STUDIES ON KEEPING QUALITY OF POTATO CULTIVARS

SALIL BHATTARAI

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

AUGUST, 2000

STUDIES ON KEEPING QUALITY OF POTATO CULTIVARS

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements for the

Degree of

MASTER OF SCIENCE (AGRICULTURE)

in

HORTICULTURE

By

SALIL BHATTARAI

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

AUGUST, 2000

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON KEEPING QUALITY OF POTATO CULTIVARS"** *submitted by* **Mr. SALIL BHATTARAI,** *for the degree of* **MASTER OF SCIENCE (AGRICULTURE)** *in* **HORTICULTURE** *to the University of Agricultural Sciences, Dharwad, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.*

DHARWAD
AUGUST, 2000

(K. RAMACHANDRA NAIK)
MAJOR ADVISOR

Approved by :

Chairman : _____
(K. RAMACHANDRA NAIK)

Members :

1. _____
(RAMA K. NAIK)

2. _____
(N. BASAVARAJA)

3. _____
(P. R. DHARMATTI)

ACKNOWLEDGEMENT

I express my deep sense of gratitude and heartfelt thanks to **Shri K. RAMACHANDRA NAIK**, *Assistant Professor, Horticulture and Special Officer, SC/ST cell and chairman of my advisory committee for his inspiring guidance timely suggestions, critical processing of the thesis manuscripts and constant encouragement throughout the period of research.*

I express my heartfelt thanks and sincere gratitude to **Dr. N. Basavaraja**, *Horticulturist and Scheme Head, AICRP (Potato) for his valuable suggestions and critical correction of thesis manuscripts. I am indebted to* **Dr. P. R. Dharmatti**, *Associate Professor, Horticulture and* **Dr.(Mrs) Rama K. Naik**, *Professor and Head, Department of Foods and Nutrition for their valuable suggestion and critical correction.*

I avail myself this opportunity to express my sincere gratitude with great reverence to Dr. G. S. Sulikeri, *Professor (retired) and* Dr. A. N. Mokashi, *Professor, Department of Horticulture, University of Agricultural Sciences, Dharwad for their support in all angles in materializing my master degree into a reality.*

It gives me immense pleasure to express my sincere thanks and gratitude to Dr. P.W. Basarkar, *Professor of Biochemistry and* Dr.(Mrs.) G.S. Sharada, *Associate Professor of Foods and Nutrition for their valuable help and guidance in my research work.*

My thanks are due to Dr. V.S. Patil, *Assistant Professor of Horticulture for taking nice snaps and all the members of Department of Horticulture for their co-operation during study period.*

I thank with great pleasure all my classmates and all other friends including my roommate Mr. Vijay Kanavi, *whose warm friendship gave me the strength to forget the complexities associated with being far away from home.*

I am greatly indebted to Government of India, for awarding me scholarship to pursue M.Sc.(Agri.) under Nepal Aid Fund Scheme, 1998-99.

I do not have any word to express my gratitude to my parents, who have taken lot of pain in raising me to this level. Lastly, I thank my companion Kavita for her co-operation and encouragement during my study programme despite many difficulties.

Any omission in this brief acknowledgement does not mean lack of gratitude to any one.

DHARWAD
AUGUST. 2000

Bhattarai

(*Salil Bhattarai*)

CONTENTS

LIST OF TABLES

Contd.....

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is a versatile food. Over a billion people consume potato, as a staple food in Europe and a principal vegetable in developing countries. The potato crop plays a pivotal role in farm economy. Even though it is cultivated on 1.2 per cent of world net cropped area in over 140 countries, it ranks fourth in production after maize, wheat and rice (Anon., 1999b).

India is a major producer of potato along with China, Russia, Ukraine and Poland. The total area and production of potato in India was 1.50 million hectares and 25.06 million tonnes during the year 1998 with a productivity of 16.71 tonnes per hectare (Anon., 1999b).

Potato crop has registered the annual compound growth rate of 3.5, 6.0 and 2.41 per cent respectively for area, production and productivity during the year 1949-50 to 1995-96 in India (Bist and Sharma, 1997).

However, the revolutionary increase in potato production has been plagued by recurrent gluts due to bumper production, inadequate cold storage facilities and relatively inelastic demand (Dahiya and Sharma, 1994). Present cold storage capacity of India is sufficient to accommodate only about 39 per cent of the crop production (Shekhawat, 1994). Moreover, the cold stores are capital intensive and beset with the problem of power failure in developing countries like India and high rental rate often makes it inaccessible to poor and marginal growers. This situation becomes hinderance for further increment in potato production, as it

results in price crash at harvest to the distress of growers and price rise in the offseason works to the disadvantage of consumers without benefiting growers.

Lack of proper storage facilities results in huge post harvest losses due to evaporation, respiration, sprouting and the incidence of pests and pathogens (Beukema and Van Der Zaag, 1990).

Fuglie *et al.* (1997) had advocated the need for alternative storage methods, which farmers can own and manage themselves.

Singh (1981), Khurana *et al.* (1986) Shekhawat (1994) and Dahiya and Sharma (1999) have suggested the alternative techniques to combat the storage problem of potatoes *viz*: Use of improved indigenous storage technology; development of short duration varieties, which can develop firm skin within 60 to 70 days; use of varieties with long storability and use of sprout inhibitors to control sprouting at higher temperature storage.

Taking the above situations into consideration, present investigation was carried out with the following objectives:

1. To study the storage behaviour of potato cultivars under different storage conditions, and

2. To study the effect of pre and post harvest treatments with different chemicals on storage life of potato cv. Kufri Pukhraj.

Review of Literature

II. REVIEW OF LITERATURE

Storage of potato is intended to minimize losses in quantity and to preserve their quality according to the mode of their utilization. Under the tropical and subtropical conditions, potatoes can not be stored without refrigeration for more than two months after harvest because of enormous losses resulting from rottage, shrinkage, sprouting and attack of microorganisms (Kaul and Mehta, 1999). The perishable nature of potato combined with the inadequate and expensive refrigerated storage facilities and their uneven distribution, difficulties in transportation, the adverse environmental conditions prevailing during the main storage season and lack of significant processing of potatoes create market gluts during the peak harvesting season. Storage studies in potatoes have been conducted by various workers and it has been found that temperature, relative humidity, genotypes, use of sprout inhibitors and the fertilizer applied to the crop in field play vital role in determining the keeping quality of potatoes.

Literature related to the storage of potatoes are reviewed under different headings in this chapter.

2.1 EFFECT OF STORAGE CONDITION ON STORABILITY OF POTATOES

Temperature during storage largely determines the shelf life of potatoes. Temperature and relative humidity are in turn determined by climatic condition, method of storage and storage design.

Verma *et al.* (1974) reported that the physiological loss in farm stores ranged from 13 to 24 per cent, whereas it was only 4 to 5.6 per cent in cold stores.

Singh (1981) reported that the losses in weight of potatoes stored at 36.5°F for 7½ month was 12.4 per cent. No sprouting was recorded at 33.5°F or 36.5°F upto 183 days of storage. Whereas all the tubers sprouted within 64 and 58 days at 48.5°F and at room temperature, respectively.

Kaul and Mehta (1988) reported that weight loss in different genotypes ranged from 8.23 to 9.17 per cent in evaporative cooled potato stores against 3.6 to 4.13 per cent in cold storage after 12 weeks. Weight loss due to disprouting was 1.15 to 2.47 per cent in different genotypes and total loss ranged from 9.38 to 11.64 per cent after 12 weeks of storage in evaporatively cooled potato stores.

Ilangantileke *et al.* (1996) reported that storage losses in potatoes stored in improved rustic storage based on evaporative cooling ranged from 4 to 11 per cent after 75 days of storage, which was lower than the losses in heaps.

According to Khatana *et al.* (1997) on-farm storage is beneficial way of storage for the farmers than cold storage in Karnataka and hence higher profits may be the rationale for on-farm technology than not having access to the cold stores.

Garg *et al.* (1999) found the highest number of sprouts per tuber, when they were stored in diffused light as compared to potato tubers stored in dark. But the sprout length and fresh weight of sprouts per tuber were reduced significantly in diffused light.

Kaul *et al.* (1999) reported that total losses were minimum (11.4 to 12.4 %) in potatoes stored in pucca pit as compared to heaped potatoes (13.2 to 16.4 %) after 105 days and they opined that the potatoes could be safely stored in low cost storage structure for 3 to 4 months so as to get remunerative prices.

Mangal *et al.* (1999) reported that physiological loss in weight was 2.5 to 5 per cent in evaporative cool chambers (max temp 20±4°C, min temp 17±3°C and RH 85±3 %) as compared to 10.5 to 13 per cent under ambient condition (max temp 29±6°, min temp 22±4° and RH 63±5 %) after 75 days of storage. Weight of potato sprouts varied from 0.36 g to 0.38 g per kg of tubers under ambient condition and 4.65 to 10.9 g per kg under evaporative cool chamber on 75th day of storage.

Paul *et al.* (1999) evaluated the heap and pit method of storage in Indo-gangetic plains of India and reported that total storage losses ranged from 7.4 in pucca pit to 15.9 per cent in heap after 90 days of storage. The major loss was due to physiological loss in weight.

2.2 GENOTYPIC DIFFERENCE IN STORABILITY

Shelf life of potato vary with varied genotypes. Difference in storability among the genotypes was studied and reported by various workers.

Verma and Jha (1990) found that genotypes PC-1021, PC-4, PC-4998, PC-20, Kufri Kuber and Kufri Dewa were superior with respect to physiological weight losses among 49 genotypes evaluated for their storability under room temperature during the month April to August.

In a study conducted by Kang and Jai Gopal (1993), genotypes Kufri Lalima, Kufri Lauvkar and JF-5106 showed less weight loss (below 30 per cent), whereas JI-5857 (Kufri Sutlej) recorded highest weight loss (52.2%) after 140 days storage at high temperature.

