माझ्या जीवनाची वाट,सुखमय आणि सुखकर होण्यासाठी
सतत प्रयत्नशील व कष्टप्रद जीवन व्यतीत
करणाऱ्या ती. आण्णा, सौ. आई. बंधू
तात्या, बापू व नाना यांच्या
शुभचरणी अर्पण

– – – – – सुर्यकांत

STUDIES ON EXTENDING THE SHELF LIFE OF SAPOTA (*Manilkara achras* (Mill.) Fosberg)

By

Suryakant Kisan Nikam

Reg No. 92159

A Thesis Submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI, 413 722 DIST - AHMEDNAGAR.
Maharashtra State (India)

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

HORTICULTURE

DEPARTMENT OF HORTICULTURE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI, DIST- AHMEDNAGAR, M. S. (INDIA)

1994

MPKV LIBRARY
T02118

STUDIES ON EXTENDING THE SHELF LIFE OF SAPOTA (*Manilkara achras* (Mill.) Fosberg)

By

Suryakant Kisan Nikam

Reg.No. 92159

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI, DIST. AHMEDNAGAR, MAHARASHTRA,
(INDIA)

in partial fulfilment of the requirements for the degree
of

MASTER OF SCIENCE (AGRICULTURE)

in

HORTICULTURE

APPROVED BY

~~Dr. D.P.~~ Waskar
(Research Guide)

Dr. U.T. Desai
(Committee Member)

Dr. R.N. Adsule
(Committee Member)

Prof. B.P. Deore
(Committee Member)

DEPARTMENT OF HORTICULTURE

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI
VIDYAPEETH, RAHURI-413 722

1994

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for Degree or Diploma.

(Suryakant K. Nikam)

Place : M.P.K.V., Rahuri.

Dated : 21 / 10 /1994.

Dr. D.P. Waskar,
Principal Investigator, (PHT),
Department of Horticulture,
Mahatma Phule Krishi Vidyapeeth,
Rahuri 413 722, Dist. Ahmednagar
Maharashtra

C E R T I F I C A T E

This is to certify that the thesis entitled, "**STUDIES ON EXTENDING THE SHELF LIFE OF SAPOTA** (*Manilkara achras* **(Mill.) Fosberg)**" submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri, for the award of the degree of **MASTER OF SCIENCE** (Agriculture) in **HORTICULTURE**, embodies the results of a *bona fide* research work carried out by **SURYAKANT KISAN NIKAM**, under my guidance and supervision and that no part of the thesis has been submitted for any Degree or Diploma.

The assistance and help recieved during the course of this investigation have been acknowledged.

Waskar

(D.P. Waskar)
Research Guide

Place : Rahuri

Dated : 21/10/1994.

Dr. N.K. Umrani,
Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri 413 722, Dist. Ahmednagar
Maharashtra

C E R T I F I C A T E

This is to certify that the thesis entitled, "STUDIES ON EXTENDING THE SHELF LIFE OF SAPOTA (*Manilkara achras* (Mill.) Fosberg)" submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri, for the award of the degree of **MASTER OF SCIENCE** (Agriculture) in **HORTICULTURE**, embodies the results of a *bona fide* research work carried out by **SURYAKANT KISAN NIKAM**, under the guidance and supervision of Dr. D.P. WASKAR, and that no part of the thesis has been submitted for any other degree or diploma.

Place : Rahuri

Dated : 29 / 10 /1994.

(N.K. Umrani)

ACKNOWLEDGEMENT

I wish to express my deepest gratitude and heartfelt appreciation to Dr. D.P. Waskar Principal Investigator, PHT Project and Chairman, advisory committee for accepting me as his ward. His constant scholastic guidance, candid constructive criticism, practical unravelment of all problems and sharing of his infinite wisdom and knowledge have indeed paved the way for this work to materialise. It was a great privilege to be associated with such an esteemed personality.

It was a great privilege to have the brother figure of Dr. U.T. Desai, member of my advisory committee whose unfailing guidance, constant inspiration and well versed counsel taught me to look for a silver lining in every cloudy sky I came across.

I am grateful to Dr. R.N. Adsule and Prof. B.P. Deore, the members of my advisory committee for going through the manuscript and making suggestions and corrections wherever necessary.

I owe my indebtedness and gratitude to Prof. B.G. Keskar, Head, Department of Horticulture, for keen interest and encouragement in completing this thesis.

My heartfelt thanks are also due to Prof. S.D. Masalkar, Dr. K.E. Lawande, Prof. A.R. Karale, Prof. S.N. Kaulgud, and Prof. V.S. Supe for their kind help and co-operation.

I wish to place on accord thanks to Shri. S.V. Damame, Shri. R.S. Gaikwad and supporting staff of PHT Project, for their help and suggestions during the conduct of the present investigation.

It would be an auric occassion to thank my fellow classmates Sanjay Takawale and Appasaheb for the continuous motivation, affection and patience showered so generously on me during all the frustrating periods which gave me the confidence and will power to tenaciously continue and fight back. I would also like to thank my friends Sanjay Pawar, Sunil Pawar, Sunil Thorve, Balasaheb Yadav, Vikas Pawar, Sudhakar Sabale, Amrut Patil, Sanjay Ghorpade, Dilip, Dattatray, Ram, Shivaji, Subrao and Ravindra Hajare for all the timely help and ecouragement given so spontaneously and continuously that it helped to drive off the melancholic and tiring hours to be replaced by rewarding and happy moments.

The unfailing patience, love, reassurance and trust placed by my parents Anna and Sau. Aai and brothers Tatya, Bapu and Nana have always been the guiding star to all my work prodding to rebound with confidence and to see beyond myself.

It would be my greatest pleasure to thank all of them for all their sacrifices, inspiration and even for their reprovals and lectures which brought me to this crescendo.

I express my heartiest thanks to all who helped directly or indirectly for building my career. Thanks are also due to SUYOG COMPUTERS for typing the script in an elegant and attractive manner.

Last but not least, I would profoundly thank the `Jindal Educational Trust, Banglore,' for helping me financially by awarding me with scholarship during the course of this Master's degree programme.

Place : MPKV, Rahuri

Dated : 21 / 10/1994.

(Suryakant K. Nikam)

LIST OF TABLES

Table No.	Title	Page No.
1.	Temperature (^{o}C) and relative humidity (R.H.%) conditions in the storage environment of sapota fruits in March, 1994.	26
2.	Effect of various packaging materials on the changes in TSS (%) content of sapota fruit at RT and in CC.	33
3.	Effect of various packaging materials on the changes in TSS (%) content of sapota fruit in CC.	34
4.	Effect of various packaging materials on the changes in acidity (%) of sapota fruit at RT and in CC.	38
5.	Effect of various packaging materials on the changes in acidity (%) of sapota fruit in CC.	39
6.	Effect of various packaging materials on the changes in reducing sugar (%) content of sapota fruit at RT and in CC.	43
7.	Effect of various packaging materials on the changes in reducing sugar (%) content of sapota fruit in CC.	44
8.	Effect of various packaging materials on the changes in total sugar (%) content of sapota fruit at RT and in CC.	49

List of Table Contd.....

Table No.	Title	Page No.
9.	Effect of various packaging materials on the changes in total sugar (%) content of sapota fruit in CC.	50
10.	Effect of various packaging materials on the changes in fruit softening of sapota fruit at RT and in CC.	54
11.	Effect of various packaging materials on the changes in fruit softening of sapota fruit in CC.	55
12.	Effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT.	58
13.	Effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT and in CC.	59
14.	Effect of various packaging materials on the changes in skin shrinkage of sapota fruit in CC.	60
15.	Effect of various packaging materials on the shelf life and organoleptic evaluation of sapota fruit at RT and in CC.	66

LIST OF FIGURES

Figure No.	Title	Between Page
1.	Pictorial view of cool chamber	25-26
2.	Effect of various packaging materials on total weight loss (per cent) of sapota fruit at RT.	63-64
3.	Effect of various packaging materials on total weight loss (per cent) of sapota fruit in CC.	63-64
4.	Effect of various packaging materials on cumulative rotting (per cent) of sapota fruit at RT.......................................	64-65
5.	Effect of various packaging materials on cumulative rotting (per cent) of sapota fruit in CC..	64-65

LIST OF PLATES

Plate No.	Title	Between Page
1.	Storage of sapota fruit in cool chamber	26-27
2.	Control and polyethylene packed sapota fruits stored at RT................................	65-66
3.	CFB and polyethylene + CFB packed sapota fruits stored at RT.........................	65-66
4.	Wooden and polyethylene + wooden packed sapota fruits stored at RT....................	65-66
5.	Control and polyethylene packed sapota fruits stored in CC................................	66-67
6.	CFB and polyethylene + CFB packed sapota fruits stored in CC..........................	66-67
7.	Wooden and polyethylene + wooden packed sapota fruits stored in CC....................	66-67

LIST OF ABBREVIATIONS USED

CC	:	Cool Chamber
CD	:	Critical difference
CFB	:	Corrugated Fiber Board box
PLW	:	Physiological loss in weight
R.H.	:	Relative Humidity
RT	:	Room Temperature
S.E.	:	Standard Error of means
TSS	:	Total Soluble Solids

A B S T R A C T

STUDIES ON EXTENDING THE SHELF LIFE OF SAPOTA (*Manilkara achras* (Mill.) Fosberg)

By

NIKAM SURYAKANT KISAN

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth,

Rahuri 413 722

1994

Research Guide	:	Dr. D.P. Waskar
Department	:	Horticulture

The present investigation entitled, "Studies on extending the shelf life of sapota (*Manilkara achras* (Mill.) Fosberg)" with six packaging treatments and two storage conditions was conducted in two sets of experiments with three replications in Factorial Completely Randomised Design.

The packed sapota fruits cv. Kalipatti were stored at room temperature (31.67-36.85°C ; 22.57-34.97 % R.H.) and in low cost, low energy input cool chamber (20.24 to 21.57°C ; 91-95% R.H.) in March 1994. There was an increase followed by subsequent decrease in TSS, reducing sugar and total sugar content with corresponding decrease in acidity upon prolonged storage under both the storge conditions irrespective of packaging treatments. Total weight loss, rotting, fruit softening and fruit skin shrinkage increased with the subsequent increase in storage in all the packaging treatments and under both storage conditions. Fruits stored in cool chamber followed the same trend of physico-chemical changes but at a slower rate.

The shelf life of unpacked sapota fruit was found to be hardly 5 days at room temperature, however, the fruit could be stored upto 9 days when it was packed in polyethylene bag (100 guage and 1.2 % vents) . The shelf life of sapota fruit when packed in polyethylene bag (100 guage and 1.2% vents) + CFB box and in polyethylene bag (100 guage and 1.2% vents) was extended upto 13 and 15 days, respectively in cool chamber. Moreover, cool chamber has the added advantage of easy construction and low cost.

Pages : 1 to 101

CONTENT

Chapter No.	Title	Page No.
1.	INTRODUCTION	1
2.	REVIEW OF LITERATURE	4
3.	MATERIAL AND METHODS	24
4.	EXPERIMENTAL RESULTS	32
5.	DISCUSSION	68
6.	SUMMARY AND CONCLUSION	79
7.	LITERATURE CITED	82
	APPENDICES	95
	VITA	101

T-3118

INTRODUCTION

1. INTRODUCTION

Sapota (Manilkara achras (Mill.) Fosberg) is a delicious fruit and valued for its mellow and sweet pulp. The fruit tree is introduced from tropical America. In India total area and production of sapota fruit crop are estimated about 27,248 hectares and 3.96 lakh tonnes, respectively (Anonymous, 1992). In India, the states growing the sapota on a commercial scale are Maharashtra, Gujrat, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, West Bengal, Punjab and Haryana (Cheema et al., 1954; Purseglove, 1968). It is not known when it was first introduced into India (Singh et al., 1963), but the sapota cultivation was taken up for the first time in Maharashtra in 1898 in a village named Gholwad in Thane district (Cheema et al., 1954).

The area amd production of sapota in Maharashtra are 3824 hectares and 24,476 tonnes, respectively with productivity of 6.92 tonnes/ha (Anonymous, 1992). In Maharashtra, traditionally it is grown mainly in coastal area of Thane, Raigarh, Ratnagiri and Sindhudurg districts. Presently, the Government of Maharashtra has launched an ambitious thrust programme on plantation of various fruit crops since 1990 under Employment Guarantee Scheme (EGS) grants, hence it is expected that both area and production of sapota will increase by many folds in near future.

The sapota fruit is a good source of sugars which ranges from 12 to 18 per cent and has appreciable amounts of protein, fat, fibre, calcium, phosphorus and iron. The usual practice is to eat only the pulp. The fruit skin can also be eaten since it is richer than the pulp in nutritive value (Gopalan et al., 1971). The pulp is utilized in the preparation of sherbats and halwas (Singh et al., 1963). It is said to be an excellent preventive against biliousness and febrile attacks. The decoction is given in diarrhoea and in paludism (Kirthikar and Basu, 1975). The mature fruits of sapota are used for making mixed jams and they provide valuable sources of raw material for the manufacture of industrial glucose, pectin and natural fruit jellies. They are also canned as slices.

The research efforts have helped to increase the production of sapota but the purpose of obtaining maximum profit will not be served unless increased production is supplemented with similar efforts to minimise their postharvest losses. This fruit is highly perishable and rated poor for processability therefore mainly used for table purpose only. The storage life of sapota fruit is short at ambient temperature conditions. It is also sensitive to cold storage (Lakshminarayana, 1980). Hence, fruits require immediate marketing soon after harvest. Under these circumstances, handling and marketing become important to sustain its increasing area and productivity for providing remunerative price to farmers.

The postharvest losses in fruits like sapota are high in tropical country like India, which ranges between 25-30 per cent (Salunkhe and Desai, 1984). These losses occur due to lack of proper storage facilities, improper handling during long distance transport, rapid ripening and microbial spoilage. Extension of shelf-life can be possible by checking the rate of respiration, transpiration and microbial infection. However, there is paucity of information on use of various packaging materials, simple, cheap storage structure for storage of sapota to maintain the quality during storage.

In view of facts mentioned above, the present investigation was undertaken with following objectives.

i) To study the effect of various postharvest treatments on physico-chemical characteristics of sapota under different storage conditions.

ii) To study the effect of various postharvest treatments on shelf-life and quality of sapota fruit under different storage conditions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Fruits are alive, even when detached from trees. Like all living organisms they carry out various physiological activities such as respiration, ripening and transpiration. They are constantly subjected to spoilage caused by senescence and microbial decay. Fleshy fruits are more complex in their senescence. All the changes that occur do not represent deterioration. In a real sense, fruit ripening may be regarded as a special case of organ senscence (Moore, 1980).

Sapota is a climacteric fruit and in such fruit it is a well known fact that it contains high moisture and is inherently more liable to deteriorate under tropical conditions such as ours. The rapid postharvest changes are observed in sapota before it reaches the edible ripe stage. Several methods have been reported for extending the shelf-life of sapota. Use of various packaging materials, storage at low temperatures, pre-treatment with fungicides, other chemicals and skin coating with waxes, etc. are some of the methods adopted for extending the shelf-life of sapota and other fruit crops. A brief review of literature pertaining to some of these aspects is presented hereunder.

2.1 Effect of packaging material

2.1.1 Polyethylene packaging

The water loss resulting from transpiration and respiration causes not only shrinkage, drying and softening of the fruit, but triggers the change from juvenile hormonal balance to an optimum edible stage and then to senescent one, leading to accelerated deterioration of the fruit (Ben-Yehoushua, 1985).

A produce package is a dynamic system in which respiration and permeation occur simultaneously. There is uptake of O_2 by the produce and evoluation of CO_2, C_2H_4 and H_2O and other volatiles. At the same time, specific restricted permeation of these gases occur through the film used for packaging (Hening, 1975).

It has been found that polyethylene package retards respiration and transpiration and helps to increase shelf-life and retention of quality of fruits (Salunkhe and Norton, 1960 and Salunkhe et al., 1962). Gorini (1985) specifically emphasized and advocated the packaging of fruits and vegetables in polyethylene film of known permeability to modify the internal atmosphere so as to extend the shelf-life and prevent decay.

Kumbhar and Desai (1986) reported shelf-life of 11 days in sapota with fruit dip treatment for three minutes in a solution of 75 ppm GA and packed in polyethylene bags (100 guage and 1.2 % vents). Weight loss under this treatment was minimum (13.89 %) compared with the control (90.00 %). Banik et al. (1988) found that sapota fruit kept in polyethylene bag with permangnate silica gel at 10-12^{o}C, could be stored well upto 18 days with minimum spoilage.

Kariyanna et al. (1993) reported in sapota cv. Kalipatti that packaging fruit in polyethylene bag (150 guage and 1 % vents) reduced the physiological loss in weight (PLW) significantly, but the spoilage due to fungal rot was maximum. However, this could be overcome by treating the fruit with Bavistin (500 ppm) before packaging. Fruit packed in polyethylene bag possessed better sensory appeal when compared to other treatments.

Jain et al. (1979) observed minimum weight loss in ber fruits cv. Umran stored in perforated polyethylene bag (400 guage and 0.4 % vents). Fruits had acceptible condition even after 8 days of storage. Jawanda et al. (1980) found that it was possible to extend the storage life upto 10 days in Umran and 12 days in Sanaur-2 at room temperature when the fruits were treated with wax and stored in ventilated polyethylene bags (100 guage and 2.5 to 3 cm square area punched).

Jain et al. (1981) also reported a lower weight loss and a better physical appearance in ber fruit cv. Umran stored for three weeks in perforated polyethylene bag (400 guage and 0.4 % vents). Banik et al. (1988) found minimum loss in weight in ber fruit cv. Gola stored in perforated polyethylene bag (150 guage).

Baviskar (1993) reported in ber cv. Umran that the fruit could be stored upto 11 days when it was treated with waxol (6 %) and packed in polyethylene bags and organoleptic rating of fruit in terms of colour, flavour and texture was maximum in this treatment.

Sadasivam et al. (1973) found minimum weight loss in orange fruit packed in polyethylene bag (100 guage and 0.2 % vents). Fungal infection was not observed in 100 guage polypack where fruit remained healthy. Organoleptic evaluation, cost and consumer appeal were best with 100 guage polypack with 0.2 % vents.

Choudhari and Kumbhare (1979) observed highest loss, in sweet orange, in control followed by pack of 300 guage film and nil in film of 100, 150 and 200 guage with 0.3 and 0.4 % ventilations.

Khedkar et al. (1982) observed that guava fruit cv. L-49 when packed in 300 guage polypack had less weight loss, more percentage of pulp and vitamin-C, no adverse change in fruit and had a high organoleptic score. Dhoot et al. (1984) reported that fruit of guava cv. Sardar treated with NAA at 150 ppm and packed in polyethylene bag had the best shelf-life.

