soc., 51(3):77-80.

*Ponting, J.D. and McBean, D.M., 1970. Temperature and dipping treatment effects on drying rates and drying time of grapes, prunes and other waxy fruits. Food Technol., 24(12):1403-1406.

Radler, F., 1964. The prevention of browning during drying by the cold dipping treatment of Sultana grapes. J. Sci. Food Agri., 15:864.

Richards, P.H., 1930. Darkening of grapes syrups. Fruit Products J., 9:149.

*Singh, J.P. and Dhawan, S.S., 1973. Use solar heat for raisin making. Indian Hort., 18(1):10-11.

*Thorat, A.K., Bhatia, B.S., Kuppuswamy, S. and Bhatia, D.S., 1963. Further studies on drying of Indian grapes. Food Science, 12:97-114.

*Winkler, A.J., 1974. General Viticulture, University of California Press, Berkeley and Los Angeles.

*Original seen

APPENDIX

Appendix-I

Maximum and minimum temperature, relative humidity and rainfall data during the sun drying

Date	Temperature		Relative humidity	Sun-shine hours	Rainfall
	Maximum	Minimum			
20-3-1981	33.2	21.5	46	6.7	-
21-3-1981	33.5	21.0	48	9.1	-
22-3-1981	33.5	21.0	45	4.1	2.7 mm
23-3-1981	32.0	18.0	57	9.4	1.4 mm
24-3-1981	33.0	18.0	44	11.2	-
25-3-1981	34.0	19.8	46	11.0	-
26-3-1981	33.0	20.0	57	10.8	-
27-3-1981	33.0	19.0	52	8.8	-
28-3-1981	33.0	21.0	58	7.4	-
29-3-1981	32.5	21.0	41	10.9	-
30-3-1981	33.5	19.0	41	11.2	-
31-3-1981	34.0	20.0	45	9.2	-
1-4-1981	34.2	19.2	52	9.8	5.3 mm
2-4-1981	34.5	22.5	39	8.5	-
3-4-1981	34.7	22.3	47	9.4	-
4-4-1981	34.8	22.0	43	10.5	-
5-4-1981	24.9	22.0	57	9.1	-
6-4-1981	35.2	21.5	46	8.6	-
7-4-1981	35.5	21.5	41	8.6	-
8-4-1981	35.8	21.5	33	9.4	-

Appendix-I (contd.)

9-4-1981	35.5	20.0	37	9.9	-
10-4-1981	35.2	15.6	31	9.8	-
11-4-1981	36.0	17.5	37	11.0	-
12-4-1981	36.0	20.0	46	10.9	-
13-4-1981	35.0	19.5	43	10.2	-
14-4-1981	35.5	21.0	45	8.5	-
15-4-1981	35.5	21.0	51	9.2	-
16-4-1981	35.2	18.0	53	10.8	22.2 mm
17-4-1981	34.0	18.0	47	10.5	-
18-4-1981	34.6	20.0	49	9.8	-
19-4-1981	34.5	20.0	59	5.4	41.0 mm
20-4-1981	36.2	21.5	49	9.9	-