Kaul and Mehta (1993) compared the keeping quality of some advanced potato hybrids with Kufri Chandramukhi at room temperature. Total losses ranged between 22.0 to 39.2 per cent with minimum values in MS/78-96 (22.0 %) and MS/79-10 (23.8 %), which was comparable to the Kufri Chandramukhi (23.2 %). Maximum total losses were recorded in hybrids JI-5857 (Kufri Sutlej), IN-1758, JI-1857 and JH-222 (Kufri Jawahar). Sprouting percentage and sprout weight were lowest in MS/78-46 and MS/79-10.

Khurana *et al* (1994) reported the lowest cumulative weight loss in Kufri Sinduri among the 31 hybrids, nine TPS families and five standard varieties stored in ambient temperature from March to June.

Kumar *et al* (1995) reported that MS/79-10 and Ms/78-46 showed lowest intensity of sprouts and low weight loss among the advanced potato selections stored for 90 days in evaporative cooled potato store as well as at room temperature.

Among the cultivars evaluated by Mehta and Kaul (1997), Kufri Sherpa showed highest weight loss (25.9 %) and Kufri Lalima with lowest (14.8 %) after 16 weeks of storage under non-refrigerated storage.

Mangal *et al.* (1999) reported that potato cv. Kufri Chandramukhi in ambient condition and Kufri Pukhraj and Kufri Badshah in evaporative cool chamber recorded minimum physiological loss in weight. Cultivar 85-P-718 showed maximum decaying under both conditions during 75 days of storage.

Naik and Basavaraja (1999) evaluated 27 genotypes for their storability under ambient condition during October to February in Dharwad condition and reported that least physiological loss in weight was observed in MS/89-60 (17 %) and maximum in JX-23 (44 %). Least per cent sprouting was recorded in JX-108 (42.5) followed by Kufri Jyoti (60.71%) and Kufri Jawahar (67.4 %) after four months of storage.

Singh and Raghav (1999) found that Kufri Bahar followed by JX-108 showed superiority and Kufri Jawahar showed poor shelf life among the 12 cultivars evaluated for their keeping quality for a period of 120 days at room temperature.

2.3 EFFECT OF SPROUT INHIBITORS ON STORABILITY OF POTATOES

A major reason for deterioration in quality of potatoes stored without refrigeration is excessive weight loss and shrinkage due to

sprouting. Several workers have conducted experiment to minimize the storage losses by way of sprout inhibition.

2.3.1 Maleic hydrazide

Maleic hydrazide (MH) is one of the important chemical sprout suppressants registered for use in India.

Doreyappa Gowda and Krishnappa (1985) studied the effect of pre-harvest foliar spray of MH on storage behaviour of potato stored at room temperature and reported that sprouting, sprouted eyes per tuber, sprout length, sprout weight, cumulative PLW and rottage of tubers were low throughout the storage period in MH treated tubers. Its effect was more pronounced with increase in concentration from 0 to 0.4 per cent and early application prior to harvest.

According to Rama and Narasimham (1987), efficiency of MH was increased with reduced temperature.

Kumar and Mukherjee (1989) reported that various concentrations of pre harvest spray with MH could not inhibit sprout initiation, but were very effective in checking sprout growth. MH reduced the sprout weight of tubers, but failed to prevent rottage.

Kaul and Mehta (1991) observed the sprouting of tubers under potato store cooled by passive evaporation as well as in ambient condition over a period of 10 weeks during March to May. But the tubers of crop sprayed with 0.3 per cent MH two weeks before harvesting showed

significantly less sprouting than those of untreated crops under both storage conditions.

In a study conducted by Mehta and Kaul (1991), it was observed that treatment with MH increased tuber rotting, but there was no significant difference with untreated control. MH treatment was more effective in evaporatively cooled store (16-30°C Temp, 75-90 % RH) than in the ambient condition (20-39°C Temp, 30-80 % RH).

Kaul and Mehta (1994) reported that pre-harvest foliar application of MH (0.3%) reduced the mean number of sprouted tubers by 27 per cent upto 10 weeks of storage. However, the mean total losses due to the combined effect of rottage, weight loss and sprout weight were not affected by the MH treatment but was significantly reduced in evaporatively cooled potato stores.

2.3.2 Isopropyl-N-(3-chlorophenyl) carbamate (CIPC)/ Isopropyl-N carbamate (IPC)

Use of CIPC and IPC for controlling sprouts during potato storage has been reported by several workers.

Maini *et al.* (1984) reported that sprouting in tubers of potato, whose dormancy period was over could be suppressed upto 35 days with the application of Germotect (a commercial mixture of IPC, CIPC and thiobendazole) as compared to seven days in the control. During that period, physiological weight loss was less in desert cooling system (at 24-28°C, 90 % RH) than in ambient temperature (36-41°C).

Post harvest application of CIPC at the rate of 5000 ppm as dip treatment was better over the pre-harvest application of MH, NAA, cycocel and TIBA as it could appreciably reduce the losses due to sprouting and dehydration in ordinary room as well as in evaporative cooling chamber storage (Khurana *et al.*, 1986).

Rama and Narasimham (1987) reported that CIPC was effective sprout suppressant only at 10°C.

Liu *et al.* (1989) reported that 1000, 1000-3000 and 3000 ppm of CIPC was effective in controlling sprouting of potato tubers kept for reconditioning at the temperature 20, 25 and 30°C, respectively. 300 to 500 ppm of CIPC was found to be effective in controlling sprouts in tubers stored at 10°C for a period of nine months.

Liu *et al.* (1990) reported that sprouting was inhibited when tubers were stored at temperature of 10°C with 80 per cent RH after treating with CIPC (300-500 µg/l) and quality of potatoes was retained upto eight months.

Wessel and Wustman (1990) studied the effect of propham chloropropham (IPC.CLPC) on ware potato cv. Bintje. They found that treatment @11 mg ai per kg at 6°C and a reapplication at 10 and 25°C, was found effective in inhibiting sprout growth. Highest loss recorded was less than 12 per cent at 25°C.

According to Kumar *et al.* (1994), repeated dusting of CIPC was effective in suppressing the sprouts, reducing the weight of sprouts and

weight loss. But the tuber rottage was slightly enhanced through treatment. Cultivars differed in their response to CIPC treatment.

Liu *et al.* (1994) did not find any sprouting during 70 days storage in tubers treated with 1000, 1400 or 1800 mg CIPC per kg tubers and stored at ambient temperature, whereas the sprouting rate was 34.5 to 65.4 per cent in untreated control.

Almost complete elimination of sprouting could be achieved by combining CIPC treatment with evaporative cooling of the stores. Treatment was less effective at room temperature. Whereas sprouting was 100 per cent in the untreated control (Anon., 1998).

2.3.3 Sodium salt of α-Napthalene acetic acid (SNA) and methylene ester of α-NAA (MENA)

Patil and Patil (1982) reported that napthalene acetic acid was not effective in preventing the storage losses in potato.

Rama and Narasimham (1987) found that the efficiency of MENA and SNA decreased with reduced temperature.

Liu *et al.* (1989) reported that MENA at the rate of 10000 ppm could prevent sprouting for only three months.

Rama and Narasimham (1989) reported that the percentage of sprouted tubers at the end of each week of storage was lower in SNA treated tubers than control and sprouting percentage was decreased with the increase in concentration of SNA. At the end of four weeks, sprouting

ranged from 42.6 to 69.5 per cent in different treatment as against 84.7 per cent in the control.

Rama *et al.* (1990) reported that storing potatoes pre-treated with SNA containing fungicide, benlate at 1000 ppm concentration, in the evaporatively cooled containers slightly reduced sprouting compared to untreated tubers and eliminated spoilage.

2.4 PESTS AND DISEASES IN STORAGE

Potato tuber moth (PTM) is known to cause heavy damage in country stores by way of reducing food and market value of potato. Damage of tubers by PTM was estimated to be upto 25 per cent in country stores in Karnataka (Raj, 1991). Saxena (1983) reported as high as 99.5 per cent infestation of PTM in country stores in Maharashtra.

Mansaur (1984) reported that dipping of potato in insecticide *viz.*, 0.06 per cent methomyl solution or 0.8 per cent propoxus solution protected the tubers against larvae of potato tuber moth upto 25 weeks in cold and warm storage condition.

Several pathogens are reported to cause rotting in storage (Gaur and Chenulu, 1981; Ghanekar *et al.*, 1984; Ramavo and Usharani, 1985; Kassim, 1986; Mishra and Rath, 1986; and Singh and Singh, 1991). Pathogens associated with rotting in storage are *Sclerotium rolfsii, Alternaria alternata, Aspergillus niger, Fusarium moniliformae, F. solani, Goetrichum candidum, Alternaria terneus, Mucor* sp. *Penicillum*

funniculosum, Trichums spirculs, Macrophomina phaseoli, pestalotia versicolor and *Erwinia* sp.

2.5 BIOCHEMICAL CHANGES DURING STORAGE AND ITS EFFECT ON PROCESSING QUALITY

The total sugar content of tubers increased under the cold stored as well as farm stored potatoes, but the accumulation of reducing sugars was very low in farm stored tubers (Verma *et al.*, 1974).

Kumar and Baijal (1978) reported that the amylase activity increased progressively at 5°C and declined at room temperature (30±2°C).

Nirmala Kumari and Mukherjee (1986) reported an increase in the amount of reducing and non-reducing sugars in potato tubers removed from cold storage after three months and stored at 10±2°C and 40±2°C. The starch breakdown and α-amylase activity were higher at 40±°C.

Uppal (1995) reported that the free sugar and invertase activity differed significantly with variety at the time of harvest and during storage. Reducing sugar content increased by 37 per cent and invertase activity coincided with the accumulation of sugars. Sucrose content decreased during storage. Among the varieties, Kufri Sherpa contained minimum level of free sugars and invertase activity.

Hill *et al.* (1996) concluded that the onset of sugar accumulation in cold stored tubers is initiated by a change in kinetics of sucrose phosphate synthatase and the appearance of new amylolytic activity.

Jeong *et al.* (1996) found an excessive accumulation of reducing sugars at 25°C temp inspite of the lower sugar accumulation and suggested that the storage temperature of potato tubers for processing be kept at 10°C.

Nielson *et al.* (1997) reported that the enzyme 'β-amylase' is responsible for degrading starch in potatoes stored at low temperature.