Jadhav et al. (1992) found among seven treatments, 400 ppm 2,4-D + 0.5 % Topsin + 100 guage polyethylene packaging with 2 % ventilation was comparatively more effective in enhancing the storage life of custard apple fruit at ambient temperature for five days without affecting fruit quality. Reddy and Nagraju (1993) recorded maximum shelf-life in custard apple when fruit treated with 200 ppm GA and Topsin 0.5 % and packed in polyethylene bag (100 guage and 2 % vents).

Bhullar et al. (1984) in mango, observed the best fruit appearance at the end of storage when fruit was packed in perforated polyethylene bag or coated with 6 % wax emulsion.

Pota et al. (1987) reported storage life of pomegranate upto twelve weeks in polyethylene bag (0.02 mm) at 10°C with slight changes in quality.

2.1.2 Corrugated fibre board packaging (CFB)

Corrugated fibre board carton is made of kraft paper manufactured from wood, bamboo and other biomass and cellulosic waste like paddy straw, wheat straw, sugarcane bagasse etc. Compared with the wooden box, this package is lighter by 70-80 %, more convenient to handle and cheaper to transport.

Joshi and Roy (1986) also reported CFB box as an effective alternative for transport and storage of mango cv. Alphonso. They found lower spoilage and shrivelling in case of fruit stored in CFB box with three partitions.

Ladania and Dhillon (1987) found, in Beauty Seedless grape, CFB carton lined with perforated polyethylene and equipped with quarter-size dual release SO_2 generators gave excellent storage life. Fruit quality and eating quality were fairly good.

6 Anand and Maini (1982) reported that CFB cartons were satisfactory during transhipment and storage in conventional cool store. The apple fruit in these CFB cartons suffered only 3 to 5 per cent bruising damage as compared to 30 to 35 per cent encountered in conventional wooden boxes. Lal Kaushal and Anand (1986) in their studies on grading and packaging of apple observed that the quality of fruit remained good when packed in CFB box. This box is lighter in weight, recyclable, pilferproof in nature, easy to stack, handle and pallatise not only for local but also export market.

Gupta et al. (1981) studied the effect of various packagings on the storage behaviour of Kaithali and Umran ber and reported that hard-board corrugated carton of 8 to 9 Kg (40 x 25 x 20 cm) size with six holes of one centimeter diameter on two sides and paper cuttings as cushion retained good fruit quality for 9 to 12 days. Singh (1987) reported in transportation study by railway and bus, using different package systems that ber fruit cv. Gola packed in CFB carton was found good in terms of organoleptic acceptance. Baviskar (1993) recommended the storage of ber cv. Umran fruit in cool chamber and cool store by giving wax treatment coupled with polyethylene and CFB packaging where shelf-life was extended upto 15 and 28 days, respectively.

Ladania and Naqvi (1993) reported that CFB box of standard size for packaging of Nagpur mandarin as preferred by importers. The box should have 4-5 % ventilation holes on lateral sides for better pre-cooling and aeration during storage. In the domestic market the traditional wooden box should be replaced with CFB box.

Reddy et al. (1993) found packing guava fruit cv. Allahabad Safeda in corrugated paper box better than bomboo basket as it showed less mechanical injury, higher organoleptic rating and less decay.

2.1.3 Wooden boxes

Patil et al. (1988) reported in sapota, the fruit packaging immediately after harvest in bamboo basket. It is advantageous to use standard wooden box for packing and transport over long distance by rail road.

Singh et al. (1976) packed guava fruit in wooden box while studying the effect of different packing materials, containers and transportation on guava fruit. The best results were obtained with fruits in perforated polyethylene bag and in wooden box.

Pilania and Chauhan (1993) packed grapes in wooden box (30 x 30 x 13 cm), cardboard box (37 x 25 x 10 cm) and bamboo basket of 30 cm height with 40 cm diameter. Among the packing materials used, maximum loss in weight of fruit was recorded in bamboo basket with minimum in cardboard box. The organoleptic rating was more in grapes packed in wooden box than in cardboard and bamboo basket.

Maini et al. (1982) found significantly less bruising in tray-packed (wooden) apple. Shrivelling due to water loss was, however, greater in the trays when apple was stored for five months and a fall in quality (TSS) was noted after three months.

Chauvan et al. (1987) packed mango fruit cv. Dashehari in wooden box with paper lining as cushioning material to found effect of some chemicals and cooling on shelf-life. Fruit was stored at room temperature and half of the fruits in each treatment were packed in wooden box lined with $KMnO_4$ soaked paper.

Patil et al. (1988) reported that citrus fruits are usually packed in wooden box for transport to distant markets. Excessive moisture loss during shipment can be reduced by placing the fruit in individual cells. Ventilation holes must be provided at the bottom and top of the containers and not at the sides.

2.2 Effect of storage environment

Fruit continues to respire even after the harvest. The respiration of the fruit and vegetable involves many enzymatic reactions. The rate of these reactions within the physiological temperature range increases exponentially with increase in temperature and may be described mathematically by use of temperature quotient (Q_{10}). Van't Hoff, the Dutch chemist, showed that the rate of a chemical reaction approximately doubles for each 10^oC rise in temperature (Wills et al., 1981).

Salunkhe and Wu (1976) reported that all the fruits continue to lose vapour after they are harvested. This water loss is rapid at low relative humidity. Humidity is dependent on temperature and water has a greater tendency to evaporate as temperature rises. Thus if the fruit is at 10^oC, the water it contains has a greater tendency to evaporate than if it were at 4.5^oC.

2.2.1 Storage of fruits at room temperature (RT)

Flores and Rivas (1975) reported that sapota fruit is highly perishable if stored at room temperature and could not be kept for eight days. Kumbhar and Desai (1986) observed increased shelf-life of sapota furit at room temperature for upto eleven days when fruit was treated with 75 ppm GA and packed in polyethylene bag (100 guage and 1.2 % vents).

Rao and Chundawat (1988) reported that under ordinary conditions sapota fruit keeps well for 5-7 days. They found rapid ethylene production, respiration and catalase activity in sapota cv. Kalipatti at ambient temperature of 29-31^{o}C. Guatam and Chundawat (1990) reported in sapota cv. Kalipatti the shelf-life of fruit could be extended by 2.5 days at room temperature when fruit was dipped in GA at 300 ppm, over the non-treated control fruit which ripened in 5.2 days.

Bal et al. (1978) reported that ber fruit cv. Umran remained satisfactorily upto nine days at room temperature. Jawanda et al. (1980) reported that the storage life of ber cv. Umran and Sanaur-2 could be extended upto 10 days and 12 days at room temperature respectively when the fruits were treated with wax and stored in perforated polyethylene bags. Bal (1982) found ripe fruit of ber cv. Sanaur-2 edible for upto 7 days when stored at room temperature and fruit colour changed to greyish purple. Baviskar (1992) reported the shelf-life of untreated ber cv. Umran fruit hardly 6 days at room temperature, howerver, the fruit could be stored upto 11 days when it was treated with waxol (6 %) and packed in perforated polyethylene bag.

Garg et al. (1971) observed that pre-packed mango fruit cv. Dashehari and treated with wax-emulsion stored at room temperature and low temperature showed negligible loss in weight and percentage spoilage. Bhullar et al. (1984) stored fully mature but unripe fruit of mango Cvs. Langra and Dashehari at room temperature for upto 12 days. The least physiological weight loss and rotting and the best fruit appearance at the end of storage at room temperature in perforated polyethylene bag was observed.

Gupta et al. (1979) studied the storage behaviour of four cultivars of guava and revealed that the fruit of Apple Colour remained in consumers acceptable condition upto six days at room temperature. The decrease in TSS and acidity was lowest. Khedkar et al. (1982) observed the extension in postharvest life of guava fruit cv. L-49 stored at room temperature when packed in 300 guage polyethylene bag.

Jadhav et al. (1992) observed that custard apple fruit when chemically treated and packed in polyethylene bag (100 guage and 2 % vents) and stored at room temperature remained good for five days over control without affecting fruit quality.

2.2.2 Storage of fruits in cool chamber (CC)

The ancient Egyptian used a primitive form of evaporative cooling dating back to 2500 B.C. and so did Moghals for better living during hot summer. Water during the process of evaporation takes the heat from its surrounding to effect cooling. Evaporative cooling consists of a wet porous bed through which air is drawn, cooled and humified by evaporation of water (Roy and Khurdia, 1986).

Roy (1982) reported that cool chamber could reduce the temperature by 17 to 18^{O}C during the peak summer months and maintain a very high humidity about 95 per cent throughout the year even when the atmospheric relative humidity falls below 20 per cent. These chambers are ideal for the storage of fresh fruits.

Reddy and Nagaraju (1993) reported increased shelf-life of sapota fruit cv. Kalipatti when stored in evaporative cool chamber. The cool chamber storage significantly reduced physiological loss in weight and shrivelling. Higher firmness due to delay in ripening and a delay in increase of TSS, reducing the total sugars, decrease in acidity and less rotting of fruit was observed leading to recovery of higher per cent of marketable fruits.

Chattopadhyay _et al_. (1994) reported storage life of 29 and 20 days of sapota fruits treated with GA_3 (100 ppm) and Bavistin (500 ppm), respectively when fruits stored in cool chamber.

Joshi _et al_. (1993) also reported that cool chamber was found to increase the shelf-life of vegetables like brinjal, chilli, bell pepper, corriander leaves, amaranthus, cluster bean, spinach, carrot, cabbage, drumsticks and fruits like mango (Cvs Alphonso, Pairi, Kesar, Ratna), sapota, banana, seedless lemon, kokum (raw and ripe) and karonda.

Gupta (1985) observed that Gola, Kaithali and Umran ber fruits could be stored for 18,14 and 15 days, respectively under evaporative cool storage conditions. Singh (1987) reported the use of zero energy cool chamber for increasing the storage life of ber fruit cv. Gola. The fruit kept in zero energy cool chamber proved better in quality as well as in biochemical and physiological factors as compared to fruit kept at room temperature. Baviskar (1993) in her studies reported the shelf-life of ber fruit cv. Umran upto 15 days in cool chamber when treated with waxol coupled with polyethylene and CFB packaging. Moreover, cool chamber had the added advantage of easy construction, low cost and simple handling.

Aror and Narsimhan (1988) reported that the coorg mandarin could be stored for 20 days under evaporative cool storage conditions when treated with 6% fungicidal wax as against a storage life of 5 days for untreated fruit stored at room temperature. The evaporative cooling storage gave six times longer storage life for apples and four times longer storage life for mandarins than ambient conditions.

Waskar (1989) from his studies on storage and ripening of banana, observed that banana fruit cv. Basrai could be stored in cool chamber upto 20.5 days as against 14 days at room temperature.

2.3 Changes in physico-chemical composition

2.3.1 Total soluble solids (TSS)

Singh and Mathur (1954) reported increase in the percentage of TSS in sapota at all temperature ranges. Sundararajan and Rao (1967) reported that TSS content of sapota ragnes from 18 to 25 %. They suggested to use TSS values as an indication of maturity.

Ingle *et al*. (1981) while studying ripening process in sapota fruit with different media for ripening observed decrease in total soluble solids in all treatment. Ingle *et al*. (1982) also reported decrease in total soluble solids during ripening process in all treatments in sapota. The decrease in TSS in case of fruit ripened in paddy straw and ethrel was comparatively rapid than the fruits treated with 2,4-D and wax emulsion.

Kumbhar and Desai (1986) reported a rise in total soluble solids (TSS) in open sapota fruit at room temperature upto 6th day and decrease thereafter. In polyethylene packed fruit TSS increased upto 9 days and decreased thereafter. Similarly, in the untreated and the treated fruits with different chemicals, the values of TSS increased upto 6 and 9 days, respectively and decreased thereafter. The untreated open sapota fruit showed fast rise and fast decrease in TSS. Banik et al. (1988) while studying shelf-life of sapota fruit reported increased TSS in all treatments including control. Guatam and Chundawat (1990) while studying postharvest changes in sapota cv. Kalipatti observed accumulation of TSS during the process of ripening. This accumulation was lower in case of treated fruit with different chemicals as compared to untreated control. Reddy and Nagaraju (1993) observed delay in increase of TSS in sapota stored in zero energy cool chamber and delay in ripening process.

2.3.2 Titrable acidity

Ingle et al. (1981) observed, during ripenig process of sapota fruit, decrease in per cent acidity in all ripening media. However, the decrease was rather more in case of fruit treated with paddy straw as compared to others. Ingle et al. (1982) also reported decrease in per cent acidity during ripening process of sapota in all treatments while studying the effect of growth regulators on ripening of sapota fruit. The decrease was rather more in case of paddy straw than ethrel treated fruit.

Selvaraj and Pal (1984) reported that the total titrable acidity in sapota, which was high in 30-day old samples, declined steadily and reached minimum in ripe fruit. Malic acid was the major acid in all developmental stages. Kumbhar and Desai (1986) reported continuous decrease in acidity of sapota fruit in all the treatments. However, the decrease was slow in polyethylene packed fruit as against open fruit and in treated fruit as against the untreated fruit. GA showed slow decrease in acidity than IBA. Banik et al. (1988) reported that the amount of titrable acidity of sapota decreased as storage period advanced.

Guatam and Chundawat (1990) reported, in sapota cv. Kalipatti, slow decline in titrable acidity throughout the period of ripening. However, the trend of decline of titrable acidity varied among treatments being most rapid in GA (30 ppm) and the lowest in the control.

Reddy and Nagaraju (1993) reported better firmness of sapota fruit in cool chamber storage due to the slow decrease in acidity than at room temperature.

2.3.3 Sugars

Ingle et al. (1981) reported that sapota fruit exposed to different ripening treatments recorded increase in reducing sugars, except in case of paddy straw, during ripening. The total sugars showed inconsistent trend.

Ingle et al. (1982) also found increase in reducing sugars during ripening of sapota fruit. Increase was more rapid with fruits treated with higher concentrations of ethrel. Increase in reducing sugars was also noted in the fruits treated with wax emulsion and 2,4-D. The total sugars showed inconsistent trend.

Kumbhar and Desai (1986) while studying shelf-life of sapota observed rise in sugars in open fruit upto 6 day and decrease thereafter. In polyethylene packed fruit, sugars increased upto 9 days and decreased thereafter. Similarly, in the untreated and the treated fruit the values increased upto 6 and 9 days, respectively and decreased thereafter. Banik et al. (1988) reported in sapota that total sugars and reducing sugars increased in all the treatments including the control.

Guatam and Chundawat (1990) while studying postharvest changes in sapota cv. Kalipatti observed that level of reducing sugars accelerated throughout the period of ripening. Accumulation of reducing sugars and total sugars during ripening is a function of starch metabolism which is slower in treated fruits compared to control. Reddy and Nagaraju (1993) observed delay in reducing the total sugars thereby increase in shelf-life of sapota in cool chamber.

Laxsh 66.

2.3.4 **Weight loss** Mattrey 56

Ingle et al. (1981) reported increasing trend of PLW upto eating ripe stage in all the treatments in sapota. In paddy straw, it was found to be maximum on 6^{th} day as compared to other ripening media.

Khedkar 1982

Ingle et al. (1982) also reported increased physiological loss in weight at eating ripe stage in ethrel treated fruit as compared to paddy straw. Higher PLW was observed in the treatments given for accelerating ripening process.

Dhon 84

Kumbhar and Desai (1986) while studying shelf-life of sapota observed that the cumulative total weight loss during the course of storage was considerably high in open fruit. After 11 days of storage, the weight loss in polyethylene packed fruit was 46.3 % as against 72.1% in open fruit. A significant reduction in the weight loss was observed in 75 ppm GA treated fruit packed in polyethylene bag after 11 days, the loss was 11.89 % as against 90.2 % in untreated open fruit.

Banik et al. (1988) reported in sapota that PLW increased progressively as the storage period advanced. On the 6^{th} day of storage PLW was maximum in fruit under control and least PLW was noted in fruit kept in polyethylene bag with permangnate-silica gel at 10-12^{o}C. Fruit treated with MH, NAA and GA alone or in combination with wax emulsion recorded less PLW as compared to control.

Guatam and Chundawat (1990) found PLW was due to loss of water from fruit surface during ripening. The pattern of PLW was identical in all treatments but the rates varied with the treatments being the lowest in kinetin (100 ppm), followed by silver nitrate (40 ppm), gibberellic acid (300 ppm) and control. This reduction in PLW in these treatments could be due to slow release of free water due to reduced metabolism and reduced rate of transpiration. Kariyanna et al. (1993) found that packaging the sapota fruit in polyethylene bag (150 guage and 1 % vents) reduced the PLW significantly.

Reddy and Nagaraju (1993) also reported singificant reduction in physiological loss in weight and shrivelling when sapota fruit stored in zero energy cool chamber.

Naik 94 Ven & Reddy 94

2.3.5 **Rotting and spoilage**

Salunkhe and Desai (1984) reported that the ripe sapota is remarkably susceptible to mechanical injuries during handling and transportaion. The fruit is also highly susceptible to chilling injury. Sapota fruit is also infected by insects viz. Nephopteryx engraphella Rag. and a black borer. A Phytopthora sp. and a black yeast cause fruit rot. Phytophthora palmivora cause fruit rot and infect both immature and ripe fruits.

Kumbhar and Desai (1986) reported that upto 7th day of storage of sapota, there was no rotting in any of the treatments. Thereafter, at all the stages, the rotting in open fruit was more than the packed fruit. Similarly, the treated fruits had low rotting than the untreated fruits. The rotting was mainly the development of water soaked spots which subsequently made fruits unmarketable.

Banik et al. (1988) recorded cent per cent spoilage on the 9th day of storage of sapota fruit. The fruit kept in polypack with permangnate-silica gel at 10-12^{o}C, could be stored well upto 18 days with minimum spoilage (30 %).

Kariyanna et al. (1993) reported in sapota that though polyethylene packaging reduced the PLW significantly, but the spoilage due to fungal rot was maximum. However, this could be overcome by treating the fruit with Bavistin 500 ppm before packaging.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The present investigation "Studies on extending the shelf life of sapota (*Manilkara achras* (Mill.) Fosberg). cv. Kalipatti" was conducted at the Postharvest Technology Laboratory, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, during the year 1993-94.

The experimental material, sapota fruits variety Kalipatti were obtained from the experimental orchard. For this purpose, fruits of uniform size, shape and colour were selected for the experiment. The fruits were harvested at proper stage of maturity and directly kept in bamboo baskets underlaid with sapota leaves. The fruits were then brought to the laboratory for further experimentation.