Anon., (1999a) reported that mean chip colour of cultivar improved after 75 days of storage under both the evaporatively cooled potato store (ECPS) and ordinary farm store. But the average peeling losses were lower and chip yield was higher from potatoes stored in ECPS.

Kumar *et al.* (1999) reported the significant interaction between cultivar and storage period on dry matter and sugars. A slight decline in sugar ranging from 2.0 to 42.0 mg/100 g fresh weight was noticed after a fortnight of storage. Thereafter, the sugars increased, but increase was more in indigenous cultivars than in exotic hybrids.

Marwaha (1999) reported that ECPS stored potatoes produced crispy chips as compared to hard dry chips in the farm stored potatoes and tubers of Indian potato cultivars (Kufri Chandramukhi, Kufri Jyoti and Kufri Lauvkar) displayed a significantly lower dry matter, higher reducing sugar and produced darker chips irrespective of the storage condition. Average content of dry matter and sucrose increased during storage with decline in total phenols and free amino acids.

According to Peshin (1999), tubers stored at 20°C showed a slight increase in invertase activity upto 30 days followed by general decline in the activity, whereas at 6°C, there was sharp increase in both basal and total invertase activity after 30 days followed by slow increase upto 90 days. Invertase activity was positively correlated with reducing sugar content.

Uppal (1999) studied the effect of storage environments on chip colour and sugar levels in tubers of potato cultivars and reported that reducing sugar accounted for the accumulation of total sugar under cold store. Whereas it was due to accumulation of sucrose under room condition and evaporatively cool storage. The chips made from the tubers stored in ECPS were highly acceptable and far superior in colour and texture.

Uppal and Ezekiel (1999) reported that reducing sugar content decreased by 1.8 to 3.5 folds in the tubers stored in traditional storage methods for 80 days, but increased by 3.7 times in cold stored tubers. Sucrose content increased in all storage methods and chip colour improved significantly during storage in all traditional methods except cold stores.

Nirmala Kumari and Mukherjee (1985) reported that the potatoes stored at the temperature of 0° and 8±2°C showed a marked reduction in ascorbic acid during storage, but no significant difference was observed between two conditions in the loss of ascorbic acid.

Azarang and Shahidi (1994) reported that vitamin C and crude fibre content decreased during storage in the variety with the thinner skin.

2.5.1 Effect of sprout inhibitors on processing quality and chemical composition

2.5.1.1 Maleic hydrazide (MH)

Yuda *et al.* (1991) did not find any consistent difference between the colour of chips made from MH treated and untreated tubers. They found that MH had no effect on sugar content.

Gichohi and Pritchard (1995) reported that MH tended to cause darker fry colour, though not statistically significant.

Anonymous (1998) reported that treatment with MH (0.3%) did not affect processing quality of potatoes.

2.5.1.2 CIPC

Liu *et al.* (1990) reported that reducing sugar content remained at a low value for upto eight months at 10°C and 80 per cent RH in tubers treated with 300 to 500 ppm CIPC.

CIPC 1 per cent dust applied at the rate of 2.5 g/kg tubers and stored at 8°C did not affect chipping quality, whereas in tubers stored at 4°C, chip colour deteriorated due to rapid accumulation of reducing sugars (Anon., 1998).

2.5.1.3 Sodium salt of α-NAA

Rama and Narasimham (1989) reported that sugar content of SNA treated tubers after 12 weeks remained well within the limits for processing into chips, highest value being 1.43 g/100 g dry weight, which was higher than that of the untreated tubers.

Material and Methods

III. MATERIAL AND METHODS

The experiment was conducted in the Department of Horticulture, College of Agriculture, Dharwad during the period October, 1999 to February, 2000. The details of the materials used to carry out the investigations and methods adopted to arrive at possible inferences are presented in this chapter.

3.1 CLIMATE OF DHARWAD

Dharwad is situated in transitional tract of North Karnataka. Dharwad gets mean annual rainfall of 783 mm, which is well distributed from June to October. April and May are the hottest months with maximum temperature ranging from 36.24 to 38.23°C. January and December are the coolest months with minimum temperature ranging from 13.48 to 14.60°C. The relative humidity fluctuates between 56 to 88 per cent. Data on maximum and minimum monthly temperature and relative humidity recorded during the period of investigation in meteorological center of UAS, Dharwad is presented in Appendix – I. Data on temperature and relative humidity recorded in zero energy cool chamber and room condition at 4 days interval during the period of investigation is presented in Appendix – II.

3.2 MATERIALS FOR POST HARVEST STUDIES

Potato tubers required for experiment were collected from All India Coordinated Potato Improvement Project, Dharwad. Tubers were produced

by raising crop during *kharif* season in black cotton soil of Dharwad. The fertilizer and other cultivation practices were followed as per the recommendation of UAS, Dharwad. Fully matured crop was harvested after 3 weeks of haulm removal. Injured or diseased tubers as well as too big and too small tubers were sorted out and apparently healthy tubers were used for storage studies.

3.3 PRE-HARVEST SPRAY WITH MALEIC HYDRAZIDE

Potato cv. Kufri Pukhraj was grown separately to impose maleic hydrazide (MH) treatment. 13.5 ml of Desprout (MH as diethyl amine salt, 30 per cent ai) was dissolved in little quantity of ethanol and volume was made upto 10 litres with water to prepare 400 ppm solution of MH and it was uniformly sprayed on the crop three weeks before haulm removal.

3.4 POST HARVEST TREATMENT WITH ISOPROPYL – N - (3 -CHLOROPHENYL) - CARBAMATE (CIPC)

10 ml of CIPC (50 per cent ai) supplied by M/S United phosphorus us limited, Mumbai was dissolved in little quantity of ethanol and the volume was made upto 5 litres with water to make solution of 1000 ppm concentration. Healthy tubers of Kufri Pukhraj were dipped in CIPC solution for 5 minutes and shade dried before keeping them in storage.

3.5 POST HARVEST TREATMENT WITH SODIUM SALT OF α-NAA (SNA)

Sodium napthyl acetate (SNA) solution was prepared by the method followed by Rama and Narasimham (1989). 1.98 g of α-NAA was dissolved in 100 ml of 0.1 N NaoH solution and volume was made upto 3.96 litre

with water to make the solution of 500 ppm concentration. The tubers of cv. Kufri Pukhraj were dipped for 5 minutes in this solution and shade dried before keeping in storage.

3.6 ZERO ENERGY COOL CHAMBER (ZECC)

Zero energy cool chamber developed by Indian Agriculture Research Institute, Delhi is one of the storage structure for preservation of fresh horticultural produce (Roy and Khurdiya, 1986). It requires no energy to cool internal environment and works on principle of direct evaporative cooling. The chamber is constructed by using cheap and locally available raw materials such as mud, bricks, river bed sand, bamboo and gunny clothes. The structure is basically a double walled mud brick chamber with sand in between. It is kept completely wet by sprinkling water and pouring on to the sand. Present investigation is carried out to know the storability of potato under such structures with or without chemical treatments.

3.7 EXPERIMENT DETAILS

Two sets of experiment were conducted to meet the stated objectives.

3.7.1 EXPERIMENT I : Studies on storage behaviour of potato cultivars under different storage conditions

Storage condition	I.	Zero energy Cool chamber	(S_1)
	II.	Room condition	(S_2)
Cultivar	I.	Kufri Ashoka	(V_1)
	II.	Kufri Pukhraj	(V_2)
	III.	Kufri Jawahar	(V_3)
	IV.	Kufri Jyoti	(V_4)
	V.	Kufri Sutlej	(V_5)
	VI.	Kufri Chandramukhi	(V_6)

The various effects due to interactions between storage condition and genotype were studied with the following combination.

Treatments :	S_1XV_1	S_2XV_1
	S_1XV_2	S_2XV_2
	S_1XV_3	S_2XV_3
	S_1XV_4	S_2XV_4
	S_1XV_5	S_2XV_5
	S_1XV_6	S_2XV_6

Total number of treatments – 12

Replications – 3

3.7.2 EXPERIMENT II : Studies on the effect of different chemical treatments on storage life of potato cv. Kufri Pukhraj

Storage condition :	I.	Zero energy Cool chamber	(S_1)
	II.	Room condition	(S_2)
Chemical treatment :	I.	Chloropropham (CIPC) 1000 ppm post harvest dipping for 5 minutes	(C_1)
	II.	Maleic hydrazide (MH) 400 ppm pre harvest foliar spray 3 weeks before haulm removal	(C_2)
	III.	Sodium salt of α-NAA (SNA) 500 ppm post harvest dipping for 5 minutes	(C_3)
	IV.	Control	(C_4)

Various effects due to interactions between storage conditions and chemical treatments were studied with the following combinations.

Treatments :	S_1XC_1	S_2XC_1
	S_1XC_2	S_2XC_2
	S_1XC_3	S_2XC_3
	S_1XC_4	S_2XC_4

Plate 1. Photograph of tubers stored under zero energy cool chamber

Plate 2. Photograph of potato tubers kept at ambient storage condition

Total number of treatments - 8

Replications - 3

Tubers were kept in 3 tired perforated plastic trays with each tire representing a replication. Tubers for ambient storage were kept in the field laboratory of AICRP (Potato) or zero energy cool chamber (ZECC) as per the treatment.

3.8 OBSERVATIONS RECORDED

3.8.1 Physiological loss in weight (PLW)

Weight loss in storage is due to physiological reasons like dehydration and respiration and due to rottage. Physiological weight loss was calculated by deducting weight loss due to rotting from total weight loss and PLW was calculated by the following formula.

$$\text{PLW (\%)} = \frac{\text{Total weight loss– Rottage}}{\text{Initial weight}} \text{ X } 100$$

3.8.2 Weight loss due to rottage

Weight of rotted tubers was taken and percentage of loss due to rottage was calculated by the following formula.

$$\text{Weight loss due to rottage (\%)} = \frac{\text{Weight of tuber rotted}}{\text{Initial weight}} \text{ X } 100$$

3.8.3 Total weight loss

Physiological loss in weight and weight loss due to rottage were combined to estimate total weight loss in storage.

3.8.4 Decay percentage

Number of rotten tubers was counted and decay percentage was calculated by the following formula.

$$\text{Decay percentage} = \frac{\text{Number of rotted tubers}}{\text{Total number of tubers}} \times 100$$

3.8.5 Pathogens associated with rolting

Fungus associated with rotting was observed under microscope and identified based on vegetative hyphae and conidial structures with the help of experts from the Department of Plant Pathology.

3.8.6 Sprouting percentage

Tubers having at least one sprout longer than 0.5 cm was counted as sprouted tuber and sprouting percentage was calculated by the following formula.

$$\text{Sprouting (\%)} = \frac{\text{Number of sprouted tubers}}{\text{Total number of tubers}} \times 100$$

3.8.7 Number of sprouts per tuber

Five randomly selected tubers from each replication were observed and number of sprouted buds per tuber was recorded. Five readings were averaged to get number of sprouts per tuber.

3.8.8 Length of sprout

Five randomly selected tubers were observed and length of the longest sprout in tuber was measured. Five readings were averaged and average length of sprout was expressed in cm.

3.8.9 Sprout Weight

At the end of storage (After 120 days), sprouts were removed and percentage of the sprout weight to the tuber weight was calculated by the following formula

$$\text{Sprout weight (\%)} = \frac{\text{Sprout weight}}{\text{Tubers weight}} \times 100$$

3.8.10 Dry matter

Dry matter was estimated before storage and after the completion of storage period. Three randomly selected tubers were cut into thin slices with stainless steel knife and kept in hot air oven at 60°C till it attained constant weight. Dry matter was calculated by the following formula.

$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh Weight}} \times 100$$

3.8.11 Sugar estimation

5 g fresh weight of tuber was taken and grinded with 80 per cent ethanol in pistle and mortar. It was filtered through Muslin cloth and then through Whatman filter paper No.1. The extract was used for

estimation of reducing and total sugars following dinitrosalicyclic method described by Sadasivam and Manicham (1992). Sugar content was expressed in mg per 100 g fresh weight.

3.8.12 Ascorbic acid estimation

5g of fresh sample was ground with 4 per cent oxallic acid, and 5 ml of extract taken from known volume was titrated against 2,6 dichlorophenol Indophenol dye (Sadasivam and Manicham, 1992). Ascorbic acid content was expressed in mg per 100 g fresh weight.

3.8.13 Amylase activity assay

Potato tuber without peel was ground with chilled acetone in pistle and mortar and washed with chilled acetone on buchner funnel. Amylase extraction and assay was done by the method described by Thimmaiah (1989) and it was expressed in μg of maltose produced per mg of protein in 15 min incubation with 1 per cent starch. Protein in enzyme extract was estimated by Lowry's method (Thimmaiah, 1989).

3.8.14 Cooking quality

After 120 days of storage, tubers were cooked in a known quantity of water and after peeling they were subjected for sensory evaluation by a panel of experts from Department of Food and Nutrition. Score card used for sensory evaluation is given in Appendix – III.

3.8.15 Frying quality

After 120 days of storage tubers were sliced into thin pieces and blanched with hot saline water. Potato slices were air dried and then fried in edible oil. Sensory evaluation was done by experts from the Department of Foods and Nutrition and Horticulture following 4 point scale. Score card used for sensory evaluation of fried potato is given in appendix – IV.

3.8.16 Statistical analysis

Experimental data was analysed statistically at the computer center of UAS, Dharwad using MSTAT Computer programme. The design used for analysis was factorial completely randomized design. Percentage data of physiological weight loss, weight loss due to rottage, total weight loss, decay loss and sprouting was angularly transformed by using table given by Fisher and Yates (1963) before subjecting to analysis. Probability level of 1 per cent was used for mean comparison of sugar and ascorbic acid data and 5 per cent level was used for mean comparison of other data.

Correlation analysis were carried out to study the nature and degree of relationship between various characters of potato tubers after four months of storage. Interpretation of data was done following the method of Panse and Sukhatme (1967).

Experimental Results

IV. EXPERIMENTAL RESULTS

4.1 POST HARVEST BEHAVIOUR OF POTATO GENOTYPES UNDER DIFFERENT STORAGE CONDITIONS

Due to insufficient cold storage facilities in the country, more than half of the potato produce is stored at ambient temperature before it is disposed off (Kaul and Mehta, 1988). Thus it is important to evaluate the varieties of potato for storability under non-refrigerated storage. In the present investigation, six potato varieties were evaluated for their storability with or without chemical treatment under zero energy cool chamber (ZECC) and Ambient storage condition (ASC)

4.1.1 Physiological loss in weight (PLW%)

Data pertaining to PLW (%) of potato genotypes stored under different storage conditions are presented in Table 1. There was gradual increase in per cent cumulative PLW irrespective of storage condition and variety. PLW of tubers increased from 2.32 per cent during first month to 11.27 per cent after four months of storage. However, the tubers under ZECC maintained significantly low PLW (%) throughout the storage period and cumulative PLW (%) after four months was 8.54 per cent as compared 14.0 per cent under ASC.

Among the varieties, Kufri Ashoka and Kufri Jawahar recorded lower (1.75%) and higher (3.34%) PLW, respectively during first month. However the cumulative PLW (%) was lower in tubers of Kufri

Table 1. Physiological loss in weight (PLW%) * in different potato cultivars during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	1.64 (7.21)	3.22 (10.31)	4.39 (12.02)	8.54 (17.08)	4.45 (11.65)
S_2	3.05 (9.81)	6.00 (14.04)	9.55 (17.86)	14.00 (21.87)	8.14 (15.90)
Variety (V)					
V_1	1.75 (7.51)	3.84 (11.26)	7.50 (15.61)	11.17 (19.47)	6.07 (13.46)
V_2	2.34 (8.71)	5.46 (13.28)	6.96 (14.87)	10.96 (19.05)	6.43 (13.98)
V_3	3.34 (10.05)	5.17 (12.98)	8.25 (16.38)	12.34 (20.43)	7.28 (14.96)
V_4	2.17 (8.31)	3.83 (11.19)	5.83 (13.66)	10.96 (19.11)	5.70 (13.07)
V_5	2.17 (8.10)	5.79 (13.46)	8.88 (17.05)	14.46 (20.66)	7.83 (15.32)
V_6	2.17 (8.40)	3.59 (10.89)	4.42 (12.06)	7.75 (16.15)	4.48 (11.87)
$S_1 \times V_1$	1.5 (6.96)	3.5 (10.75)	4.67 (12.50)	9.17 (17.65)	4.71 (11.96)
$S_1 \times V_2$	2.17 (8.36)	3.5 (10.76)	4.0 (11.45)	7.17 (15.50)	4.21 (11.51)
$S_1 \times V_3$	1.5 (6.93)	3.5 (10.80)	5.17 (13.13)	9.25 (17.73)	4.86 (12.15)
$S_1 \times V_4$	1.67 (7.26)	2.83 (9.69)	3.33 (10.53)	7.58 (16.00)	3.85 (10.87)
$S_1 \times V_5$	1.0 (5.70)	3.0 (9.86)	5.67 (13.76)	11.25 (20.50)	5.23 (12.45)
$S_1 \times V_6$	2.0 (8.06)	3.0 (10.03)	3.5 (10.76)	6.83 (15.13)	3.83 (11.00)
$S_2 \times V_1$	2.0 (8.06)	4.17 (11.76)	10.33 (18.73)	13.17 (21.29)	7.42 (14.96)
$S_2 \times V_2$	2.57 (9.05)	7.42 (15.80)	9.92 (18.30)	14.75 (22.60)	8.65 (16.43)
$S_2 \times V_3$	5.18 (13.16)	6.83 (15.16)	11.33 (19.63)	15.42 (23.12)	9.69 (17.77)
$S_2 \times V_4$	2.67 (9.36)	4.83 (12.70)	8.33 (16.80)	14.33 (22.33)	7.54 (15.27)
$S_2 \times V_5$	3.33 (10.50)	8.58 (17.06)	12.08 (20.33)	17.67 (24.83)	10.42 (18.18)
$S_2 \times V_6$	2.33 (8.73)	4.17 (11.75)	5.33 (13.36)	8.67 (17.16)	5.13 12.75
Mean	2.32 (8.51)	4.61 (12.18)	6.97 (14.94)	11.27 (19.48)	6.30 (13.78)

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.104	0.18	0.254	0.147	0.208	0.367	0.509
CD (5%)	0.29	0.50	0.71	0.41	0.58	1.01	1.42

* Initial weight – 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Chandramukhi (7.75%) and higher in Kufri Sutlej (14.46) after four month storage period.

Storage condition variety and storage period interaction was significant for PLW (%). Tubers of Kufri Sutlej stored in ZECC recorded lower PLW (1.0%) during first month. But the per cent PLW after four months of storage was recorded lower in cv. Kufri Chandramukhi (6.83%) followed by Kufri Pukhraj (7.17%) and higher in Kufri Sutlej (11.25%). The per cent PLW after one month storage under ambient condition was lower in tubers cv. Kufri Ashoka (2.0) and higher in Kufri Jawahar (5.18), whereas tubers of Kufri Chandramukhi and Kufri Sutlej respectively recorded lower (8.67%) and higher (17.67%) values respectively after the storage period of four months.

4.1.2 Per cent weight loss due to rottage

There was a general increase in per cent cumulative weight loss due to rottage with increasing storage period (Table 2). Mean per cent weight loss due to rottage was 0.61 per cent during first month, which gradually rose to 8.84 per cent after the storage period of four months. However, weight loss due to rottage was significantly lower under ZECC throughout the storage period and it was recorded only 4.29 per cent after storage period of four months as compared to 13.39 per cent under ambient storage.