3.1 Experimental details

The experiment was conducted in Factorial Completely Randomised Design with six packaging treatments and two storage conditions. The treatments were replicated three times. The treatment details are as follows.

3.1.1 Postharvest treatments

3.1.1.1 Packaging treatments

The following six packaging treatments were given to sapota fruits.

1. Control (Untreated) (T_1)
2. Polyethylene bag (100 guage and 1.2 % vents) (T_2)
3. Corrugated Fibre Board box (CFB) (T_3)

MPKV LIBRARY
T02118

4. Wooden box (T_4)

5. Polyethylene bag (100 guage and 1.2 % vents) + Corrugated Fiber Board box (CFB) (T_5)

6. Polyethylene bag (100 guage and 1.2 % vents) + Wooden box (T_6).

3.1.1.2 **Storage treatments**

The sapota fruits were stored at two different storage environments viz. at room temperature (RT) and in cool chamber (CC). The temperatures and relative humidities were recorded for the above mentioned storage conditions during the period of experiment.

a) **Storage of sapota fruits at room temperature (RT)**

Sapota fruits were stored at room temperature. They were divided into two sets, one for observations on weight loss and rotting during storage and the other for the physico-chemical analysis.

b) **Storage of sapota fruits in cool chamber (CC)**

Based on the principle of direct evaporative cooling, low cost, low energy input, cool chamber has been developed in the Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi. The details of the design, construction and storage methods are presented in Fig. 1. The structure is made out of cheap, locally available raw material such as bricks, sand, bamboo, vitiver grass (Khuskhus) and gunny bags, etc. with a source of

T-3118
MPKV
(Rahuri)

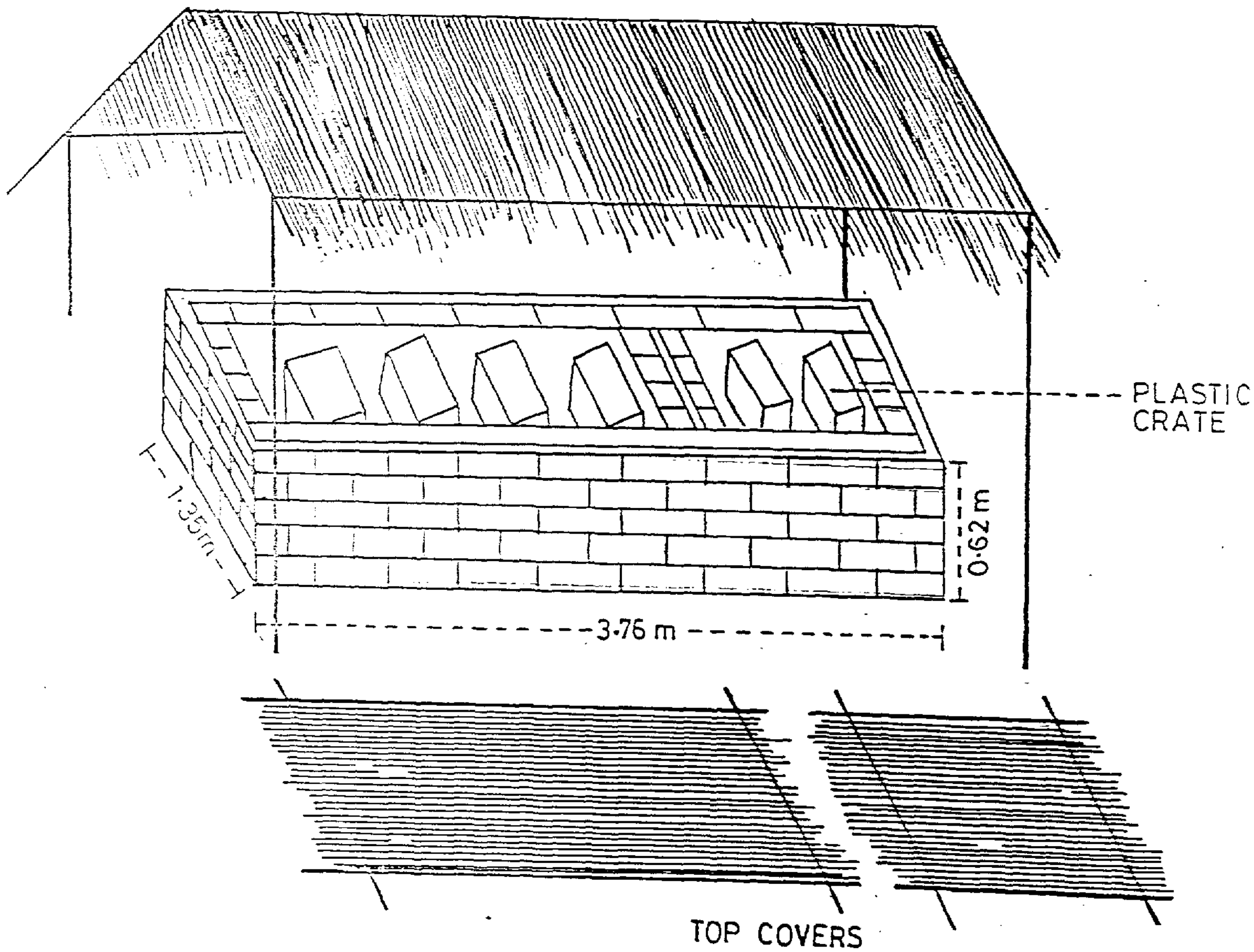

Fig. 1 Pictorial view of cool chamber

water supply. The floor of this storage place is made with single layer of bricks and the side walls with a double layer of bricks. The space between the double walled bricks (3") is filled up with riverbed sand. This is made under a temporary shed (thatch) made out of locally available bamboo and sirki. The design and the construction are made according to the method described by Anon. (1985). Once, the cool chamber is saturated with water, sprinkling of water once in the morning and once in the evening is enough to maintain the temperature and relative humidity.

The treated fruits were kept in the plastic crates. These plastic crates were kept in the cool chamber and covered with polyethylene sheets to prevent the water from dropping on material (Plate 1). The material was divided into different sets for various observations according to the method described earlier.

Table 1. Temperature (°C) and relative humidity (R.H. %) conditions in the storage environment of sapota fruits in March -1994.

Storage condition	Temperature range (°C)	R.H. range (%)
Room Temperature (RT)	31.67 to 36.85	22.57 to 34.97
Cool Chamber (CC)	20.24 to 21.57	91 to 95

Plate - 1 Storage of sapota fruits in cool chamber

3.2 Details of observations

The observations in respect of weight loss was recorded daily. The observations regarding other biochemical parameters were recorded initially and then at one day interval for fruits stored at room temperature and in cool chamber.

3.2.1 Physico-chemical analysis

3.2.1.1 Fruit softening

The progress of fruit ripening as denoted by fruit softening was observed manually by finger feel at one day interval. The intensity of softening was worked out on 0 to 4 scale as given below, as described by Kumbhar and Desai (1986).

Degree of softening	Score
Hard	0
Slightly soft	1
Medium	2
Considerable softening	3
Complete softening	4

At each observation, the stage of softening of each fruit under each treatment of packaging and storage was noted and the score was given. The scores obtained by all the fruits under a treatment were summed up and divided by the number of fruits to obtain the average softening score of that treatment on that day.

3.2.1.2 Fruit skin shrinkage

The progress of development of fruit skin shrinkage was observed visually at one day interval. The intensity of skin shrinkage was worked out on 0 to 4 scale as given below, as described by Desai and Kumbhar (1986).

Intensity of shrinkage	Score
No shrinkage	0
Slightly shrinkage	1
Medium shrinkage	2
Heavy shrinkage	3
Complete shrinkage	4

The average score for shrinkage ~~was~~ worked out for each treatment of packaging and storage as described earlier.

3.2.1.3 Total weight loss

The weight of fruits under each treatment was taken at an interval of one day. At each observation, the rotten fruit, if any, was removed and weighed. The weight loss was worked out and percentage of cumulative total weight loss both on account of physiological weight loss and rotting was recorded. Weight loss was expressed as percentage.

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

3.2.1.4 Rotting percentage

At each observation of weight loss the rotten fruit, if any, was removed and weighed. The percentage of weight loss on account of rotting was also calculated.

3.2.1.5 Total soluble solids (TSS)

Total soluble solids (%) were determined with the help of a hand refractometer and the values were corrected to 20^{o}C with the help of temperature correction chart (A.O.A.C, 1975)..

3.2.1.6 Total titrable acidity

Total titrable acidity (%) was determined by titrating of known quantity of macerated pulp diluted with distilled water against standard sodium hydroxide solution, using phenolphthalein indicator till pink colour observed. The percentage acidity was expressed in terms of malic acid. (A.O.A.C., 1975).

3.2.1.7 Sugars

.202

Determination of sugars was done by the volumetric method of Lane and Eynon (1923). The known quantity of freshly extracted pulp was taken in a conical flask and little water was added to it. The sample was stirred well and poured in to the volumetric flask. The conical flask was rinsed 2 to 3 times. To it, neutral lead acetate was added for clarification. The excess of lead acetate was precipitated with saturated potassium oxalate solution and the volume was made to 250 ml with distilled water. The mixture was stirred well, allowed to stand for some time and then filtered.

i. **Reducing sugar**

The clear filterate was titrated against 5 ml each of Felhing A and Felhing B solutions using methylene blue as an indictor, to brick red precipitate and the sugar content calculated on percentage basis was presented.

ii. **Total sugar**

Estimation of total sugars was carried out by taking 50 ml clear extract in 50-55 ml volumetric flask. To this, 5ml of concentrated hydrochloric acid was added and kept in hot water bath for half an hour for hydrolysis. After hydrolysis, excess of hydrochloric acid was neutralised with sodium carbonate. The mixture was transferred to 250 ml volumetric flask and volume was made upto the mark. It was titrated with 5ml each of Felhing A and Felhing B solutions using methylene blue as an indicator and percentage of total sugar was calculated.

3.2.2 Organoleptic evaluation

The organoleptic evaluation for assessing the colour, flavour and texture at edible ripe stage of sapota fruit was done by a panel of seven judges using a nine points Hedonic scale (Amerine et al., 1965) as given below.

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

The overall rating was calculated by averaging the score. Sample which obtained a score of 5.5 and above were considered as acceptable. Storage life of fruit obtaining the score less than 5.5 was terminated.

3.2.3 Pathological studies

The fruits were observed daily for microbial infection. The infected material was isolated, cultured and organisms associated were identified.

3.3 Statistical analysis

Analysis of variance for all the characters except organoleptic evaluation was done as per the method of analysis of variance given by Gomez and Gomez (1984).

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The present investigation was undertaken with a view to study the effect of different packaging materials and storage environments on the shelf life and the changes in physico-chemical characteristics of sapota fruit (cv. Kalipatti) during storage.

The periodical observations of physico-chemical parameters were recorded. Data pertaining to total soluble solids (TSS %), acidity (%), sugars (%), skin shrinkage, fruit softening, total weight loss (%), weight loss due to rotting (%), organoleptic evaluation of sapota fruits as influenced by various packaging materials and storage environments are presented hereunder.

4.1 Effect of various packaging materials on the changes in total soluble solids (per cent) of sapota fruit at RT and in CC

The data on the effect of various packaging materials on the changes in TSS content of sapota fruit at RT and in CC have been given in Table 2 and 3.

It was obvious from the statistical analysis that with the advancement of storage period, there was a significant increase in TSS content of sapota fruit till it reached the peak, followed by a gradual decline irrespective of both : packaging materials and storage conditions. It was

T-3118

Table 2. Effect of various packaging materials on the changes in TSS (%) content of sapota fruit at RT and in CC.

Treatment	Day after storage											
	3rd			5th			7th			9th		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Initial value	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13
T_1	19.53	18.87	19.20	23.47	21.20	22.33	21.67	22.80	22.23	18.00	24.33	21.17
T_2	18.27	18.07	18.17	20.27	19.53	19.90	22.73	20.07	21.40	24.27	21.73	23.00
T_3	18.53	18.43	18.48	21.00	20.53	20.77	22.40	21.53	21.97	19.27	22.73	21.00
T_4	18.73	18.70	18.72	20.73	20.40	20.57	22.13	21.40	21.77	18.67	22.87	20.77
T_5	18.33	18.13	18.23	20.43	20.07	20.25	23.53	21.33	22.43	21.13	22.00	21.57
T_6	18.47	18.40	18.43	21.03	20.40	20.72	23.13	21.13	22.13	20.73	22.07	21.40
Mean	18.64	18.43		21.16	20.36		22.60	21.38		20.34	22.62	

	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%
Packaging	0.025	0.072	0.052	0.152	0.024	0.069	0.025	0.073
Storage	0.043	0.125	0.090	0.263	0.041	0.120	0.043	0.126
Packaging x storage	0.061	0.177	0.128	0.372	0.058	0.169	0.061	0.178

Table 3. Effect of various packaging materials on the changes in TSS (%) content of sapota fruit in CC.

Treatment	Day after storage		
	11^{th}	13^{th}	15^{th}
Initial value	18.13	18.13	18.13
T_1	21.33	19.87	18.53
T_2	22.08	23.13	24.17
T_3	23.87	21.07	20.33
T_4	24.67	20.53	19.27
T_5	23.20	24.23	21.60
T_6	23.43	24.07	21.20
S.E. $\pm$	0.058	0.846	0.054
C.D. at 5%	0.168	2.608	0.168

also clear from data that the storage conditions such as RT and CC had a significant effect on the TSS content of sapota fruit. The rise in TSS content of sapota fruit was at slower rate in CC storage as compared to RT stored fruit. Similarly, interaction of the packaging material and storage condition was also found to be significant.

At the beginning of the storage, the TSS content of sapota fruit was 18.13 per cent. On 3rd day of storage at RT, the TSS content was the highest (19.53 per cent) in control fruit (T_1) while the lowest (18.27 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_3, T_5 and T_6 had significantly low TSS as compared to T_4. However, the values of TSS of sapota fruit were significantly lower in CC that of RT storage. In CC storage, the TSS content was the highest (18.87 per cent) in control fruit (T_1) while the lowest (18.07 per cent) in the fruit packed in ventilated polyethylene bag (T_2). Treatments T_3, T_5 and T_6 showed significantly low TSS as compared to T_4.

On 5th day of storage at RT, the TSS content was the highest (23.47 per cent) in control fruit (T_1) and the lowest (20.27 per cent) in the fruit packed in ventilated polyethylene bag (T_2). All other treatments showed significantly low TSS values. The values for TSS content of sapota fruit were significantly low in CC storage as compared to that of RT ones. The TSS content was the highest (21.20 per cent) in control fruit (T_1) and the lowest (19.53 per cent) in fruit packed in ventilated polyethylene bag (T_2) and stored in cool chamber (CC). Treatment T_5 had significantly low TSS as compared to T_3, T_4 and T_6.

It was clear that after the storage period of 7 days at RT, the TSS content was the highest (23.53 per cent) in fruit packed in ventilated polyethylene bag + CFB box (T_5) and the lowest (21.67 per cent) in control fruit (T_1). Treatments T_2, T_3 and T_4 showed significantly low TSS as compared to treatment T_6. However, the values of TSS content of sapota fruit were the highest (22.80 per cent) in control fruit (T_1) and the lowest (20.07 per cent) in fruit packed in ventilated polyethylene bag (T_2) and stored in CC. Treatments T_5 and T_6 had significantly low TSS as compared to treatments T_3 and T_4.

At the end of 9^{th} day of storage period at RT, the values of TSS content of sapota fruit were 24.27, 21.13, 20.73, 19.27, 18.67 and 18.00 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively. However, in CC storage, the values of TSS content of sapota fruit were the highest (24.23 per cent) in control fruit (T_1) and the lowest (21.73 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_5 and T_6 had significantly low TSS as compared to T_3 and T_4.

At the end of storage life of 9 days at RT conditions, sapota fruits in most of the packaging treatments had lost its shelf life. Therefore, the storage experiment at RT condition was terminated for physico-chemical analysis. It was interesting to note that in CC storage, the fruits were found to be still in good condition. Hence further observations of TSS content of sapota fruit on 11,13 and 15^{th} day were recorded for CC storage only.

At the end of 11^{th} day of storage in cool chamber, the values for TSS content of sapota fruit were 24.67, 23.87, 23.43, 23.20, 22.08 and 21.33 per cents for T_4, T_3, T_6, T_5, T_2 and T_1, respectively while on 13^{th} day of storage the values were 24.23, 24.07, 23.13, 21.07, 20.53 and 19.87 per cents for T_5, T_6, T_2, T_3, T_4 and T_1, respectively. At the of 15 days of storage period in CC storage, the values of TSS content of sapota fruit were 24.17, 21.60, 21.20, 20.33, 19.27 and 18.53 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively. At the end of storage period of 15^{th} day fruit packed in ventilated polyethylene bag (T_2) showed the highest TSS content.

4.2 Effect of various packaging materials on the changes in acidity (per cent) of sapota fruit at RT and in CC

The data on the effect of various packaging materials on the changes in acidity of sapota fruit at RT and in CC have been given in Table 4 and 5. It was obvious from

Table 4. Effect of various packaging materials on the changes in acidity (%) of sapota fruit at RT and in CC.

Treatment	Day after storage											
	3^{rd}			5^{th}			7^{th}			9^{th}		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Initial value	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
T_1	0.14	0.21	0.17	0.06	0.16	0.11	0.05	0.09	0.07	0.03	0.05	0.04
T_2	0.26	0.26	0.26	0.20	0.22	0.21	0.14	0.18	0.16	0.08	0.14	0.11
T_3	0.18	0.22	0.20	0.09	0.18	0.13	0.06	0.14	0.10	0.05	0.10	0.07
T_4	0.17	0.22	0.19	0.08	0.17	0.12	0.05	0.11	0.08	0.04	0.08	0.06
T_5	0.23	0.25	0.24	0.17	0.19	0.18	0.09	0.16	0.13	0.07	0.12	0.10
T_6	0.21	0.24	0.23	0.17	0.18	0.17	0.08	0.14	0.11	0.05	0.11	0.08
Mean	0.20	0.24		0.13	0.18		0.08	0.14		0.06	0.10	

	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%
Packaging	0.004	0.011	0.002	0.005	0.001	0.003	0.001	0.003
Storage	0.007	0.020	0.003	0.008	0.002	0.005	0.002	0.005
Packaging x storage	0.010	0.028	0.004	0.011	0.003	0.007	0.002	0.007

Table 5. Effect of various packaging materials on the changes in acidity (%) of sapota fruit in CC.

Treatment	Day after storage		
	11^{th}	13^{th}	15^{th}
Initial value	0.27	0.27	0.27
T_1	0.04	0.03	0.02
T_2	0.11	0.08	0.05
T_3	0.05	0.04	0.03
T_4	0.05	0.03	0.02
T_5	0.09	0.05	0.04
T_6	0.07	0.05	0.03
S.E. $\pm$	0.001	0.001	0.001
C.D. at 5%	0.004	0.004	0.004

the data that the acidity was the highest at the time of storage and decreased with advancement of storage period irrespective of both packaging materials and storage conditions. The decrease in acidity was significantly influenced by the packaging treatment and also by the storage condition. The interaction between packaging material and storage condition was also significant.

Initially, acidity of sapota fruit was 0.27 per cent. At the end of 3rd day of storage period at RT, the acidity was the highest (0.26 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.14 per cent) in control fruit (T_1). Treatments T_3 and T_4 had significantly low acidity as compared to treatments T_5 and T_6. While, in CC storage, the acidity was the highest (0.26 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.21 per cent) in control fruit (T_1). Treatments T_3, T_4 and T_6 showed significantly low acidity as compared to treatment T_5.

After the 5th day of storage period at RT, the acidity was the highest (0.20 per cent) in fruit packed in ventilated polyethylene bag (T_2) while the lowest (0.06 per cent) in control fruit (T_1). Treatments T_3 and T_4 had significantly low acidity than treatments T_5 and T_6. The values for acidity of sapota fruit were significantly low in CC storage as compared to RT storage. The acidity in CC storage was the highest (0.22 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.16 per cent) in control fruit (T_1). The treatments T_3, T_4 and T_6 showed significantly low acidity as compared to treatment T_5.

On 7[th] day of storage period at RT, the acidity was the highest (0.14 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.05 per cent) in control fruit (T_1) and in fruit packed in wooden box (T_4). Treatment T_3 had significantly low acidity as compared to treatments T_5 and T_6. However, the values of acidity were the highest (0.18 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.09 per cent) in control fruit (T_1) stored in CC. Treatment T_4 showed significantly low acidity as compared to that of T_3, T_5 and T_6.

At the end of 9th day of storage period at RT, the values of acidity of sapota fruit were 0.08, 0.07, 0.05, 0.05, 0.04 and 0.03 per cents for the treatments T_2, T_5, T_6, T_3, T_4 and T_1, respectively. However, in CC storage, the values of acidity of sapota fruit were the highest (0.14 per cent) in fruit packed in ventilated polyethylene bag (T_2) and the lowest (0.05 per cent) in control fruit (T_1). Treatments T_3 and T_4 had significantly low acidity than treatments T_5 and T_6.

At the end of storage life of 9 days at RT storage condition, fruits in most of the packaging treatments had lost its shelf-life. But the fruits stored in cool chamber were found to be in good condition. Therefore, the observations for acidity (%) of sapota fruit on 11, 13 and 15th day were recorded for CC storage only.

At the end of 11th day of storage in cool chamber, the values for acidity of sapota fruit were 0.11, 0.09, 0.07, 0.05, 0.05 and 0.04 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively. After 13th day of storage period in CC storage, the values were 0.08, 0.05, 0.05, 0.04, 0.03 and 0.03 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively. At the end of 15th days of storage period, the values of acidity of sapota fruit were 0.05, 0.04, 0.03, 0.03, 0.02 and 0.02 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively. The fruits packed in ventilated polyethylene bag (T_2) had the highest acidity.

4.3 Effect of various packaging materials on the changes in reducing sugar (per cent) content of sapota fruit at RT and in CC

The data on the effect of various packaging materials on the changes in reducing sugar content of sapota fruit at RT and in CC have been given in Table 6 and 7. Statistical analysis revealed that with the advancement of storage period, there was significant increase in reducing

Table 6. Effect of various packaging materials on the changes in reducing sugar (%) content of sapota fruit at RT and in CC.

Treatment	Day after storage						Day after storage					
	3^{rd}			5^{th}			7^{th}			9^{th}		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Initial value	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
T_1	4.95	4.39	4.67	7.88	6.39	7.14	6.19	7.61	6.90	5.81	8.31	7.06
T_2	4.02	4.01	4.01	5.81	4.62	5.21	6.94	5.31	6.12	8.08	6.03	7.06
T_3	4.56	4.23	4.40	7.07	5.18	6.13	7.94	5.77	6.86	6.67	6.90	6.79
T_4	4.91	4.33	4.62	7.23	5.44	6.33	7.50	6.25	6.87	6.48	7.53	7.00
T_5	4.24	4.06	4.15	6.73	4.79	5.76	8.37	5.40	6.89	7.71	6.54	7.12
T_6	4.29	4.13	4.21	6.83	4.81	5.82	8.46	5.67	7.06	7.59	6.59	7.09
Mean	4.49	4.19		6.93	5.21		7.56	6.00		7.05	6.98	

	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%
Packaging	0.013	0.037	0.013	0.038	0.022	0.065	0.022	0.064
Storage	0.022	0.064	0.023	0.066	0.038	0.112	0.038	0.110
Packaging x storage	0.031	0.090	0.032	0.094	0.054	0.158	0.054	0.156

Table 7. Effect of various packaging materials on the changes in reducing sugar (%) content of sapota fruit in CC.

Treatment	Day after storage		
	11^{th}	13^{th}	15^{th}
Initial value	3.85	3.85	3.85
T_1	7.15	6.27	5.52
T_2	6.85	7.38	8.08
T_3	7.96	7.32	6.70
T_4	8.04	7.02	6.61
T_5	7.25	8.44	7.61
T_6	7.42	8.23	7.37
S.E. $\pm$	0.064	0.104	0.028
C.D. at 5%	0.187	0.321	0.085

sugar content of sapota fruit till it reached the peak, followed by a gradual decline irrespective of the packaging treatments and storage conditions. The data further revealed that the storage conditions such as RT and CC had a significant effect on the reducing sugar content of sapota fruit during storage. Similarly, there was a significant difference in the reducing sugar content of sapota fruit due to interaction between packaging material and storage condition.

At the beginning of storage, the reducing sugar content of sapota fruit was 3.85 per cent. On 3rd of storage period at RT, the reducing sugar content was the highest (4.95 per cent) in control fruit (T_1) while the lowest (4.02 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_5 and T_6 showed significantly low reducing sugar content as compared to T_3 and T_4. In CC storage, the reducing sugar content was the highest (4.39 per cent) in control fruit (T_1) and the lowest (4.01 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_5 and T_6 had significantly lower reducing sugar content than that of T_3 and T_4.

On the 5th day of storage period at RT, the reducing sugar content was the highest (7.88 per cent) in control fruit (T_1) and the lowest (5.81 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_5 and

T_6 showed significantly low reducing sugar content as compared to that of T_3 and T_4. The values for reducing sugar content of sapota fruit were significantly low in CC storage. The reducing sugar content in CC storage was the highest (6.39 per cent) in control fruit (T_1) and the lowest (4.62 per cent) in fruit packed in ventilated polyethylene bag (T_2). The treatments T_3, T_5, and T_6 showed significantly low reducing sugar content as compared to treatment T_4.

It was clear that after 7^{th} day of storage period at RT, the reducing sugar content was the highest (8.46 per cent) in fruit packed in ventilated polyethylene bag + wooden box (T_6) and the lowest (6.19 per cent) in control fruit (T_1). Treatment T_2 had comparatively low reducing sugar content than the remaining treatments. However, the values of reducing sugars were the highest (7.61 per cent) in control fruit (T_1) and the lowest (5.31 per cent) in fruit packed in ventilated polyethylene bag (T_2) and stored in CC. Treatments T_3, T_5 and T_6 had significantly lower reducing sugar content as compared to that of T_4.

At the end of 9^{th} day of storage period at RT, the values of reducing sugar content of sapota fruit were 8.08, 7.71, 7.59, 6.67, 6.48 and 5.81 per cents for the treatments T_2, T_5, T_6, T_3, T_4, and T_1, respectively. However, in CC storage, the values of reducing sugar of sapota fruit were the highest (8.31 per cent) in control fruit (T_1) and the lowest (6.03 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatments T_3, T_5 and T_6 had significantly low reducing sugars as compared to treatment T_4.

At the end of storage life of 9 days at RT, the sapota fruits had lost its shelf-life. However, the fruits stored in cool chamber were found to be still in good condition. Therefore, the observation for reducing sugar content of sapota fruit on 11, 13 and 15th day were recorded for CC storage only.

In CC storage, after the 11th day of storage period, the values for reducing sugar content of sapota fruit were 8.04, 7.96, 7.42, 7.25, 7.15 and 6.85 per cents for T_4, T_3, T_6, T_5, T_1 and T_2, respectively. However, on 13th day of storage period, the values were 8.44, 8.23, 7.38, 7.32, 7.02 and 6.27 per cents for T_5, T_6, T_2, T_3, T_4 and T_1, respectively. At the end of 15th day of storage period, the values of reducing sugars were 8.08, 7.61, 7.37, 6.70, 6.61 and 5.52 per cents for T_2, T_5, T_6, T_3, T_4 and T_1 , respectively.

4.4 Effect of various packaging materials on the changes in total sugar (per cent) content of sapota fruit at RT and in CC

The data on the effect of various packaging materials on the changes in total sugar content of sapota fruit at RT and in CC have been shown in Table 8 and 9. The data clearly indicated that the packaging treatments significantly influenced the rise and corresponding fall in total sugar content of fruits. The storage conditions also had a significant effect on total sugar content of sapota fruit. The interaction between packaging tretament and storage condition was also found to be significant. It was also noticed from the data that, fruits experienced the rise in total sugar content till it reached the peak, followed by a gradual decline irrespective of packaging treatments and storage conditions.

Initially, the total sugar content of sapota fruit was found to be 8.14 per cent. On 3^{rd} day of storage at RT, the total sugar content of sapota fruit was the highest (10.42 per cent) in control fruit (T_1) and the lowest (9.26 per cent) in fruit packed in ventilated polyethylene bag (T_2). Treatment T_5 had significantly low total sugars as compared to treatments T_3, T_4 and T_6. In CC storage, the total sugar content was the highest (9.96 per cent) in control fruit (T_1),

Table 8. Effect of various packaging materials on the changes in total sugar (%) content of sapota fruit at RT and in CC.

Treatment	Day after storage											
	3^{rd}			5^{th}			7^{th}			9^{th}		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Initial value	8.14	8.14	8.14	8.14	8.14	8.14	8.14	8.14	8.14	8.14	8.14	8.14
T_1	10.42	9.96	10.19	14.51	11.39	12.95	13.06	12.97	13.01	11.18	14.67	12.93
T_2	9.26	8.47	8.86	11.59	9.25	10.42	13.13	10.35	11.74	15.19	11.77	13.48
T_3	10.15	9.05	9.60	12.80	10.11	11.45	13.82	11.82	12.82	12.10	13.34	12.72
T_4	10.18	9.10	9.64	12.81	10.17	11.49	13.56	11.96	12.76	12.09	13.48	12.79
T_5	9.99	8.69	9.34	12.27	9.70	10.99	14.97	10.74	12.82	13.45	12.73	13.09
T_6	10.10	8.78	9.43	12.35	9.88	11.12	15.01	11.03	13.01	13.42	12.69	13.06
Mean	10.01	9.00		12.72	10.08		13.92	11.48		12.91	13.11	

	S.E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%
Packaging	0.029	0.084	0.028	0.082	0.021	0.060	0.026	0.074
Storage	0.050	0.146	0.049	0.142	0.036	0.104	0.044	0.129
Packaging x storage	0.071	0.206	0.069	0.201	0.051	0.147	0.063	0.182

Table 9. Effect of various packaging materials on the changes in total sugar (%) of sapota fruit in CC.

Treatment	Day after storage		
	11^{th}	13^{th}	15^{th}
Initial value	8.14	8.14	8.14
T_1	13.05	11.13	9.31
T_2	12.46	13.72	15.20
T_3	14.35	12.15	10.97
T_4	14.53	12.08	10.55
T_5	13.34	15.26	13.52
T_6	13.87	15.15	13.42
S.E. $\pm$	0.076	0.043	0.097
C.D. at 5%	0.220	0.133	0.298

while the lowest (8.47 per cent) in fruit packed in ventilated polyethylene bag (T_2). The teratment T_5 showed significantly lower total sugar content than remaining treatments.

After 5^{th} day of storage period at RT, the total sugar content of sapota fruit was found to be the highest (14.51 per cent) in control fruit (T_1) and the lowest (11.59 per cent) in fruit packed in ventilated polyethylene bag (T_2). However, the difference in total sugar content of sapota fruit of remaining treatments was found to be negligible. The values of total sugar content of sapota fruit were significantly low in CC storage. The total sugar content in CC storage was the highest (11.39 per cent) in control fruit (T_1) and the lowest (9.25 per cent) in fruit packed in ventilated polyethylene bag (T_2). The treatment T_5 had lower total sugar content than the remaining treatments.

On 7^{th} day of storage period at RT, the total sugar content was the highest (15.01 per cent) in fruit packed in ventilated polyethylene bag + wooden box (T_6), while the lowest (13.06 per cent) in control fruit (T_1). Treatment T_2 showed significantly low total sugars as compared to remaining ones. However, the values of total sugars were the highest (12.97 per cent) in control fruit (T_1) and the lowest (10.35 per cent) in fruit packed in ventilated polyethylene bag (T_2) and stored in cool chamber. The treatment T_5 had significantly lower total sugars than remaining treatments.

At the end of 9^{th} day of storage period at RT, the values of total sugar content of sapota fruit were 15.19, 13.45, 13.42, 12.10, 12.09 and 11.18 per cents for the treatments T_2, T_5, T_6, T_3, T_4 and T_1, respectively. However, in CC storage, the values of total sugars of sapota fruit were the highest (14.67 per cent) in control fruit (T_1) and the lowest (11.77 per cent) in fruit packed in ventilated polyethylene bag (T_2). The treatment T_6 had significantly low total sugars as compared to remaining ones.

At the end of storage life of 9 days at RT, the fruits in most of the packaging treatments had lost its shelf-life. But the fruits stored in cool chamber were found to be still in good condition. Therefore, the observations for total sugar content of sapota fruit on 11, 13 and 15^{th} day of storage were recorded for CC storage only.

On 11^{th} day of storage period, in CC storage, the values for total sugar content of sapota fruit were 14.53, 14.35, 13.87, 13.34, 13.05 and 12.46 per cents for T_4, T_3, T_6, T_5, T_1 and T_2 , respectively. However, after 13^{th} day of storage period, the values were 15.26, 15.15, 13.72, 12.15, 12.08 and 11.13 per cents for T_5, T_6, T_2, T_3, T_4 and T_1, respectively. At the end of 15^{th} day of storage period, the values of total sugars were 15.20, 13.52, 13.42, 10.97, 10.55 and 9.31 per cents for T_2, T_5, T_6, T_3, T_4 and T_1, respectively.

4.5 Effect of various packaging materials on the changes in softening of sapota fruit at RT and in CC

The data in respect of the effect of various packaging materials on the progress of softening of sapota fruit at RT and in CC have been given in Table 10 and 11. The data presented in the tables revealed that the packaging treatments significantly influenced the progress of fruit softening. The storage conditions also had a significant effect on fruit softening. The interaction between packaging treatments and storage conditions was also found to be significant. The progress of fruit softening was at a faster rate in fruits stored at RT than in CC. At all the stages (days) of storage, fruit softening score was constantly high in RT stored fruits as against the CC ones.

On 3^{rd} day of storage at RT, the fruit softening score was the highest (1.97) in control fruit (T_1) and the lowest (0.26) in fruit packed in ventilated polyethylene bag (T_2). Treatment T_6 had significantly low score of fruit softening as compared to remaining treatments. In CC storage, the values for sapota fruit softening were found to be 0.61, 0.30 and 0.19 for T_1, T_4 and T_3, respectively. The score of fruit softening was nil in other treatments viz. T_2, T_5 and T_6, which showed that there was no sign of softening in these treatments.

Table 10. Effect of various packaging materials on the changes in softening ofsapota fruit at RT and in CC.

Treatment	Day after storage								
	3^{rd}			5^{th}			7^{th}		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Initial value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	1.97	0.61	1.29	4.00	1.92	2.96	4.00	3.04	3.52
T_2	0.26	0.00	0.13	1.47	0.00	0.74	2.92	0.92	1.92
T_3	1.64	0.19	0.92	3.40	1.03	2.22	4.00	2.11	3.05
T_4	1.83	0.30	1.06	3.79	1.39	2.59	4.00	2.24	3.12
T_5	0.94	0.00	0.47	2.88	0.11	1.49	3.54	1.13	2.34
T_6	0.86	0.00	0.43	3.04	0.16	1.60	3.87	1.29	2.58
Mean	1.25	0.18		3.10	0.77		3.72	1.79	

	S.E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%
Packaging	0.329	0.958	0.407	1.186	0.388	1.131
Storage	0.569	1.659	0.705	2.054	0.672	1.958
Packaging x Storage	0.805	2.346	0.997	2.904	0.951	2.769

Table 11. Effect of various packaging materials on the changes in softening of sapota fruit in CC.

Treatment	Day after storage		
	9^{th}	11^{th}	13^{th}
Initial value	0.00	0.00	0.00
T_1	4.00	4.00	4.00
T_2	1.66	2.42	3.50
T_3	3.04	4.00	4.00
T_4	3.73	4.00	4.00
T_5	2.06	3.01	3.91
T_6	2.18	3.33	4.00
S.E. $\pm$	0.900	0.481	0.688
C.D. at 5%	2.776	1.482	2.120

T-3118

On 5th day of storage period at RT, the fruit softening score was the highest (4.00) in control fruit (T_1) and the lowest (1.47) in fruit packed in ventilated polyethylene bag (T_2). Treatment T_5 had significantly low fruit softening score as compared to remaining treatments. The values for softening of sapota fruit were significantly low in CC storage. The softening score in CC storage was the highest (1.92) in control fruit (T_1) and the lowest (0.00) in fruit packed in ventilated polethylene bag (T_2). Treatment T_5 had significantly lower fruit softening score than remaining ones.

At the end of 7th day of storage period at RT, the values for fruit softening score were found to be 3.87, 3.54 and 2.92 for treatments T_6, T_5 and T_2, respectively. Complete fruit softening (score : 4.00) was observed in treatments T_1, T_3 and T_4, . In CC storage condition, the highest fruit softening score was (3.04) in control fruit (T_1) and the lowest (0.92) in fruit packed in ventilated polyethylene bag (T_2). Treatment T_5 had significantly low fruit softening score as compared to other treatments.