Potato cv. Kufri Ashoka and Kufri Jawahar did not show any rotting during first month of storage. But weight loss due to rottage was lower in

Table 2. Per cent weight loss * due to rottage in different potato cultivars during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	0.47	1.61	2.57	4.29	2.24
	(2.05)	(6.05)	(7.24)	(11.13)	(6.62)
S_2	0.75	4.69	9.78	13.39	7.15
	(3.66)	(11.33)	(17.72)	(20.88)	(13.40)
Variety (V)					
V_1	0.00	3.59	9.42	10.92	5.98
	(0.00)	(9.28)	(14.50)	(16.58)	(10.09)
V_2	1.59	3.38	6.04	11.30	5.58
	(7.11)	(10.36)	(13.31)	(18.38)	(12.29)
V_3	0.00	0.50	4.67	6.75	2.98
	(0.00)	(2.30)	(8.90)	(14.10)	(6.32)
V_4	0.83	0.83	2.08	3.92	1.92
	(4.23)	(4.23)	(7.37)	(11.36)	(6.80)
V_5	0.84	6.00	10.21	13.96	7.75
	(3.68)	(13.76)	(18.60)	(21.75)	(14.45)
V_6	0.42	4.63	4.63	6.21	3.97
	(2.11)	(12.21)	(12.21)	(13.88)	(10.10)
$S_1 \times V_1$	0.00	0.67	0.67	1.17	0.63
	(0.00)	(3.80)	(3.80)	(6.13)	(3.43)
$S_1 \times V_2$	2.00	2.00	2.00	3.67	2.42
	(8.1)	(8.1)	(8.10)	(11.00)	(8.82)
$S_1 \times V_3$	0.00	0.00	0.00	2.33	0.58
	(0.00)	(0.00)	(0.00)	(8.70)	(2.17)
$S_1 \times V_4$	0.83	0.83	0.83	3.33	1.46
	(4.23)	(4.23)	(4.23)	(10.53)	(5.81)
$S_1 \times V_5$	0.00	3.25	9.00	12.33	6.15
	(0.00)	(10.30)	(17.46)	(20.56)	(12.08)
$S_1 \times V_6$	0.00	2.92	2.92	2.92	2.19
	(0.00)	(9.86)	(9.86)	(9.86)	(7.40)
$S_2 \times V_1$	0.00	6.50	18.17	20.67	11.34
	(0.00)	(14.76)	(25.20)	(27.07)	(16.75)
$S_2 \times V_2$	1.17	4.75	10.08	18.92	8.73
	(6.13)	(12.63)	(18.53)	(25.76)	(15.76)
$S_2 \times V_3$	0.00	1.00	9.33	11.17	5.38
	(0.00)	(4.60)	(17.80)	(19.50)	(10.47)
$S_2 \times V_4$	0.83	0.83	3.33	4.50	2.37
	(4.23)	(4.23)	(10.50)	(12.20)	(7.79)
$S_2 \times V_5$	1.67	8.75	11.42	15.58	9.36
	(7.36)	(17.23)	(19.73)	(22.93)	(16.82)
$S_2 \times V_6$	0.83	6.33	6.33	9.50	5.75
	(4.23)	(14.56)	(14.56)	(17.90)	(12.81)
Mean	0.61	3.15	6.17	8.84	4.69
	(2.85)	(8.69)	(12.48)	(16.01)	(10.01)

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.089	0.154	0.218	0.126	0.178	0.308	0.436
CD (5%)	0.25	0.43	0.61	0.35	0.50	0.86	1.22

* Initial weight – 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Kufri Jyoti (3.92%) and higher in Kufri Sutlej (13.96%) after four months of storage.

Potato tubers cv. Kufri Ashoka, Kufri Jawahar, Kufri Sutlej and Kufri Chandramukhi stored under ZECC and Kufri Ashoka and Kufri Jawahar stored in ambient condition did not show any rotting during the first month. But per cent weight loss after four months of storage was recorded higher in Kufri Ashoka (20.67) followed by Kufri Pukhraj (18.92) and lower in Kufri Jyoti (4.50%) under ambient storage. Whereas it was higher in cv. Kufri Sutlej (12.33%) and lower in Kufri Ashoka (1.17%) under zero energy cool chamber after storage period of four months.

4.1.3 Pathogens associated with rotting

Rotting of tubers stored in ZECC might have occurred due to fungal infection and some of the genera associated with rotting were *Fusarium, Rhizopus* and *Aspergillus*. Most tubers stored under ambient condition rotted without showing any visible fungal growth. Infestation of potato tuber moth also accounted for rotting of tuber under ambient condition.

4.1.4 Per cent total weight loss

Storage condition, variety, storage period and their interaction had significant effect on per cent total weight loss (Table 3 and Figure 1). Mean total cumulative weight loss increased from 2.93 per cent during first month to 20.11 per cent at the end of four months storage. However, total weight loss in ZECC was significantly lower throughout the storage

Table 3. Per cent total weight loss * in different potato cultivars during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	2.11	4.83	6.96	12.83	6.68
	(8.15)	(12.62)	(14.93)	(20.86)	(14.14)
S_2	3.75	10.69	19.33	27.38	15.29
	(10.92)	(18.84)	(25.55)	(31.38)	(21.67)
Variety (V)					
V_1	1.75	7.42	16.92	22.08	12.94
	(7.50)	(15.41)	(22.83)	(27.16)	(18.23)
V_2	3.91	8.83	13.0	22.25	12.0
	(11.36)	(17.00)	(19.36)	(27.36)	(18.77)
V_3	3.34	5.66	12.92	19.08	10.25
	(10.05)	(13.53)	(20.08)	(25.46)	(17.28)
V_4	3.00	4.67	7.91	14.87	7.61
	(9.91)	(12.40)	(15.85)	(22.51)	(15.17)
V_5	3.00	11.79	19.09	28.91	15.57
	(9.31)	(19.55)	(25.98)	(32.50)	(21.83)
V_6	2.58	8.21	9.04	13.95	8.44
	(9.10)	(16.49)	(17.33)	(21.73)	(16.16)
$S_1 X V_1$	1.5	4.17	5.34	10.33	5.34
	(6.93)	(11.76)	(13.36)	(18.73)	(12.70)
$S_1 X V_2$	4.17	5.5	6.0	10.84	6.63
	(12.23)	(13.56)	(14.13)	(19.23)	(14.79)
$S_1 X V_3$	1.5	3.5	5.17	11.58	5.44
	(6.93)	(10.80)	(13.13)	(19.90)	(12.69)
$S_1 X V_4$	2.5	3.66	4.16	10.92	5.31
	(9.06)	(11.03)	(11.73)	(19.30)	(12.78)
$S_1 X V_5$	1.0	6.25	14.67	23.58	11.38
	(5.70)	(14.46)	(22.53)	(29.76)	(18.11)
$S_1 X V_6$	2.0	5.92	6.42	9.75	6.02
	(8.06)	(14.09)	(14.70)	(18.23)	(13.77)
$S_2 X V_1$	2.0	10.67	28.5	33.84	18.75
	(8.07)	(19.06)	(32.30)	(35.60)	(23.76)
$S_2 X V_2$	3.67	12.17	20.0	33.67	11.37
	(10.50)	(20.43)	(24.60)	(35.50)	(22.75)
$S_2 X V_3$	5.18	7.83	20.66	26.59	15.07
	(13.16)	(16.26)	(27.03)	(31.03)	(21.87)
$S_2 X V_4$	3.5	5.66	11.66	18.83	9.91
	(10.76)	(13.76)	(19.97)	(25.73)	(17.56)
$S_2 X V_5$	5.0	17.33	23.50	33.25	19.77
	(12.93)	(24.63)	(29.43)	(35.23)	(25.55)
$S_2 X V_6$	3.16	10.50	11.66	18.17	10.87
	(10.13)	(18.90)	(19.96)	(25.23)	(18.55)
Mean	2.93	7.76	13.15	20.11	10.99
	(9.54)	(15.73)	(20.24)	(26.12)	(17.91)

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.1180	0.2044	0.2891	0.1669	0.2360	0.4088	0.5781
CD (5%)	0.33	0.57	0.81	0.47	0.66	1.14	1.62

* Initial weight – 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

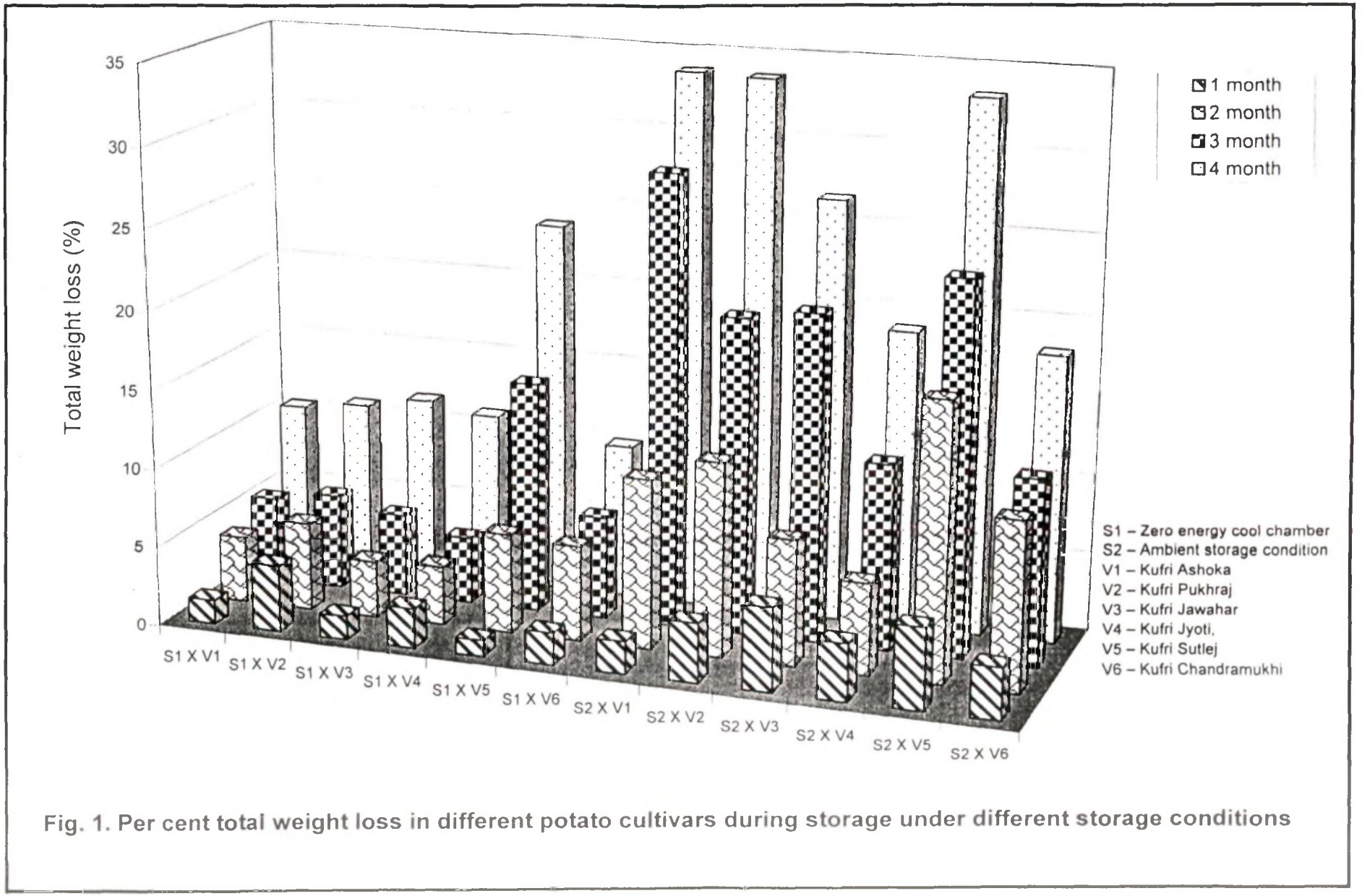

Fig. 1. Per cent total weight loss in different potato cultivars during storage under different storage conditions

period and it was recorded only 12.83 per cent after storage period of four months as compared to 27.38 per cent under ambient storage.