At the end of the storage period of 9 days at RT, the fruits in most of the packaging treatments showed complete fruit softening. It was interesting to note that the fruits stored in cool chamber were found to be hard. Therefore, the observations for fruit softening on 9th, 11th and 13th day of storge were recorded for CC storage only.

It was clear that on 9^{th} day of storage period, in CC, the values for softening of sapota fruit were 4.00, 3.73, 3.04, 2.18, 2.06 and 1.66 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively. However, after 11^{th} day of storage period the values for fruit softening were 3.33, 3.01 and 2.42 for T_6, T_5 and T_2, respectively. Complete softening (score : 4.00) was observed in treatments T_1, T_3 and T_4. At the end of 13^{th} day of storage period, the values for fruit softening were found to be 3.91 and 3.50 for T_5 and T_2, respectively. Sapota fruits in other treatments viz. T_1, T_3, T_4 and T_6 had shown complete softening (score : 4.00).

4.6 Effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT and in CC

The data on the effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT and in CC have been given in Table 12,13 and 14. Statistical analysis revealed that with the advancement of storage period, there was significant increase in skin shrinkage of sapota fruit irrespective of the packaging materials and storage conditions. The data further revealed that the storage conditions such as RT and CC had significant effect on the progress of fruit skin shrinkage druing storage. Similarly, there was a significant difference in skin

Table 12. Effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT.

Treatment	Day after storage		
	1^{st}	3^{rd}	5^{th}
Initial value	0.00	0.00	0.00
T_1	0.25	1.16	3.75
T_2	0.00	0.09	0.48
T_3	0.07	0.72	1.88
T_4	0.09	0.99	1.98
T_5	0.00	0.28	1.12
T_6	0.00	0.60	1.61
S.E. $\pm$	0.111	0.089	0.536
C.D. at 5%	0.341	0.274	1.653

Table 13. Effect of various packaging materials on the changes in skin shrinkage of sapota fruit at RT and in CC.

Treatment	Day after storage	$(7^{th}$ day) 9^{th}	
	RT	CC	Mean
Initial value	0.00	0.00	0.00
T_1	4.00	0.51	2.26
T_2	0.75	0.00	0.38
T_3	3.54	0.13	1.84
T_4	4.00	0.15	2.08
T_5	2.85	0.09	1.47
T_6	3.39	0.12	1.76
Mean	3.09	0.17	

	S.E. $\pm$	C.D. at 5%
Packaging	0.919	2.679
Storage	1.593	4.639
Packaging x Storage	2.252	6.561

Table 14. Effect of various packaging materials on the changes in skin shrinkage of sapota fruit in CC.

Treatment	Day after storage		
	9^{th} 11	11^{th} 13	13^{th} 15
Initial value	0.00	0.00	0.00
T_1	1.54	3.34	4.00
T_2	0.24	1.03	2.29
T_3	0.72	2.04	3.87
T_4	0.93	2.22	3.90
T_5	0.47	1.61	2.83
T_6	0.52	1.80	2.92
S.E. $\pm$	1.638	0.844	1.078
C.D. at 5%	5.051	2.601	3.324

shrinkage of sapota fruit due to interaction between packaging material and storage condition. The fruits stored at RT showed faster skin shrinkage than CC stored ones.

Under CC storage condition, the fruits did not show skin shrinkage upto 5^{th} day of storage, while progress of skin shrinkage was at a faster rate in fruits stored at RT. Hence, the observations for skin shrinkage of sapota fruit on 1^{st}, 3^{rd} and 5^{th} day were recorded for RT storage only.

At RT storage condition, after one day of storage period, the fruit skin shrinkage score was 0.25, 0.09 and 0.08 for treatments T_1, T_4 and T_3, respectively. However, there was no sign of skin shrinkage in treatments T_2, T_5 and T_6. On 3^{rd} day of storage period, the score of fruit skin shrinkage was 1.16, 0.99, 0.72, 0.30, 0.28 and 0.10 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively. At the end of 5^{th} day of storage period, the fruit skin shrinkage score was 3.75, 1.98, 1.88, 1.61, 1.12 and 0.48 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively.

At the end of storage period of 7 days at RT, the fruit skin shrinkage score was the highest (4.00) in control fruit (T_1) and fruit packed in wooden box (T_4) and the lowest (0.75) in fruit packed in ventilated polyethylene bag (T_2). Treatment T_5 had significantly low fruit skin shrinkage score as compared to T_3 and T_6. On the contrary at the end of 7^{th}

day of storage period, the fruit skin shrinkage score was the highest (0.51) in control (T_1) and the lowest (0.00) in fruit packed in ventilated polyethylene bag (T_2) and stored in CC. Treatment T_5 had sigificantly lower fruit skin shrinkage score than that of remaining treatments.

The fruit showed skin shrinkage irrespective of packaging materials at the end of storage period of 9 days at RT, thereafter the observations were not taken for this parameter. It was interesting to note that the fruits stored in cool chamber were found to be in good condition throughout the storage period. Therefore, the observations for skin shrinkage of sapota fruit on 9, 11 and 13th day were recorded for CC storage only.

In CC storage, after 9th day of storage period, the score for skin shrinkage of sapota fruit was 1.54, 0.93, 0.72, 0.51, 0.47 and 0.24 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively. However, on 11th day of storage period the score was 3.34, 2.22, 2.04, 1.80, 1.61 and 1.03 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively. At the end of 13th day of storage period, the score of fruit skin shrinkage was 4.00, 3.90, 3.87, 2.92, 2.83 and 2.29 for T_1, T_4, T_3, T_6, T_5 and T_2, respectively.

4.7 Effect of various packaging materials on cumulative total weight loss (per cent) of sapota fruit at RT and in CC

The data on effect of various packaging materials on the changes in total weight loss (per cent) of sapota fruit at RT and in CC have been graphically depicted in Fig. 2 and 3, respectively and in Appendix I to III.

It was clear from the figures that with the advancement of storage period, the per cent total weight loss of sapota fruit increased during storage regardless of packaging treatments and storage conditions. It was also clear from the figures that packaging treatments and storage conditions both had significant effect on per cent total weight loss of sapota fruit throughout the storage period. But the rate of weight loss of sapota fruit was found to be faster at RT than CC storage condition. The interaction between packaging treatment and storage condition was also found to affect significantly the per cent total weight loss of sapota fruit.

The persual of the data further indicated that at RT storage, cumulative total weight loss increased relatively slowly in fruits packed in ventilated polyethylene bag (T_2) than the remaining treatments. The similar trend was also observed in sapota fruits stored in cool chamber. The highest

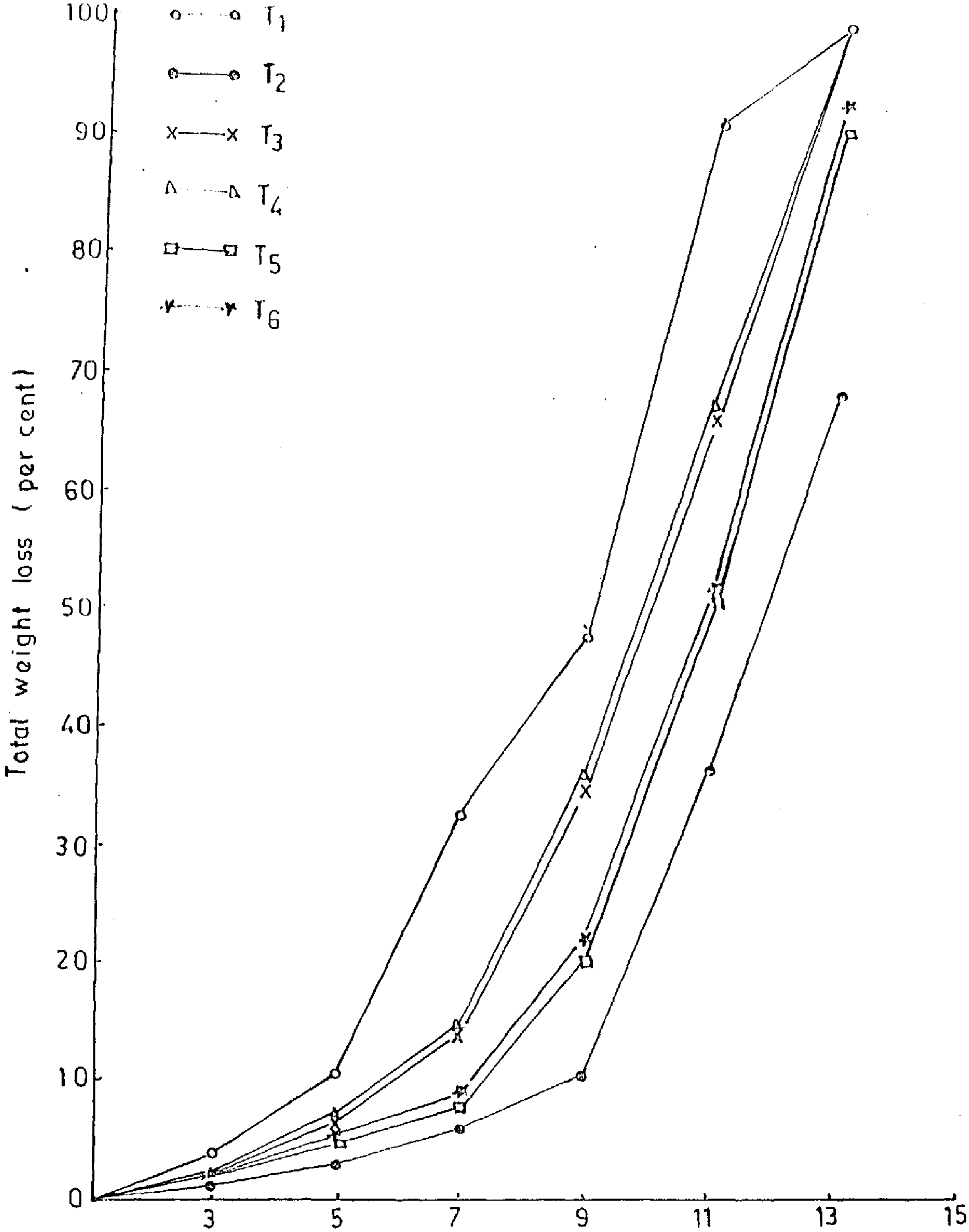

Fig. 2 Effect of various packaging materials on cumulative total weight loss (per cent) of sapota fruit at RT.

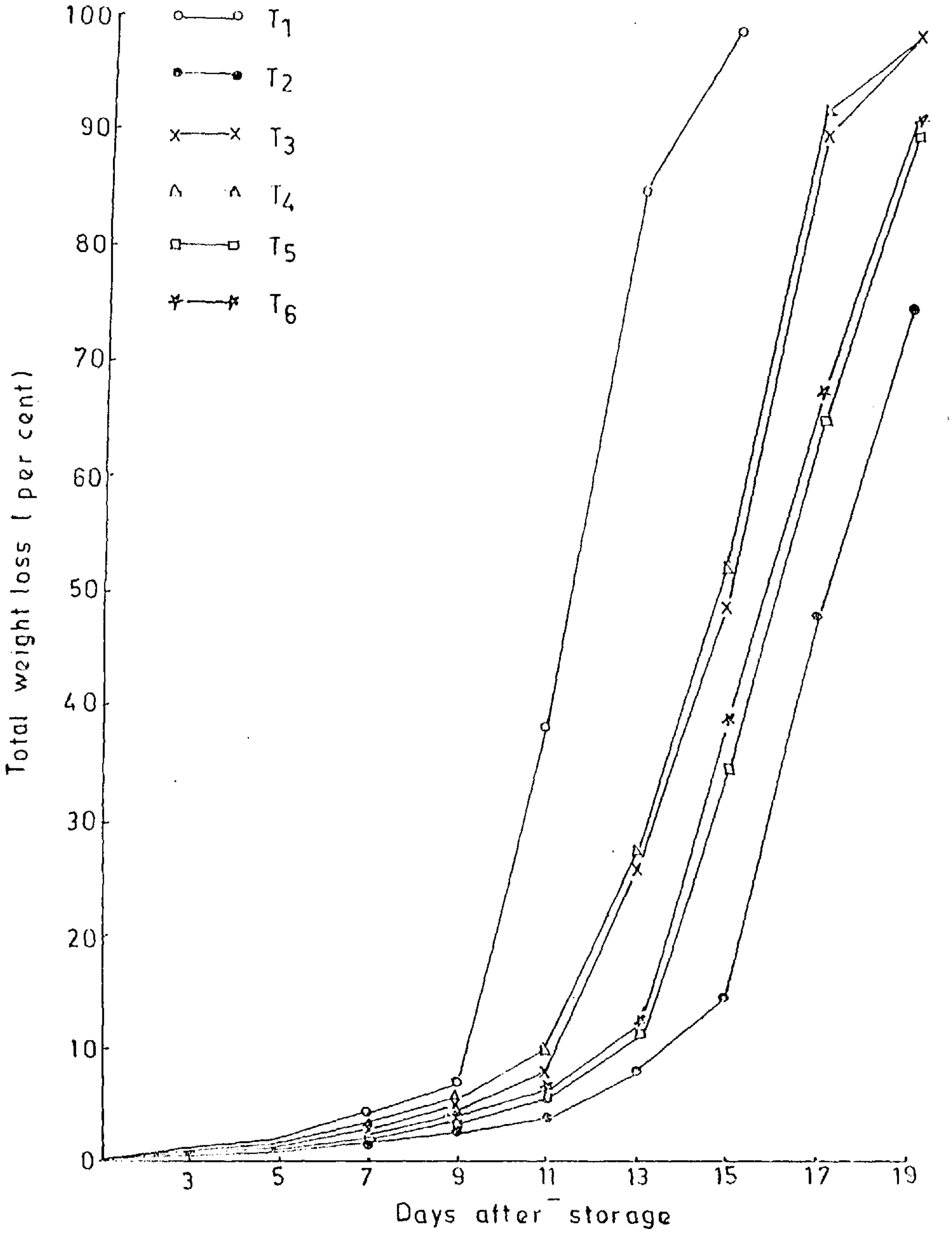

Fig. 3 Effect of various packaging materials on cumulative total weight loss (per cent) of sapota fruit in CC.

weight loss was observed in control fruit (T_1). It could be seen from the data that sapota fruits packed in polyethylene bag + CFB box (T_5) and polyethylene bag + wooden box (T_6) proved to be superior to exclusively CFB box (T_3) and wooden box (T_4) packagings under both the storage environments.

4.8 **Effect of various packaging materials on cumulative rotting (per cent) of sapota fruit at RT and in CC**

The data on the effect of various packaging materials on cumulative rotting (per cent) of sapota fruit at RT and in CC have been graphically represented in Fig. 4 and 5, respectively and in Appendix IV to VI. The figures clearly indicated that the packaging treatments significantly influenced the rotting of sapota fruit. The storage conditions also had a significant effect on rotting of sapota fruits. The interaction between packaging treatment and storage condition was also found to be significant.

It was obvious from the Fig. 4 that upto 6th day, no rotting was observed in sapota fruit in any of the packaging treatment at RT storage and hence, the data from 9th day onwards have been graphically presented. Similarly, the data in respect of rotting (per cent) of sapota fruit in CC storage from 13th day onwards are presented in Fig.5 as the rotting in fruit kept at RT storage condition was very high as

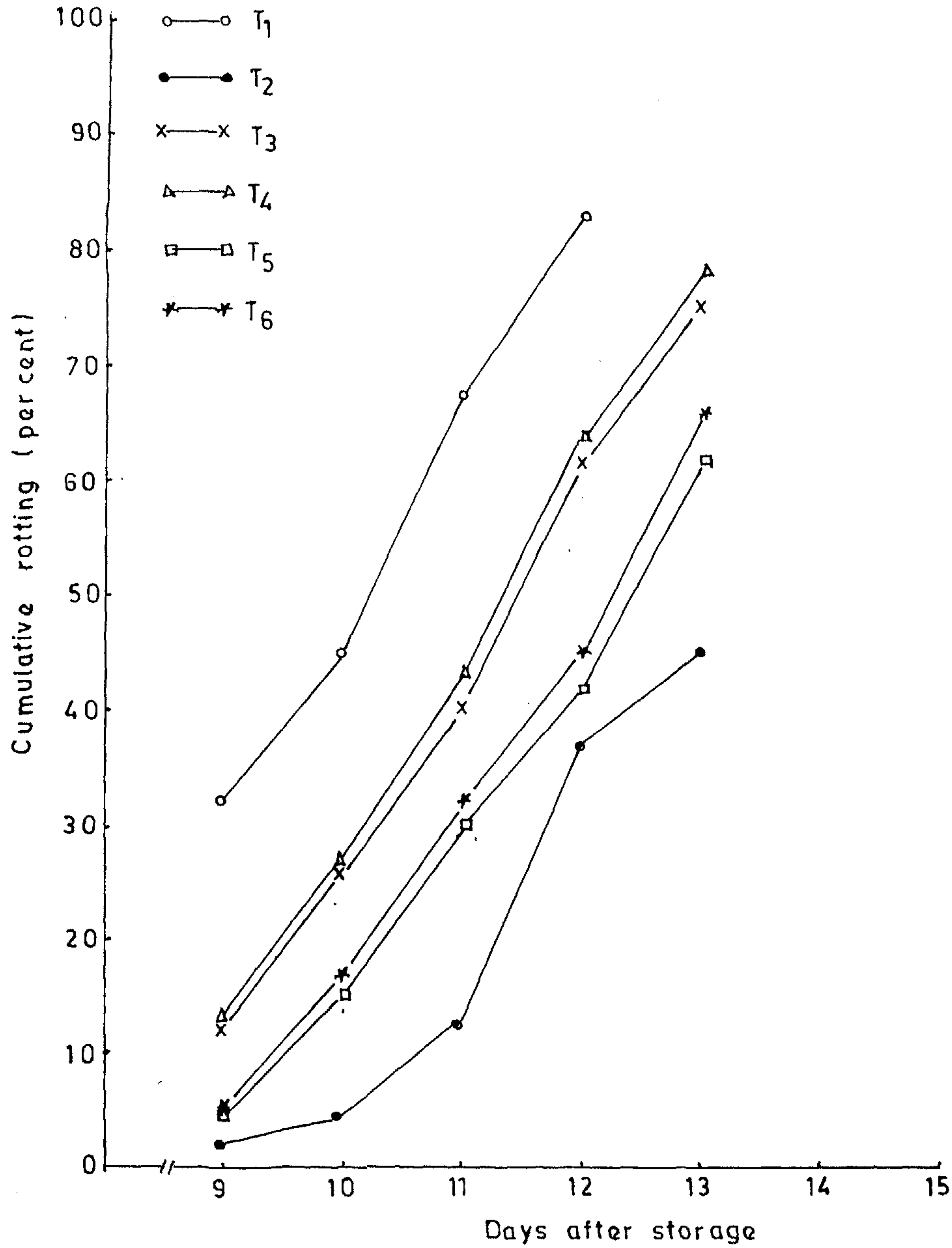

Fig. 4 Effect of various packaging materials on cumulative rotting (per cent) of sapota fruit at RT.

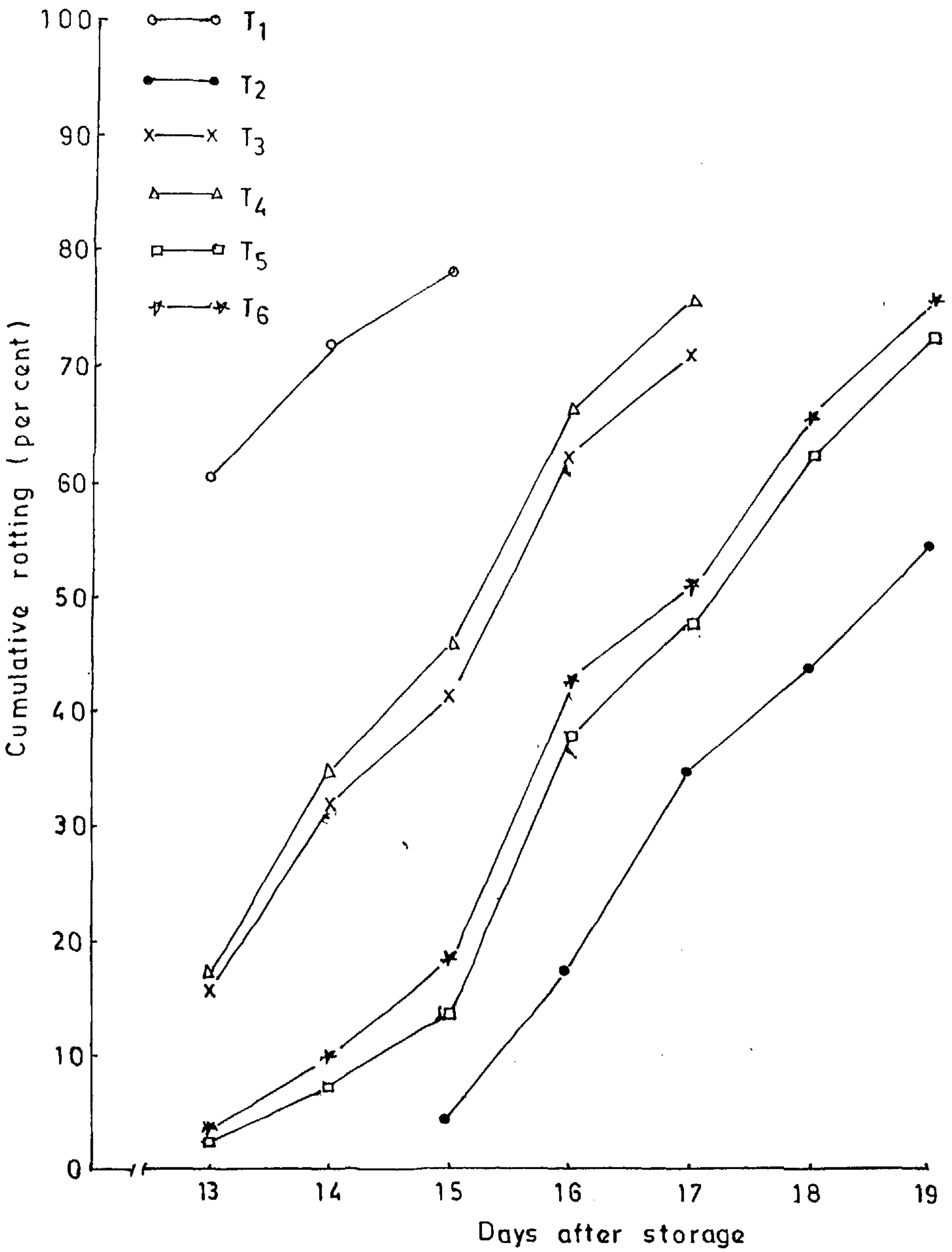

Fig. 5 Effect of various packaging materials on cumulative rotting (per cent) of sapota fruit in CC.

against low in the fruit stored in cool chamber. It was also noticed from the data that as the storage period progressed, the cumulative rotting (per cent) was increased.

The rate of rotting was the lowest in the fruit packed in ventilated polyethylene bag (T_2) and the highest in control fruit (T_1) in both the storage conditions. Polyethylene + CFB box (T_5) and polyethylene + wooden box (T_6) were found to be superior over exclusively CFB box (T_3) and wooden box (T_4) packaging treatments.

The fruit showed rotting both at RT and in CC storge conditions. The isolation and culturing of organism causing rotting was done. It was clear that Fusarium sp. and Rhizophus sp. were associated with rotting of sapota fruit.

4.9 Effect of various packaging materials on the shelf-life and organoleptic evaluation of sapota fruit stored at RT and in CC

The data on effect of various packaging materials on shelf-life and organoleptic evaluation of sapota fruit stored at RT and in CC have been given in Table 15. It was obvious from the data that the shelf-life of the fruits stored in CC was better than that fruits stored at RT. At RT, the shelf-life of the sapota fruits could be extended upto 9 days with use of 1.2 % ventilated polyethylene bags for packaging. The shelf-life of sapota fruit was found to be 9,8,8,7,7 and 5

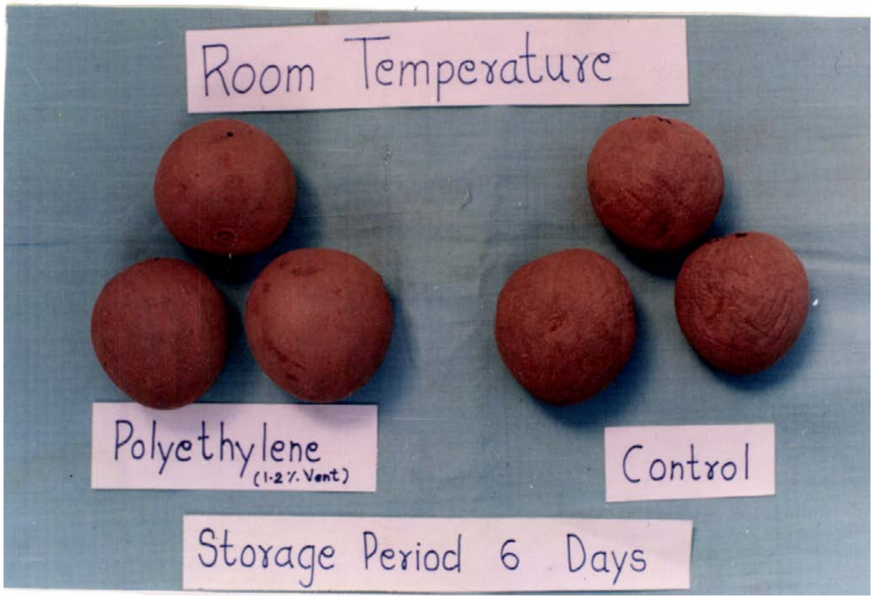

Plate-2

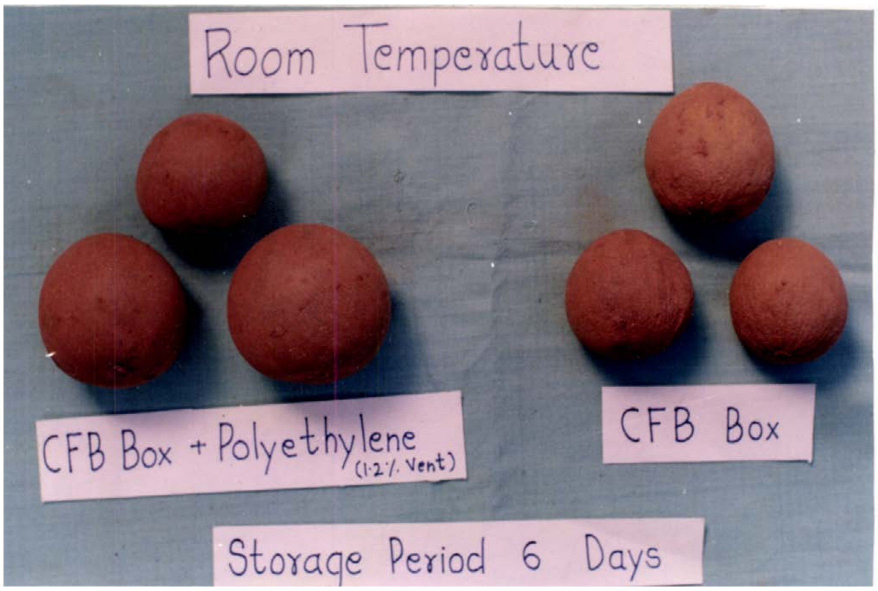

Plate-3

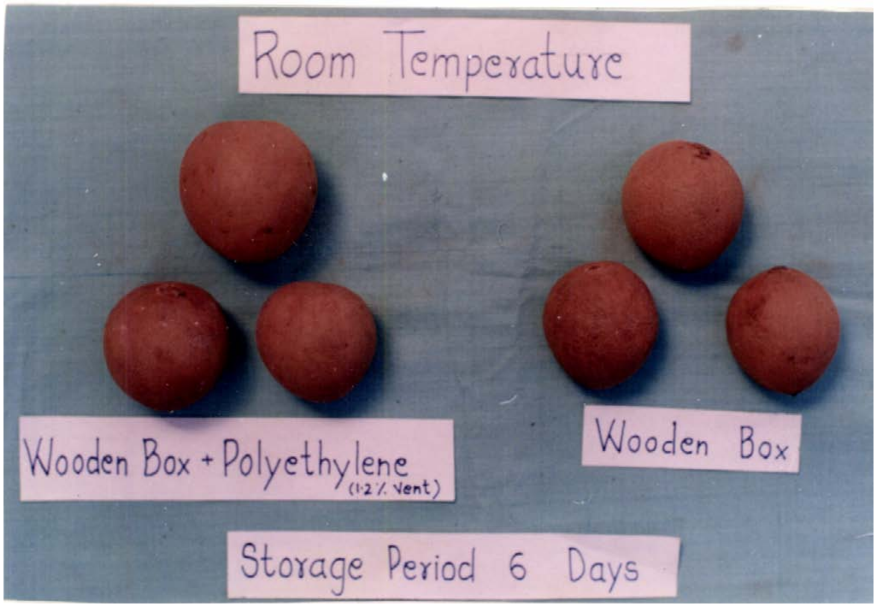

Plate: 4

T-3118

Table 15. Effect of various packaging materials on the shelf-life and organoleptic evaluation of sapota fruit stored at RT and in CC.

Treatment	Shelf-life (days)	Organoleptic evaluation			
		6^{th} day	9^{th} day	12^{th} day	15^{th} day
1. Control (T_1)	RT - 5	5.44	2.66*	---	---
	CC - 10	8.88	8.33	4.44	2.33*
2. Polyethylene bag (T_2)	RT - 9	9.00	5.55*	---	---
	CC - 15	7.66	8.44	9.00	5.44*
3. CFB box (T_3)	RT - 7	7.44	3.88*	---	---
	CC - 11	8.33	8.66	5.11	3.33*
4. Wooden box (T_4)	RT - 7	7.33	3.77*	---	---
	CC - 10	8.11	8.55	4.88	2.88*
5. Polyethylene bag +	RT - 8	8.44	4.66*	---	---
CFB box (T_5)	CC - 13	7.88	9.00	5.88	4.44*
6. Polyethylene bag +	RT - 8	8.33	4.22*	---	---
Wooden box (T_6)	CC - 12	7.77	8.88	5.33	4.11*

Note : * storage period terminated.

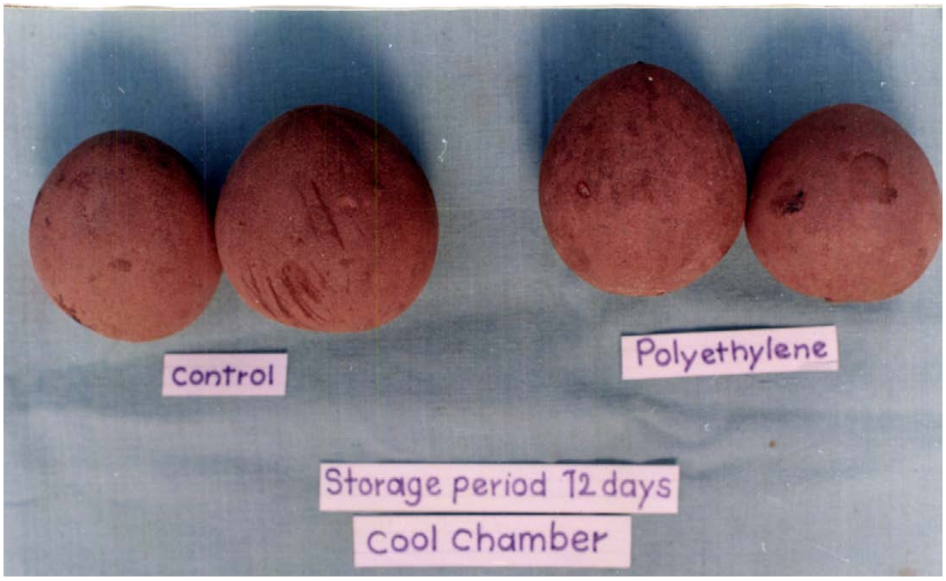

Plate-5

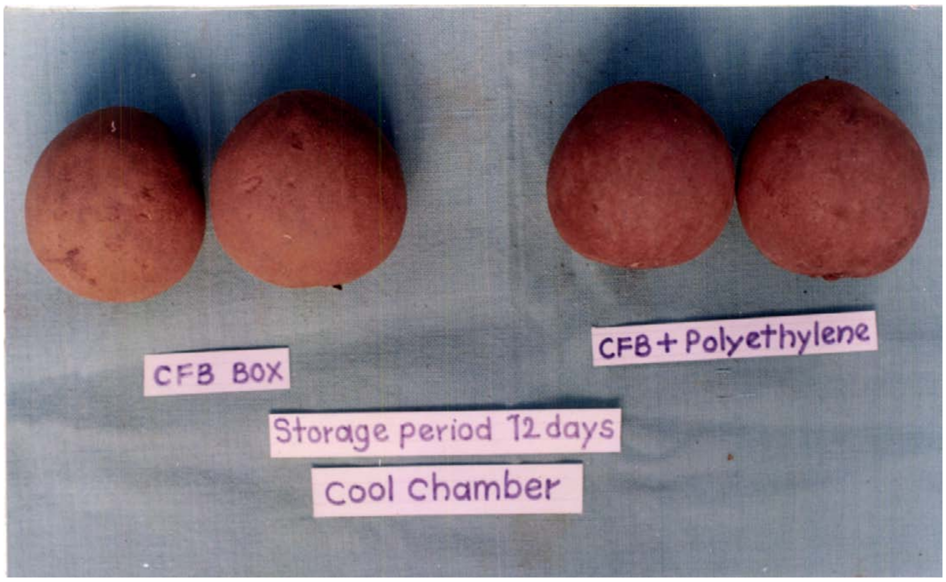

Plate-6

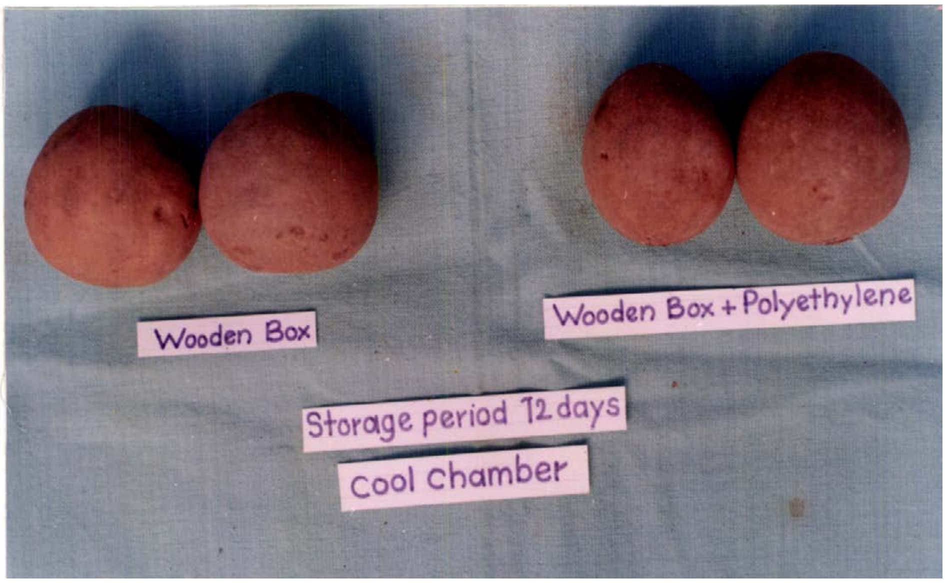

Plate-7

days for treatments T_2, T_5, T_6, T_3, $T_4$and T_1, respectively during storage at room temperature. It was interesting to note that the shelf-life of sapota fruits was found to be 15,13,12,11,10 and 10 days for treatments T_2, T_5, T_6, T_3, $T_4$and T_1, respectively when stored in cool chamber. The shelf-life of sapota fruit could be extended upto 15 day in CC storage when packed in polyethylene bag (1.2 % vents).

The organoleptic rating of the fruits in terms of colour, flavour and texture was the highest in the fruits packed in ventilated polyethylene bag (T_2) stored at RT and in CC at the end of the storage period. However, the fruits packed in polyethylene bag + CFB box (T_5) and polyethylene bag + wooden box (T_6) showed more organoleptic accpetance over those packed in exclusively CFB box (T_3) and wooden box (T_4) packagings.

In general, all the fruits were found to be organleptically accpetable at the end of shelf-life under both the storage environments. However, the fruits stored in cool chamber were found to be fresh, firm even at the end of shelf-life as compared to that of room temperature stored ones (Plate 2 to 7).

DISCUSSION

5. DISCUSSION

The results of the present investigation entitled, "Studies on extending the shelf life of sapota (Manilkara achras (Mill.) Fosberg)" are discussed in this chapter.

5.1 Effect of storage conditions on physico-chemical parameters and shelf life of sapota fruit

Freshly harvested fruits are living entities and continue to respire after harvesting. The respiration in fruits involves many enzymatic reactions. The rate of these reactions (Q_{10}) increases exponentially with increase in temperature and approximately doubles for each $10^{o}C$ rise in temperature (Wills et al., 1981). In case of number of fruits, this Q_{10} for the respiration rate is 2.4 (Gore, 1911). It clearly indicates that the respiration rate increases by 2.4 times with each $10^{o}C$ rise in temperature.