Among the varieties, higher and lower total weight loss was recorded in potato tubers cv. Kufri Pukhraj (3.91%) and Kufri Ashoka (1.75%) respectively during first month. But it was higher in Kufri Sutlej (28.91%) and lower in Kufri Chandramukhi (13.95%) followed by Kufri Jyoti (14.87%) after four months of storage.

During the first month of storage potato tubers cv. Kufri Pukhraj and Kufri Sutlej respectively recorded higher (4.17%) and lower (1.0%) total weight loss under ZECC, whereas Kufri Jawahar and Kufri Ashoka recorded higher (5.18%) and lower (2.0%) values respectively under ambient condition.

Per cent total weight loss after four months of storage was recorded higher in cv. Kufri Sutlej (23.58) and lower in Kufri Chandramukhi (9.75) under ZECC. Whereas under ambient storage, Kufri Ashoka and Kufri Chandramukhi respectively recorded higher (33.84) and lower (18.17) values. However, Kufri Ashoka, Kufri Pukhraj and Kufri Jyoti under ZECC and Kufri Jyoti under ambient storage were statistically on par with Kufri Chandramukhi.

4.1.5 Per cent decay loss

Data on per cent decay loss of potato tubers under different storage conditions are presented in Table 4. Per cent decay loss increased from

Table 4. Losses due to decay (%) in different potato cultivars during storage under different storage condition

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	0.42	1.72	2.60	4.32	2.27
	(1.93)	(6.19)	(7.29)	(10.94)	(6.59)
S_2	1.15	5.60	11.22	15.05	8.26
	(4.29)	(12.52)	(19.22)	(22.49)	(14.63)
Variety (V)					
V_1	0.00	3.61	7.11	8.70	4.86
	(0.00)	(9.50)	(12.88)	(15.54)	(9.48)
V_2	2.15	4.27	7.71	12.50	6.66
	(8.20)	(11.04)	(14.31)	(18.76)	(13.08)
V_3	0.00	0.60	4.76	6.92	3.07
	(0.00)	(2.50)	(8.94)	(13.29)	(6.18)
V_4	1.37	1.37	2.53	4.41	2.42
	(5.43)	(5.43)	(8.15)	(12.04)	(7.76)
V_5	0.46	6.51	11.49	16.13	8.65
	(2.23)	(14.30)	(19.72)	(23.51)	(14.94)
V_6	0.73	5.62	7.88	9.92	6.04
	(2.80)	(13.35)	(15.51)	(17.15)	(12.20)
$S_1 \times V_1$	0.00	0.90	0.90	1.93	0.93
	(0.00)	(4.40)	(4.40)	(7.93)	(4.18)
$S_1 \times V_2$	1.39	1.39	1.39	2.62	1.70
	(6.63)	(6.63)	(6.63)	(9.32)	(7.30)
$S_1 \times V_3$	0.00	0.00	0.00	1.86	0.47
	(0.00)	(0.00)	(0.00)	(6.36)	(1.59)
$S_1 \times V_4$	1.15	1.15	1.15	3.62	1.77
	(4.96)	(4.96)	(4.96)	(10.91)	(6.45)
$S_1 \times V_5$	0.00	3.78	9.03	12.76	6.39
	(0.00)	(10.93)	(17.53)	(20.93)	(12.35)
$S_1 \times V_6$	0.00	3.12	3.12	3.12	2.34
	(0.00)	(10.2)	(10.2)	(10.2)	(7.65)
$S_2 \times V_1$	0.00	6.32	13.31	15.46	8.77
	(0.00)	(14.6)	(21.36)	(23.14)	(14.77)
$S_2 \times V_2$	2.91	7.15	14.02	22.37	11.61
	(9.77)	(15.45)	(21.99)	(28.21)	(18.85)
$S_2 \times V_3$	0.00	1.19	9.51	11.98	5.67
	(0.00)	(5.01)	(17.88)	(20.21)	(10.77)
$S_2 \times V_4$	1.59	1.59	3.91	5.19	3.07
	(5.90)	(5.90)	(11.34)	(13.17)	(9.08)
$S_2 \times V_5$	0.92	9.23	13.94	19.50	10.90
	(4.46)	(17.67)	(21.91)	(26.10)	(17.54)
$S_2 \times V_6$	1.45	8.11	12.64	16.72	9.73
	(5.60)	(16.50)	(20.83)	(24.11)	(16.76)
Mean	0.79	3.66	6.91	9.74	5.27
	(3.11)	(9.35)	(13.25)	(16.71)	(10.61)

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.095	0.164	0.232	0.134	0.19	0.328	0.464
CD (5%)	0.27	0.46	0.65	0.38	0.53	0.92	1.30

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Plate 3. Photograph of the potato tubers of different cultivars after four month of storage under ZECC

Plate 4. Photograph of the potato tubers of different cultivars after four months of storage under ambient storage condition

0.79 during first month to 9.74 at the end of four months. However, tubers stored under ZECC recorded significantly lower values throughout the storage period and it was recorded 4.32 per cent after the storage period of four months as compared to 15.05 per cent under ambient storage.

Per cent cumulative decay loss was found more in tubers cv. Kufri Sutlej (16.13%) and less in Kufri Jyoti (4.41%) after storage period of four months.

No rotting was observed in tubers cv. Kufri Ashoka, Kufri Jawahar, Kufri Sutlej and Kufri Chandramukhi during first month of storage under ZECC, whereas it was recorded 1.39 per cent in Kufri Pukhraj. Under ambient condition, cv. Kufri Ashoka and Kufri Jawahar did not show any decay and it was 2.91 per cent in Kufri Pukhraj during first month. However, after four months of storage, decay loss ranged from 1.86 (Kufri Jawahar) to 12.76 per cent (Kufri Sutlej) under ZECC and 5.19 (Kufri Jyoti) to 22.37 per cent (Kufri Pukhraj) under ambient storage condition.

4.1.6 Per cent sprouting

Tubers of all varieties started sprouting within a month and attained more than 90 per cent sprouting at the end of three months storage except Kufri Chandramukhi, which showed 85.47 per cent sprouting (Table 5 and Figure 2). Sprouting percentage was significantly higher in tubers stored under ZECC than those under ambient condition upto three months and there was cent per cent sprouting after four months under both storage conditions.

Table 5. Sprouting percentage of potato cultivars during storage under different storage condition

Treatment	Storage period in month (P)				
	1	2	3	4	Mean
Storage condition (S)					
S_1	16.17	58.95	99.37	100	68.62
	(23.28)	(50.25)	(88.14)	(90.0)	(62.92)
S_2	9.20	42.13	93.20	100	61.13
	(17.26)	(40.40)	(77.80)	(90.0)	(56.36)
Variety (V)					
V_1	12.55	51.09	98.23	100	65.47
	(20.38)	(45.62)	(84.56)	(90.0)	(60.14)
V_2	7.10	52.54	97.54	100	64.30
	(15.39)	(46.49)	(83.61)	(90.0)	(58.87)
V_3	14.21	52.03	97.34	100	65.90
	(21.15)	(46.18)	(83.38)	(90.0)	(60.18)
V_4	16.68	61.17	100	100	69.46
	(24.09)	(51.69)	(90.0)	(90.0)	(63.94)
V_5	18.34	54.48	99.16	100	68.0
	(25.11)	(47.65)	(86.94)	(90.0)	(62.42)
V_6	7.21	31.92	85.47	100	56.15
	(15.49)	(34.33)	(69.33)	(90.0)	(52.29)
$S_1 X V_1$	17.24	54.95	100	100	68.05
	(24.52)	(47.84)	(90.0)	(90.0)	(63.09)
$S_1 X V_2$	8.35	61.02	100	100	67.34
	(16.77)	(51.37)	(90.0)	(90.0)	(62.04)
$S_1 X V_3$	22.49	61.14	100	100	70.91
	(28.30)	(51.43)	(90.0)	(90.0)	(64.93)
$S_1 X V_4$	16.92	73.58	100	100	72.63
	(24.26)	(59.09)	(90.0)	(90.0)	(65.83)
$S_1 X V_5$	23.63	66.93	100	100	72.64
	(29.05)	(54.90)	(90.0)	(90.0)	(65.98)
$S_1 X V_6$	8.36	36.06	96.24	100	60.17
	(16.78)	(36.86)	(78.87)	(90.0)	(55.63)
$S_2 X V_1$	7.86	47.22	96.46	100	62.89
	(16.24)	(43.40)	(79.12)	(90.0)	(57.12)
$S_2 X V_2$	5.84	44.06	95.07	100	61.24
	(14.0)	(41.60)	(77.22)	(90.0)	(55.71)
$S_2 X V_3$	5.92	42.92	94.67	100	60.88
	(14.0)	(40.94)	(76.76)	(90.0)	(55.42)
$S_2 X V_4$	16.44	48.76	100	100	66.30
	(23.91)	(44.29)	(90.0)	(90.0)	(62.05)
$S_2 X V_5$	13.07	42.03	98.32	100	63.36
	(21.18)	(40.41)	(83.89)	(90.0)	(58.87)
$S_2 X V_6$	6.05	27.77	74.69	100	52.13
	(14.20)	(31.80)	(59.80)	(90.0)	(48.95)
Mean	12.68	50.54	96.29	100	64.88
	(20.27)	(45.33)	(82.97)	(90.0)	(59.64)

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.1383	0.2395	0.3387	0.1956	0.2766	0.4790	0.6675
CD (5%)	0.39	0.67	0.95	0.55	0.77	1.34	1.90

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy coo chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

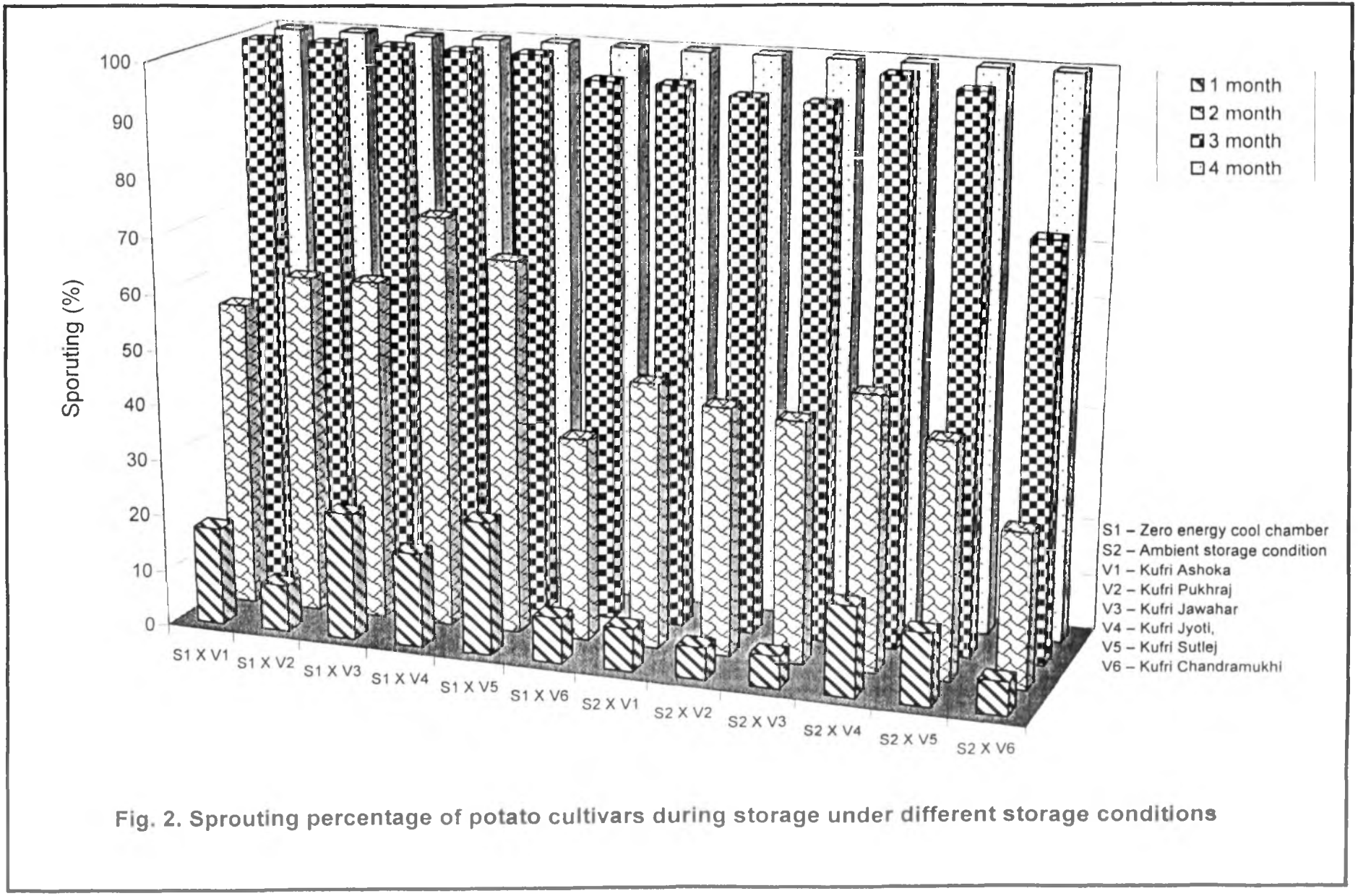

Fig. 2. Sprouting percentage of potato cultivars during storage under different storage conditions

Among the combinations of storage condition and varieties, sprouting under ZECC was 100 per cent in all varieties except in cv. Kufri Chandramukhi (96.24%) after three months of storage. Whereas under ambient storage condition, it ranged from 74.69 per cent (Kufri Chandramukhi) to 100 per cent (Kufri Jyoti).

4.1.7 Number of sprout per sprouted tuber

Number of sprouts increased with increasing storage period (Table 6). The mean sprout number was 2.79 and 3.13 respectively after three and four months storage. However, the tubers stored under ZECC recorded higher number of sprouts during both observation period and mean number recorded was 3.39 under ZECC and 2.53 under ambient storage.

Among the cultivars, Kufri Jawahar recorded higher number of sprouts during both observation period (3.55 and 3.80 respectively) and it was lower in cv. Kufri Chandramukhi (1.0 and 1.53 respectively). Interaction of storage condition, variety and storage period with respect to number of sprout was significant. Higher number of sprouts was recorded in tubers cv. Kufri Jawahar (4.40 and 4.73 respectively) and lower in Kufri Chandramukhi (1.0 and 1.86 respectively) after three and four months of storage under ZECC. Under ambient condition tubers cv. Kufri Jyoti recorded higher (2.93) and Kufri Chandramukhi with lower (1.0) sprout number after three months. But tubers of Kufri Jyoti and Kufri Ashoka were on par with 3.10 sprouts followed by Kufri Pukhraj (3.0) and Kufri

Table 6. Number of sprout per tuber in different potato cultivars during storage under different storage conditions

Treatment	Storage period in month (P)		Mean
	3	4	
Storage condition (S)			
S_1	3.21	3.57	3.39
S_2	2.37	2.69	2.53
Variety (V)			
V_1	3.01	3.48	3.25
V_2	2.80	3.10	2.95
V_3	3.55	3.80	3.67
V_4	3.13	3.33	3.23
V_5	3.25	3.55	3.40
V_6	1.00	1.53	1.26
$S_1 \times V_1$	3.46	3.86	3.66
$S_1 \times V_2$	3.06	3.20	3.13
$S_1 \times V_3$	4.40	4.73	4.56
$S_1 \times V_4$	3.33	3.56	3.45
$S_1 \times V_5$	4.0	4.20	4.10
$S_1 \times V_6$	1.0	1.86	1.43
$S_2 \times V_1$	2.56	3.10	2.83
$S_2 \times V_2$	2.53	3.00	2.77
$S_2 \times V_3$	2.70	2.86	2.78
$S_2 \times V_4$	2.93	3.10	3.01
$S_2 \times V_5$	2.50	2.90	2.70
$S_2 \times V_6$	1.00	1.20	1.10
Mean	2.79	3.13	2.96

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.018	0.032	0.045	0.018	0.026	0.045	0.063
CD (5%)	0.05	0.09	0.13	0.05	NS	0.13	0.18

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Chandramukhi recorded only 1.20 after storage period of four months. Tubers cv. Kufri Jawahar and Kufri Sutlej, which recorded higher number of sprouts under ZECC surprisingly recorded lower number under ambient condition.

4.1.8 Length of longest sprout (cm)

Data on length of longest sprout recorded after three and four months of storage are presented in Table 7.

Mean length of longest sprout increased with increasing storage period. Higher value for the length of longest sprout was recorded in tubers under ZECC during both observation period and mean length was 3.02 cm under ZECC as compared to 1.60 cm under ambient storage. Among the varieties, tubers of Kufri Sutlej recorded longer sprout length during both observation period (2.53 and 3.02 cm) and Kufri Chandramukhi with shorter (1.48 and 1.87 cm) length.

Under both ZECC and ambient storage conditions, mean longest sprout length among the varieties was higher (3.70 and 1.84 cm respectively) in Kufri Sutlej and lower (2.20 and 1.20 cm respectively) in Kufri Chandramukhi. However, interaction of storage condition, variety and storage period was non-significant.

4.1.9 Sprout weight

Data on sprout weight (g /500 g tuber) and per cent sprout weight to tuber weight recorded at the end of four months of storage is presented in table 8.

Table 7. Length of longest sprout (cm) in different potato cultivars during storage under different storage conditions

Treatment	Storage period in month (P)		Mean
	3	4	
Storage condition (S)			
S_1	2.93	3.12	3.02
S_2	1.29	1.91	1.60
Variety (V)			
V_1	2.34	2.68	2.51
V_2	2.18	2.60	2.39
V_3	1.92	2.42	2.17
V_4	2.23	2.52	2.37
V_5	2.53	3.02	2.77
V_6	1.48	1.87	1.67
S_1 X V_1	3.14	3.33	3.24
S_1 X V_2	3.07	3.20	3.13
S_1 X V_3	2.70	2.93	2.82
S_1 X V_4	3.04	3.20	3.12
S_1 X V_5	3.53	3.88	3.70
S_1 X V_6	2.09	2.20	2.14
S_2 X V_1	1.53	2.04	1.78
S_2 X V_2	1.28	2.0	1.64
S_2 X V_3	1.13	1.90	1.52
S_2 X V_4	1.41	1.84	1.63
S_2 X V_5	1.52	2.16	1.84
S_2 X V_6	0.86	1.54	1.20
Mean	2.11	2.52	2.31

	Storage condition (S)	Variety (V)	S X V	Storage period (P)	S X P	V X P	S X V X P
S.Em±	0.0244	0.0422	0.0597	0.0244	0.0345	0.0597	0.0844
CD (5%)	0.07	0.12	0.17	0.07	0.10	NS	NS

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Sprout weight per 500 g tuber was recorded significantly higher in tubers stored under ZECC (11.74 g) as compared to those under ambient storage (8.72 g). Among the varieties, it was higher in tubers of Kufri Sutlej (12.71 g) and lower in Kufri Chandramukhi (7.26 g). Interaction of storage condition and variety was also significant. Sprout weight/500 g tubers was recorded higher in tubers of Kufri Sutlej (14.61 and 10.80 g) and lower in Kufri Chandramukhi (9.05 and 5.47 g) under ZECC and ASC respectively. Tubers of cv. Kufri Jyoti (10.06 g/500 g tuber) did not differ statistically from Kufri Sutlej under ambient storage.