The temperature of the fruits at harvest is equal to atmospheric temperature. At this temperature, respiration rate is extremely high and storage life is very short. All the biochemical processes leading to the loss of quality of stored fruits are related to temperature. The temperature thus influences the rate and type of physiological, biochemical changes and microbial growth. Many fruits rapidly deteriorate at higher temperature leading to loss of nutritive value.

The harvested fruits continue to lose moisture. If this water loss (or transpiration) is not retarded, fruit rapidly become wilted, tough or mushy and consequently inedible. Hence, high relative humidity (over 95%) is highly essential to avoid shrivelling, weight loss and subsequent loss of flavour components. Humidity again depends on temperature and water has a greater tendency to evaporate as temperature rises. Thus, if the fruit is stored at 10°C, the water it contains has a greater tendency to evaporate than if it were at 4.5°C. Thus, high humidity and low temperature have major effects on storage life of fruits (Salunkhe and Wu, 1976).

By using the principle of evaporative cooling, temperature can be reduced by 17 to 18°C during the peak summer months and a very high humidity about 95 per cent throughout the year can be maintained (Roy, 1982 and Roy and Khurdiya, 1986). Effective use of such cool chamber to extend the shelf life of sapota fruit was reported by Reddy and Nagaraju (1993) and Joshi et al. (1993). Similarly, extended shelf life by using cool chamber have also been reported by Gupta (1985), Singh (1987) and Baviskar (1993) for ber; Kumar et al., (1987) and Singh et al. (1987) for grapes; Aror and Narsimhan (1988) for mandarin and apple; Waskar (1989) for banana and Joshi et al. (1993) for several fruits and vegetables. The results obtained in present study of storage of sapota fruit in cool chamber are in confirmity with the observations of these workers.

In the present investigation, fruits were stored at two different storage conditions viz., at RT (31.67 - 36.85°C and 22.57 - 34.97 % R.H.) and in CC (20.24 - 21.57°C and 91-95 % R.H.).

The loss in quality of fruit increased with the advancement of storage period under both the storage conditions. The weight losses of sapota fruit were constantly low in CC storage condition as against constantly high at RT storage. Till the end of 6th day, there was no rotting and the total loss was to be accounted exceptionlly towards the physiological loss. It was noted that the physiological weight loss of sapota fruit during initial storage period was constantly low in CC storage as against constantly high at RT storage condition. It was interesting to note that by the end of 9th day, there was 48.44 per cent total weight loss in control fruit stored at RT as against only 6.90 per cent in control fruit stored in CC. From this, it could be inferred that higher humidities and low temperatures in CC were significantly effective in keeping down the weight loss. Whereas, at RT, higher temperatures and low relative humidities resulted in rapid transpiration and respiration. Reduced weight loss in CC storage has been reported by Reddy and Nagaraju (1993) for sapota. Similarly, reduced weight loss was observed by Joshi and Roy (1986) for mango (cv. Alphonso); Sharma et al., (1990) for kinnow mandarin; Baviskar

(1993) for ber and Waskar (1989) for banana. On 11th day of storage in case of control fruit, the cumulative rotting was 67.77 per cent at RT while 12.43 per cent in CC storage. It was obvious that decay losses were found to be the lowest in cool chamber. The organisms associated for spoilage of fruit were found to be Fusarium sp. and Rhizophus sp. Wherein the infection might have taken place before the storage of fruits as fruits were not given any fungicidal treatment.

The increase in fruit softening and skin shrinkage with the advancement of storage period in both the storage conditions was observed. The progress of fruit softening and skin shrinkage was also very slow in fruits stored in CC as against stored at RT. Similar results were also observed by Kumbhar and Desai (1986) for sapota fruit stored at RT.

The initial rise in TSS and sugars and fall afterwards, were observed under both the storage conditions. But the rate of increase of TSS and sugars was found to be faster at RT. Higher temperature and low humidity enhanced ripening resulting in faster utilization of soluble solids and sugar at RT resulting in shorter shelf-life of sapota fruit. These changes were found to be at slower rate when the fruits were stored in CC. Similar results have also been reported by Reddy and Nagaraju (1993), while at RT storage condition similar reports were given by Ingle et al. (1981); Ingle et al.,(1982); Selvaraj and Pal (1984); Kumbhar and Desai (1986); Banik et al. (1988) and Guatam and Chundawat (1990) in sapota.

The acidity content declined with increased storage period under all the storage conditions and in all packaging treatments. But this decline was at a faster rate at RT. Decline in acidity at faster rate could be because of higher rate of respiration at RT. During respiration, the fruit cells use organic acid as respiratory substrate (Wenjer, 1967).

It could be inferred that CC was more effective in extending the storage life of sapota fruit as compared to RT storage due to low temperature coupled with high humidity prevailing in cool chamber.

5.2 Effect of various packaging materials on physico-chemical parameters and shelf life of sapota fruit

Fruits after harvest lead to an independent life as they are removed from the plant and the normal supply of water, mineral and other organic molecules is cut off. The harvest lesions caused by separation of the organ from the plant are unavoidable, but the ripening and ultimate deterioration can be delayed by adopting proper postharvest treatments.

The fruits are very high in moisture content ranging from 75 to 95 per cent. Their equilibrium humidities are as high as 98 per cent. Sapota fruit contains 73.3 per cent moisture (Gopalan et al., 1971). Under normal conditions, such commodities lose moisture very rapidly causing shrinkage and loss of turgidity. Secondly, the freshly harvested fruits are the living entities and consume oxygen for respiration and emit CO_2, ethylene and water vapour. The loss of water and gaseous exchange, if prevented would extend shelf-life. The gaseous composition in micro-climate around stored fruits is related to anaerobic and aerobic respiration i.e. the concentration of O_2 and CO_2 is critical for each commodity. A semipermeable polyethylene packaging material modifies the gaseous atomsphere around the fruit and also controls secondary infection (Salunkhe and Norton, 1960).

The rapid development of semipermeable polyethylene films and growing use of this packaging material for prewrapping the produce had led to the consideration of the possibilities for establishing controlled atmosphere produce package. Polyethylene is easy for handling, moisture proof, heat sealable, transparent and easily transportable. The beneficial effects of polyethylene in respect of physical and chemical parameters in extending shelf-life of sapota were reported by Kumbhar and Desai (1986), Banik et al. (1988) and Kariyanna et al. (1993) for sapota. Extended shelf-life by polyethylene packaging was also reported by Banik et al.

(1988) and Baviskar et al. (1993) for ber; Sadasivam et al. (1973) and Choudhari and Kumbhare (1979) for sweet orange; Khedkar et al. (1982) and Dhoot et al. (1984) for guava; Jadhav et al. (1992) and Reddy and Nagaraju (1993) for custard apple; Bhullar et al. (1984) for mango and Pota et al. (1987) for pomegranate.

The weight loss of sapota was found to be the highest in control fruit and the lowest in fruit packed in polyethylene bag among all the packaging treatments. The weight loss in ascending order was observed in treatments like polyethylene, polyethylene + CFB box, polyethylene + wooden box, CFB box, wooden box and control under both the storage environments. It could be inferred that reduced weight loss was mainly due to use of polyethylene packaging either alone or in combination with CFB and wooden box as it controlled the transpiration and respiration of sapota fruit during storage. On the contrary the total weight loss was found to be the highest in wooden box followed by CFB box apart from control fruit. The same trend for rotting, softening, skin shrinkage of sapota fruit for all the treatments was observed. In general, sapota fruit packed either in polyethylene bag or its combiation with CFB box and wooden box showed better fruit quality, firmness and marketable quality till the end of storage life.

As the fruit started ripening, the total soluble solids and sugars increased continuously till they reached the peak. The increase in TSS and sugars of sapota fruit could be attributed to the conversion of starch and other insoluble carbohydrates into soluble sugars. TSS and sugar content increased markedly during ripening of sapota fruits and then decreased. (Selvaraj and Pal, 1984 and Kumbhar and Desai, 1986). The total soluble solids and sugars were further utilized for respiration, thus showing the lower content of these in fruit tissue.

The rise and fall in TSS and sugars were found to be delayed in polyethylene packaging, but rapid in control fruit among all the packaging treatments. The rate of rise and fall in TSS and sugars in increasing order in different packaing treatments such as polyethylene, polyethylene + CFB box, polyethylene + wooden box, CFB box, wooden box and control was observed throughout the storage period. The values of TSS and sugars indicated that polyethylene packed fruits retained more TSS and sugars.

The acidity of fruit generally decrease with the advancement of storage period (Salunkhe and Desai, 1984). The same was confirmed in the present investigation. Decrease in acidity may be attributed to conversion of acids to sugars as reported in Thompson Seedless grape by Pool et al. (1972) or it may be due to utilization of acids during respiration (Ulrich, 1970).

Higher levels of acidity could be noticed in polyethylene packed fruits. Similar results were also obtained by Selvaraj and Pal (1984), Kumbhar and Desai (1986), Banik et al. (1988), Guatam and Chundawat (1990) and Reddy and Nagaraju (1993) for sapota. In addition, polyethylene packed fruits were better in quality even with extended storage life. However, the ascending order for the rate of decrease in acidity of sapota fruit in different packaging treatments such as polyethylene, polyethylene + CFB box, polyethylene + wooden box, CFB box, wooden box and control, was observed during the investigation.

The guage, size and perforation of polyethylene for packaging for fruit and vegetable depend on weight of commodity, stage of maturity, temperature and light. The type of commodity is important because the injury of O_2 depletion and CO_2 increase depend upon the tissue and better results could be achieved by standardising the perforations (Hening, 1975). The extended shelf-life was obtained by packaging the sapota fruit in 100 guage polyethylene bag with 1.2 % vents (Kumbhar and Desai, 1986). The results obtained in the present study of sapota fruit are in confirmity with the observations of these workers.

Now-a-days, CFB boxes are becoming more popular for storage and transport of fruits and vegetables as they are lighter in weight, easy to stack and handle. Effective use of CFB boxes for storage and transport has been reported by Anand and Maini (1982) and Lal Kaushal and Anand (1986) for apple; Joshi and Roy (1986) for mango; Gupta et al. (1981), Singh (1987) and Baviskar (1993) for ber. The results obtained in the present investigation are analogous with the findings of these workers. The CFB boxes were found to maintain better physico-chemical parameters of sapota fruit. However, the packaging of sapota fruit in polyethylene bag coupled with CFB box was found to be better for extending the shelf-life and maintaining fruit quality than that of using CFB boxes alone. These boxes substantially reduced the water loss fo sapota fruit in it than that of control fruit. In addition, at the time of packing, there is often a vapour pressure difference between the produce (fruit) and the package, so that water is evaporated from the produce and is absorbed by packing material (Wills et al. 1981). This could be the reason that at high temperature and low humidity condition at RT, the CFB boxes were not much effective in checking the weight loss and arresting the ripening.

The results of present study discouraged the packaging of sapota fruit in wooden boxes . Morever, wooden box has disadvantages like heaviness which adds to the freight cost, consumes 2 to 3 times more wood as required for a similar size corrugated fibre board box. They are not also convenient for handling, packing, ventilation and causing more bruising to the fruit. Beautiful printing at low cost for international acceptance and export is not possible in wooden boxes. It has positive advantage like good stacking strength. But extensive use of wooden boxes will deplete the forest wealth and bring an ecological imbalance.

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

The present investigation entitled, "Studies on extending the shelf life of sapota (Manilkara achras (Mill.) Fosberg)" cv. Kalipatti, was undertaken at the Postharvest Technology Laboratory, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 1993-94. The sapota fruits were obtained from the Instructional cum Research orchard. During these studies, attempts were made to study (i) the effect of various packaging treatments on physico-chemical characteristics of sapota fruit under different storage conditions and (ii) the effect of various packaging treatments on shelf life and quality of sapota fruit under different storage conditions.

I. To study the effect of various packaging treatments on physico-chemical characteristics of sapota fruit under different storage conditions

Sapota fruit in all the packaging treatments at room temperature, showed the same traits of rise and fall in TSS and sugar content and decreasing acidity with increasing rotting, total weight loss, fruit softening and fruit skin shrinkage. Fruits stored in cool chamber followed similar trend of physico-chemical changes but at a slower rate.

The present study made it clear that the packaging treatments such as polyethlene packaging (100 gaugae and 1.2% vents) and CFB + polyethylene packaging (100 guage and 1.2%

vents) had a great significance in retaining the physico-chemical characteristics and reducing the wastage.

Fruits after harvest become a highly perishable commodity. In tropical contries like India, postharvest losses are colossal due to higher temperature, insufficient packaging, dilatory and unspecialised transport, power shortages, mechanical injury and careless handling. This problem of fruit growers and handlers may be solved by adopting simple and cheap packaging materials like polyethylene and CFB boxes and use of cool chamber which is a simple method of storing the fruits for extending storage period with minimum loss of desirable attributes.

II. Effect of various packaging treatments on shelf life and quality of sapota fruit under different storage conditions

Sapota fruits given with different packaging treatments were stored at RT and in a simple zero energy cool chamber. The shelf life of the fruits was extended upto 15 days in CC. Polyethylene packaging was found to be beneficial in extending the shelf life of sapota fruit at RT and in CC. However, for easy transport and handling, use of CFB + polyethylene packaging was found to be beneficial over polyethylene packaging. The advantage of storage of sapota fruit in a zero energy cool chamber is that it does not require any mechanical or electrical energy and is easily installable with cheap and locally available raw material.

To conclude, it may be stated that the storage of sapota fruit in cool chamber with CFB + polyethylene (100 guage and 1.2% vents) packaging should be recommended. The cool chamber has the added advantage of easy construction, low cost and simple handling. The present study indicated that cool chamber could be a possible solution to the problem of storage of sapota fruit in India.

LITERATURE CITED

7. LITERATURE CITED

Amerine, M.A.; Pangborn, R.M. and Rossler, E.A. (1965). Principles of Sensory Evaluation of Food. Academic press, New York and London.

Anand, J.C. and Maini, S.B. (1982). Fibre board packaging for fruits. Indian Hort., 27 : 19.

Anonymous (1985). Zero energy cool chamber. I.A.R.I. Research Bulletin, (43) : 24.

Anonymous (1992). Horticultural statistics of India (Part-A).

A.O.A.C. (1960). Official methods of analysis. Association of Agricultural Chemists. 9th ed., Washington, D.C. 20044.

A.O.A.C. (1975). Official methods of analysis. Association of Agricultural Chemists. 12th ed., Washington, D.C. 20044.

Aror, H.E. and Narsimhan, P. (1988). Extension of the storage life of fungicidal and Waxol dip treated apples and oranges under evaporative cooling storage conditions. J. Food Sci. Tech., 25 (2) : 75.

Bal, J.S. (1982). A study on biochemical changes during room and refrigerator storage of ber fruits. Prog. Hort. 14 (23) : 158-161.

Bal, J.S.; Singh, P. and Singh, R. (1978). Preliminary observations on the storage behaviour of ber at room and refrigerated temperatures. J. Res. PAU, Ludhiana. 15 (4) : 396-399.

T-3118

Banik, D.; Dhua, R.S.; Ghosh, S.K. and Sen. S.K. (1988). Studies on extension of storage life of sapota (Achras sapota L.). Indian J. Hort. 45 (3-4) : 241-248.

Banik, D.; Hore, J.K. and Sen S.K. (1988). Studies on storage life of ber (Zizyphus mauritiana Lamk.). Haryana J. Hort. Sci. 17 (1-2) : 49-55.

Baviskar, M.R. (1993). Studies on extending the shelf life of ber (Zizyphus mauritiana Lamk.) M.Sc. (Agri.) Thesis, MPKV, Rahuri.

Baviskar, M.R.; Waskar, D.P. and Kaulgud, S.N. (1993). Effect of various postharvest treatments on shelf life of ber. Third International Food Convention. Abstracts PP. 142. (Mysore, September 7-12, 1993).

Baviskar, M.R.; Waskar, D.P. and Kaulgud, S.N. (1993). Studies on extending the shelf-life of ber under various storage environments. Third International Food Convention. Abstracts PP. 145. (Mysore, September 7-12, 1993).

Ben-Yehoushua, S. (1985). Individual seal packaging of fruits and vegetables in plastic film - a new postharvest technique. Hortscience, 20 (32) : 1985.

Bhullar, J.S.; Dhillon, B.S. and Randhwa, J.S. (1984). Ambient storage of Langra and Dusheri mangoes. J. Res. Punjab Agric. Univ. 21 (1) : 33-38.

Chadha, K.L. (1991). Strategy for optimization of productivity and utilization of sapota (Manilkara achras (Mill.) Fosberg.), National Symposium on "Optimization of productivity and utilization of sapota" held at GAU, Navasari.

Chattopadhyay, P.K.; Mondal, A. and Hasan, A. (1994). Studies on the storage behaviour of sapota under zero energy cool chamber. National Seminar on Strategies for packaging and storage of Fresh and Processed fruits and vegetables in 21st Centuary. PP. 81. (New Delhi, September 2-3, 1994).

Chauvan, K.S.; Jitender Kumar; Sharma, R.K. and Ran Singh (1987). Effect of some chemicals and cooling on the shelf-life of mango. Haryana J. Hort. Sci. 16 (3-4) : 218-222.

Cheema, G.S.; Bhat, S.S. and Naik, L.L. (1954). Commercial Fruits of India, MacMillan and Co.

Choudhari, K.G. and Kumbhare, G.B. (1979). Post-harvest life of sweet orange (Citrus sinesis L. Osbeck) as influenced by various polythene film pack J. Mah. Agric. Univ. 4 (2) : 228-229.

Christopher, E.P.; Pieniazek, S.A.; Shutak, V. and McElroy. L. (1984). Transpiration of apples in cold storage. Proc. Am. Soc. Hort. Sci. 51 : 114-119.

Desai, U.T. and Kumbhar, S.S. (1986). Influence of perforations of polyethylene on shelf life of sapota fruits. Mah. J. Hort. 3 (1) : 147-151.

Dhoot, L. R.; Desai, U.T. and Rane, D.A. (1984). Studies on the shelf-life of guava fruits with polyethylene packaging and chemical treatments. J. Mah. Agric. Univ. 9 (2) : 185-188.

**Flores, G.A. and Rivas, D. (1975). Studies on the ripening and frozen storage of sapodilla (Achras sapota). Fitotecnia Latinoamericane. 11 (1) : 43-51. (Hort. Abs. 47 : 3111).

Garg, R.C.; Srivastava, R.K.; Ram, H.B. and Verma, R.A. (1971). *Role of pre-packaging and skin coating on* the storage behaviour of mangoes variety Dashehari. Prog. Hort. 3 (2) : 49-67.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research, 2nd ed., An International *Rice Research Institute Book*. Willey Interscience Publishers, New York, P. 306-308.

Gopalan, C.; Ramasastri, B.V. and Balasubramanian, S.C. (1971). Nutritive value of Indian Foods. National Institute of Nutrition. ICMR, Hyderabad, India.

*Gore, H.C. (1911). Studies in fruit respiration. U.S. Dept. Agric. Bur. Chem. Bull. 142 (Cited from "Handling, transportation and storage of fruits and vegetables". Fruit and Tree Nuts, by A. Lloyd Ryoll and W. T. Pentzer, Westport, Conn, AVI Pub. Co. Inc. 1974, Vol. 2. P. 1-36.

*Gorini, F. (1985). Aspects of the use of plastic film in the packaging of fruit and vegetable products. Atti dell Intituto Sperimentale per la valorizzazione Tecnologica dei Prodotti Agricoli, Milano. 8 : 265-290. (Hort. Abs. 57 (12) : 9144).

Guatam, S.K. and Chundawat, B.S. (1990). Post-harvest changes in sapota Cv. Kalipatti. II. Effect of various post-harvest treatments on physico-chemical attributes. Indian J. Hort. 47 (3) : 264-269.

Guatam, S.K and Chundawat, B.S. (1992). Effect of post-harvest treatments on biochemical changes in sapota Cv. Cricket Ball. J. Food Sci.Technol. 29 (1): 53-54.

Gupta, D.P.; Singh, B.P. and Gupta, A.K. (1979). Studies on the shelf-life of different guava cultivars. Harayana Agric. Univ. J. Res. 9 (3) : 247-250.

Gupta, O.P. (1985). Evaluation of various storage chambers for shelf-life of ber. Research Papers and Reports. Third National Workshop on Arid Zone Fruit Research. All India Coordinated Fruit Imporvement Project, ICAR, pp. 208-215.

Gupta, O.P.; Singh, J.P. and Chauvan, K.S. (1981) Evaluation of various packings on the storage behaviour of ber Cv. Umran. Research Reports and Project Proposals. First National Workshop on Arid Zone Fruit Research, All India Coordination Fruit-Improved Project, ICAR, P. 159-161.

Hening, Y.S. (1975). Storage stability and quality of produce packed in polymeric films. In "Post-harvest biology and handling of fruits and vegetables". Ed. N.F. Haard and D.K. Salunkhe. The AVI publishing Co. Inc. West Port, Connecticut, U.S.A. P. 144-152.

Ingle, G.S.; Khedkar, D.M. and Dabhade, R.S. (1981). Ripening studies in sapota fruit (Achras sapota L.). Indian Food Packer. 35 (6) : 42-45.

Ingle, G.S.; Khedkar, D.M. and Dabhade, R.S. (1982). Effect of growth regulators on ripening of sapota fruit (Achras sapota L.). Indian Food Packer. 36(1):72-77.

Jadhav, S.B.; Kaulgud, S.N. and Waskar, D.P. (1992). Studies on extending the shelf-life of custard-apple (A. squamosa L.) fruits by using 2,4-D and polyethylene packaging. Mah.J. Hort. 6 (1) : 56-61.

Jain, R.K.; Chitkara, S.D. and Kartar Singh (1979). Effect of various post-harvest treatments on storage of Umran cultivar of ber (Zizyphus mauritiana Lamk.). Haryana J. Hort. Sci. 8 (3-4) : 181-185.

Jain, R.K.; Chitkara, S.D. and Chauhan, K.S. (1981). Studies on physico-chemical characters of ber (*Zizyphus mauritiana*, Lamk.) fruit Cv. Umran in cold storage. Harayana J. Hort. Sci. 10 (3-4) : 141-146.

Jawanda, J.S.; Bal, J.S.; Joson, J.S. and Mann, S.S. (1990). Studies on the storage of ber fruits. I. Room Temp. Punjab Hort. J. 20 (1-2) : 56-61.

Joshi, G.D. and Roy, S.K. (1986). CFB box - An effective alternative to wooden crates for transport and storage of Mango Cv. Alphonso. Indian Food Packer, 40 (6) : 32-47.

Joshi, G.D.; Relekar, P.P.; Bhingarde, R.T.; Pawar, C.D.; Salvi, M.J. and Magdum, M.B. (1993). Studies on cool chamber storage of fruits and vegetables. Golden Jubilee Symposium, Horticultural Research on Changing Scenario, Abstract, pp. 366. (Banglore, May 24-28, 1993).

Kariyanna, K.M.; Bojappa and Reddy, T.V. (1993). Influence of some Harvest Treatments on ripening and quality of sapota fruits. Golden Jubilee Symposium, Horticultural Research on Changing Scenario, Abstract, pp. 360. (Banglore, May 24-28, 1993).

Khedkar, D.M.; Ansarwadkar, K.W.; Dabhade, R.S. and Ballal, A.L. (1982). Extension of storage life of guava var. L-49. Indian Food Packer. 36 (2) : 49-52.

Kirthikar, K.R. and Basu, B.D. (1975). Indian medicinal plants. Bishen Singh, Mahendra Pal Singh, Dehradun.

Kumbhar, S.S. (1984). Studies to prolong shelf-life of sapota fruits (Manilkara achras Mill.). M.Sc. (Agri.) Thesis, MPKV, Rahuri (India).

Kumbhar, S.S. and Desai, U.T. (1986). Studies on the shelf-life of sapota fruits. J. Mah. Agric. Univ. 11 (2) : 184-187.

Ladania, M.S. and Dhillon B.S. (1987). Studies on long term storage of Beauty Seedless grapes. Indian J. Hort. 44 (1/2) : 34-40.

Ladania, M.S. and Naqvi, S.A.M.H. (1993). Post-harvest handling of Nagpur mandarin. Indian Hort. 38 (2) : 24-29.

Lakshminarayana, S. (1980). Sapodilla and prickly pear in: Tropical and Subtropical Fruits, Nagy, S. and Shaw, P.E. Eds. AVL Publishing, Westport, Conn. 415.

Lal Kaushal, B.B. and Anand, J.C. (1986). Recent trials on grading and packaging of apples. Indian Food Packer. 40 (2) : 29-36.

Lane, J.H. and Eynon, L. (1923). Determination of reducing sugars by Fehlings solution with methylene blue as an indicator.J. Sco. Chem. of India, 42 : 327.

Maini, S.B.; Diwan, B; Lal, B.B. and Anand, J.C. (1982). Packaging, transport and storage of apples in wooden containers. Indian Food Packer. 36(3):43-47.

Moore, T.C. (1980). Physiology and biochemistry of plant hormones. Publisher, Springer verlag, New York, U.S.A.

Nikam, S.K. (1994) - Studies on extending shelf life of Sapota Thesis.

Patil, V.K., Chakrawar, V.R. and Shinde G.S.(1988). Packaging of Citrus, Sapota Fruits. In "Packaging of Fruit and Vegetables in India". Agri. Hort. Soc. (Regd.) Public Gardens, Hyberabad - 500 004.

Pilania, S. and Chauhan, K.S. (1993). Evaluation of packing and cushioning material for transportation of grapes. Golden Jubilee Symposium, Horticultural Research on Changing Scenario. Abstracts. pp. 346 347. (Banglore, May 24-28, 1993).

Pool, K.M.; Weaver, R.J. and Kliewer, M. (1972). The effect of growth regulators on changes in fruits of Thompson Seedless during cold storage J. American Sco. Hort. Sci. 97 : 67-70.

*Pota, S.; Ketsa, S. and Thongtham, M.L.C. (1987). Effect of packing materials and temperatures on quality and storage of pomegranate fruits. Kasetsart J. Natural Sci. 21 (4) : 328-333.

Purseglove, J.W. (1968). Tropical Crops, Dicotyledons, Longman Group Ltd., 1 : 647.

Rao, D.V.R and Chundawat, B.S. (1988). Ripening changes in sapota Cv. Kalipatti (Manilkara achras (Mill.) Fosberg) at ambient temperature. Indian J. Plant Physiol. 31 (2) : 205-208.

Rao, V.N.M.; Shanmugavelu, K.G.; Srinivasan, C. and Iah, D.R.P. (1971). Studies on the effect of etherel on the ripening of fruits. South Indian Hort. 19 (14) : 1-8.

Reddy, P.N.; Nathulal Sen and Omprakash Sharma (1993). Packing and transport of guava (Psidium guajava L.) Cv. Allahabad Safeda. Golden Jubilee Symposium, Horticultural Research on Changing Scenario. Abstracts, pp. 359. (Banglore, May 24-28, 1993).

Reddy, T.V. and Nagaraju, C.G. (1993). Extension of post-harvest life of sapota (Manilkara achras) fruits by cool chamber storage. Golden Jubilee Symposium, Horticultural Research on Changing Scenario. Abstracts. pp. 360. (Banglore, May 24-28, 1993)

Reddy, T.V. and Nagaraju, C.G. (1993). Effect of chemical treatment and polyethylene packaging on shelf-life of Custard Apple (A. squamosa L.). Golden Jubilee Symposium, Horticultural Research on Changing Senario.Abst. pp.62-67.(Banglore, May 24-28, 1993).

Roy, S.K. (1982). Postharvest handling of fresh fruits. In " Fruits Tropical and Subtropical". Ed. T.K. Bose. Pub. Naya Prakash, Culculta, 700 006, India.

Roy, S.K. and Khurdiya, D.S. (1986). Studies on evaporatively cooled zero energy input cool chambers for the storage of horticultural produce. Indian Food Packer 40 (6) : 26.

Sadasivam, R.; Subramanian, T.M. and Raman, N.V. (1973). Note on the effect of polythene film packs on the post-harvest life of sweet orange (Citrus sinesis (L.) Osbeck) in storage. Indian J. Agri. Sci. 43 (2) : 211-212.

/*Salunkhe, D.K. and Norton, R.A. (1960). Packaging treatments to extend storage life of fruits. Utah Agric. Expt. Sta. Farm and Home Econ. Sci., 21 : 18(Cited from Fruits Tropical and sub-tropical. Ed. T.K. Bose, pp. 807).

Salunkhe, D.K.; Cooper, G.M.; Dhaliwal, A.S.; Boe, A.A. and Rivers, A.L. (1962). On storage of fruits. Effects of pre-harvest and post-harvest treatments. Food Technol. 16 : 119.

Salunkhe, D.K. and Wu, M.T. (1976). Development in technology of storage and handling of fresh fruits and vegetables. In "Storage, processing and nutritional quality of fruit and vegetables." Ed. D.K. Salunkhe , CRC press, Inc., pp. 145.

Salunkhe, D.K. and Desai, B.B. (1984). Post-harvest Biotechnology of fruits. Vol. 1 and 2, CRC press, Boca Raton.

Selvaraj, Y. and Pal, D.K. (1984). Changes in the chemical composition and enzyme activity of two sapodilla (Manilkara sapota) cultivars during development and ripening J. Hort. Sci. 59 (2) : 274-281.

Singh, K.K. and Mathur, P.B. (1984). A note on the cold storage of sapota (<u>Achras sapota</u>). Indian J. Agri. Sci. 24 (2) : 149-150.

*Singh, R. (1987). Evaluation of packages for storage and transportation of ber (<u>Zizyphus mauritiana</u> Lamk.). M.Sc. (Agri.) Thesis submitted to HAU, Hissar, (Thesis Abstract, 15 (1/47) : 42).

Singh Sham, Krishnamurthi, S. and Kalyal, S.L. (1963). Fruit Culture in India, ICAR, New Delhi.

Singh, U.R.; Pandey, I.C.; Tripathi, B.M. and Shukla, B. (1976). Effect of different packing materials, containers and transportation on guava fruits. Punjab Hort. J. 16 (3/4) : 149-152.

Smith, S.; Greeson, J. and Stow, J. (1987). Production of modified atmosphere in deciduous fruits by the use of films and coatings. Hortscience, 22 : 772.

Srivastava, M.P. and Tondon, R.N. (1968). Influence of temperature on Botryolodia rots of Citrus and Sapodilla. Indian Phytopathology. 21 : 195-197.

Sundararajan, S. and Rao, V.N.M. (1967). Studies on fruit development and fruit quality in some varieties of sapota (<u>Achras zapota</u> L.). South Indian Hort. 15 (3-4) : 52-57.

Ulrich, R. (1970). Organic acid. In " The biochemistry of fruits and their products. Vol. 1. Ed. A.C. Hulme, Academic Press, London and New York, P. 89-115.

Waskar, D.P. (1989). Studies on storage and ripening of banana (Musa AAA) var. Basrai. Ph.D. Thesis, IARI, New Delhi.

*Wenjer, R. (1967). Ber. dentsch. bot. Ges. 80 : 447-450. (Quoted by Ulrich, R. 1970).

Wills, R.H.H.; Lee, T.H.; Graham, D.; McGlasson, W.B. and Hall, E.G. (1981). In "Postharvest - An introduction to the physiology and handling of fruits and vegetables. Granada Publishing Co., P. 38-51.

---

*Originals not seen

APPENDICES

APPENDIX -I

Effect of various packing materials on cumulative total weight loss (%) of sapota fruit at RT and in CC

Treatment	Day after stoarge								
	3rd			5th			7th		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Intital value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	3.82	0.95	2.39	10.55	1.93	6.24	33.16	3.88	18.52
T_2	1.49	0.00	0.74	3.41	0.91	2.16	6.25	1.89	4.07
T_3	2.24	0.45	1.35	6.47	1.49	3.98	13.52	2.92	8.22
T_4	2.44	0.51	1.47	6.74	1.52	4.13	13.88	3.41	8.65
T_5	1.85	0.43	1.14	5.34	1.42	3.38	8.44	2.39	5.42
T_6	1.87	0.45	1.16	5.70	1.43	3.57	9.39	2.42	5.90
Mean	2.23	0.47		6.37	1.45		14.11	2.82	

	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%
Packaging	0.028	0.080	0.025	0.074	0.015	0.043
Storage	0.048	0.139	0.044	0.128	0.026	0.075
Packaging x storage	0.067	0.196	0.062	0.181	0.036	0.106

APPENDIX-II

Effect of various packaging materials on cumulative total weight loss (%) of sapota fruit at RT and in CC.

Treatment	Day after stoarge								
	9th			11th			13th		
	RT	CC	Mean	RT	CC	Mean	RT	CC	Mean
Intital value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	48.44	6.90	27.67	92.37	38.52	65.44	100.00	86.34	93.17
T_2	10.66	2.90	6.78	36.98	3.84	20.41	69.16	7.89	38.53
T_3	34.96	5.01	19.99	66.75	8.24	37.50	100.00	25.54	62.77
T_4	35.98	5.68	20.83	67.30	10.27	38.78	100.00	37.54	68.77
T_5	20.66	3.45	12.06	51.15	5.91	28.53	91.68	12.57	52.12
T_6	22.05	4.16	13.10	51.77	6.29	29.03	93.67	12.91	53.29
Mean	28.79	4.68		61.05	12.18		92.42	30.47	

	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%	S.E. ±	C.D. at 5%
Packaging	0.073	0.212	0.119	0.346	0.138	0.402
Storage	0.126	0.368	0.206	0.599	0.239	0.697
Packaging x storage	0.179	0.520	0.291	0.847	0.338	0.985

APPENDIX-III

Effect of various packaging materials on cumulative total weight loss (%) of sapota fruit in CC.

Treatment	Day after storage		
	15^{th}	17^{th}	19^{th}
Initial value	0.00	0.00	0.00
T_1	100.00	100.00	100.00
T_2	15.02	48.71	76.43
T_3	48.82	90.86	100.00
T_4	52.85	92.89	100.00
T_5	35.49	66.28	90.86
T_6	39.00	68.31	92.89
S.E. $\pm$	0.088	0.404	0.393
C.D. at 5%	0.271	1.246	1.243

APPENDIX - IV

Effect of various packaging materials on cumulative rotting (%) of sapota fruit at RT.

Treatment	Day after storage		
	7^{th}	9^{th}	11^{th}
Initial value	0.00	0.00	0.00
T_1	12.70	32.18	67.77
T_2	0.00	2.43	12.65
T_3	2.30	12.32	40.24
T_4	3.00	13.15	42.84
T_5	0.00	4.52	29.72
T_6	0.00	4.83	32.09
S.E. $\pm$	0.102	0.383	0.399
C.D. at 5%	0.313	1.182	1.230

APPENDIX - V

Effect of various packaging materials on cumulative rotting (%) of sapota fruit at RT and in CC

Treatment	Day after storage (13th day)		
	RT	CC	Mean
Initial value	0.00	0.00	0.00
T_1	-	60.49	30.24
T_2	44.95	0.00	22.48
T_3	75.54	16.32	45.93
T_4	78.86	17.06	47.96
T_5	61.83	2.98	32.41
T_6	66.05	3.61	34.83
Mean	65.45	16.74	

	S.E. ±	C.D. at 5 %
Packaging	0.147	0.428
storage	0.254	0.741
Packaging x Storage	0.360	1.048

APPENDIX - VI

Effect of various packaging materials on cumulative rotting (%) of sapota fruit in CC.

Treatment	Day after storage		
	15^{th}	17^{th}	19^{th}
Initial value	0.00	0.00	0.00
T_1	78.21	--	--
T_2	4.71	35.33	55.25
T_3	42.31	72.42	80.82
T_4	46.93	76.15	84.91
T_5	14.96	48.09	73.60
T_6	18.82	51.42	76.23
S.E. ±	0.351	0.259	0.551
C.D. at 5%	1.082	0.799	1.699

VITA

VITA

SURYAKANT KISAN NIKAM

Candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

Horticulture

M P K V (Rahuri) LIBRARY

Thesis title	:	Studies on extending the shelf life of sapota (Manilkara achras (Mill.) fosberg).
Major field	:	Horticulture (Pomology)
Biographical information	:	
- Personal data	:	Born at Apshinge (Military), Tal. and Dist. Satara on 19th October, 1970. Son of Shri. Kisan Ganpati Nikam.
- Educational	:	Attended S.S.C at Karmveer Vidyalaya, Parinche, Tal. Purandar, Dist. Pune. H.S.C. at Maharaja Sayajirao Jr. College, Satara. Recieved Bachelor of Science (Agriculture) degree with first class (3.40/4.00 CGPA) in 1992, from College of Agriculture, Kolhapur.
- Scholarships	:	Recipient of College Merit Scholarship during the undergarduate studies (1988-1992).
	:	Recipient of Jindal Education Trust's scholorship druing post-graduate studies (1992-1994).

T-3118