Per cent sprout weight varied from 1.81 (Kufri Chandramukhi) to 2.92 (Kufri Sutlej) under ZECC and it ranged from 1.16 (Kufri Chandramukhi) to 2.16 (Kufri Sutlej) under ambient storage.

4.1.10 Dry matter (%)

Dry matter content to tubers decreased during storage (Table 8). Mean dry matter content of tubers stored under ambient condition was marginally higher (18.56%) with value ranging from 17.5 (Kufri Jawahar) to 20.53 per cent (Kufri Chandramukhi). Whereas mean dry matter content of tubers stored under ZECC was 17.41 per cent with value ranging from 16.28 (Kufri Jyoti) to 20.34 per cent (Kufri Chandramukhi).

Among the varieties, Kufri Chandramukhi retained significantly higher dry matter (20.43%). Whereas other varieties did not differ statistically with respect to dry matter content after storage period of four months.

Table 8. Dry matter content, sprout weight (g/500 g tuber) and per cent sprout weight in potato cultivars after 4 months of storage under different storage conditions

Treatment	Dry matter (%)		Sprout weight g/ 500 g tuber	Per cent sprout weight
	Initial	After 4 month		
Storage condition (S)				
S_1		17.41	11.74	2.34
S_2		18.56	8.72	1.75
S.Em±		0.248	0.142	0.03
CD (5%)		0.72	0.41	0.08
Variety (V)				
V_1	18.9	17.65	9.27	1.85
V_2	20.9	17.9	10.53	2.10
V_3	18.64	17.28	10.63	2.12
V_4	20.36	17.15	10.98	2.19
V_5	20.0	17.5	12.71	2.54
V_6	20.9	20.43	7.26	1.48
S.Em±		0.43	0.25	0.05
CD (5%)		1.25	0.71	0.14
S_1 X V_1		17.0	11.68	2.33
S_1 X V_2		16.79	11.36	2.27
S_1 X V_3		17.05	11.83	2.36
S_1 X V_4		16.28	11.90	2.38
S_1 X V_5		17.0	14.61	2.92
S_1 X V_6		20.34	9.05	1.81
S_2 X V_1		18.3	6.86	1.37
S_2 X V_2		19.0	9.70	1.94
S_2 X V_3		17.5	9.43	1.88
S_2 X V_4		18.03	10.06	2.01
S_2 X V_5		18.0	10.80	2.16
S_2 X V_6		20.53	5.47	1.16
S.Em±		0.61	0.35	0.069
CD (5%)		1.77	1.01	0.20

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

4.1.11 Cooking quality

Data of sensory characteristics of cooked potato evaluated after storage period of four months are presented in table 9.

Tubers stored under ZECC scored significantly higher value than those under ambient storage with respect to all sensory characteristics except taste, which was found non-significant.

Varietal difference was found significant for all sensory characteristics. Higher score for appearance was recorded in tubers cv. Kufri Jawahar (3.41) followed by Kufri Ashoka (3.37), Kufri Pukhraj (3.31) and Kufri Jyoti (3.18), whereas Kufri Chandramukhi scored significantly lower value (2.70). Score for taste was recorded higher in tubers cv. Kufri Jawahar (3.46) followed by Kufri Pukhraj (3.05), Kufri Ashoka (2.99) and Kufri Jytoi (2.98), whereas significantly lower value was recorded in Kufri Chandramukhi (2.60).

Score with regard to texture was recorded higher in cv. Kufri Ashoka (3.87) and lower in Kufri Jawahar and Kufri Chandramukhi (3.68). Kufri Pukhraj (3.86), Kufri Jyoti (3.81) and Kufri Sutlej (3.78) were statistically on par with Kufri Ashoka.

Score with regard to flavour was recorded higher in tubers cv. Kufri Jawahar (3.13) and lower in Kufri Chandramukhi (2.52). However, Kufri Ashoka (3.0), Kufri Pukhraj (3.0) and Kufri Jyoti (2.99) were statistically on par with Kufri Jawahar.

Table 9. Cooking quality * of potato cultivars after 4 months of storage under different storage conditions

Treatment	Appearance	Taste	Texture	Flavour	Overall acceptability
Storage condition (S)					
S_1	3.50	3.08	3.90	3.03	3.05
S_2	2.82	2.82	3.66	2.74	2.73
S.Em±	0.0481	0.0913	0.0215	0.0736	0.0631
CD (5%)	0.15	NS	0.07	0.23	0.19
Variety (V)					
V_1	3.37	2.99	3.87	3.00	3.10
V_2	3.31	3.05	3.86	3.00	3.20
V_3	3.41	3.46	3.68	3.13	3.21
V_4	3.18	2.98	3.81	2.99	2.99
V_5	3.00	2.62	3.78	2.68	2.52
V_6	2.70	2.60	3.68	2.52	2.36
S.Em±	0.0833	0.1582	0.0372	0.1274	0.1092
CD (5%)	0.26	0.49	0.11	0.39	0.34
Interaction (S X V)					
S_1 X V_1	3.73	3.10	3.95	3.10	3.20
S_1 X V_2	3.78	3.37	4.0	3.21	3.41
S_1 X V_3	3.73	3.57	3.95	3.32	3.42
S_1 X V_4	3.32	2.88	3.83	3.05	2.99
S_1 X V_5	3.37	2.73	3.83	2.80	2.74
S_1 X V_6	3.05	2.85	3.83	2.69	2.58
S_2 X V_1	3.01	2.89	3.79	2.90	3.00
S_2 X V_2	2.83	2.73	3.73	2.79	2.99
S_2 X V_3	3.10	3.35	3.42	2.94	3.0
S_2 X V_4	3.04	3.08	3.78	2.94	2.99
S_2 X V_5	2.62	2.51	3.73	2.56	2.30
S_2 X V_6	2.35	2.35	3.52	2.35	2.14
S.Em±	0.1178	0.2238	0.0526	0.1802	0.1545
CD (5%)	NS	NS	0.16	NS	NS

* Scored on 4 point hedonic scale

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Score on overall acceptability was higher in tubers cv. Kufri Jawahar (3.21) followed by Kufri Pukhraj (3.20) and lower in Kufri Chandramukhi (2.36) followed by Kufri Sutlej (2.52).

Storage condition and variety interaction was significant only for texture. Tubers cv. Kufri Pukhraj scored higher (4.0) under ZECC followed by Kufri Ashoka (3.95) and Kufri Jawahar (3.95). Whereas higher score under ambient condition was recorded in tubers of Kufri Ashoka (3.79) followed by Kufri Jyoti (3.78), Kufri Pukhraj (3.73) and Kufri Sutlej (3.73).

4.1.12 Frying quality

No statistical difference for sensory characteristic could be observed between chips made from tubers stored under ZECC and ambient condition (Table 10).

Among the varieties, significant difference was noticed only for taste with higher score being recorded in Kufri Ashoka (3.25) and lower in Kufri Sutlej (2.65). Rest of varieties did not differ statistically with Kufri Ashoka with respect to taste score of chips.

Chips made from ZECC stored tubers of cv. Kufri Jyoti were good in appearance with higher score (3.45) followed by Kufri Chandramukhi (3.30) and lower score was recorded in Kufri Jawahar (2.35). But under ambient condition, chips prepared from cv. Kufri Jawahar scored higher (3.35) followed by Kufri Sutlej (3.01) and Kufri Jyoti recorded lower score (2.56).

Table 10. Chipping quality * of different potato cultivars after 4 months of storage under different storage conditions

Treatment	Appearance	Taste	Texture	Flavour	Overall acceptability
Storage condition (S)					
S_1	2.85	3.00	3.88	3.03	2.83
S_2	2.86	3.06	3.87	3.01	2.86
S.Em±	0.0618	0.0577	0.0351	0.0775	0.0511
CD (5%)	NS	NS	NS	NS	NS
Variety (V)					
V_1	2.87	3.25	3.82	3.25	3.0
V_2	2.62	2.97	3.87	3.05	2.77
V_3	2.85	3.00	3.88	2.87	2.82
V_4	3.00	3.18	3.86	3.13	2.89
V_5	2.75	2.65	3.95	2.67	2.61
V_6	3.01	3.12	3.87	3.17	2.98
S.Em±	0.1070	0.0999	0.0608	0.1342	0.0885
CD (5%)	NS	0.31	NS	NS	NS
S_1 X V_1	2.95	3.40	3.90	3.50	3.15
S_1 X V_2	2.55	2.75	3.85	2.95	2.70
S_1 X V_3	2.35	2.80	3.90	2.60	2.50
S_1 X V_4	3.45	3.25	3.90	3.25	3.00
S_1 X V_5	2.50	2.50	3.90	2.60	2.40
S_1 X V_6	3.30	3.30	3.85	3.45	3.25
S_2 X V_1	2.80	3.10	3.75	3.15	2.85
S_2 X V_2	2.70	3.20	3.90	3.15	2.85
S_2 X V_3	3.35	3.21	3.87	3.15	3.14
S_2 X V_4	2.56	3.12	3.82	3.01	2.78
S_2 X V_5	3.01	2.81	4.00	2.75	2.83
S_2 X V_6	2.73	2.95	3.90	2.90	2.71
S.Em±	0.1514	0.1412	0.0860	0.1898	0.1252
CD (5%)	0.47	0.43	NS	NS	0.38

* Scored on 4 point hedonic scale

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Plate 5. Photograph of the chips made from ZECC stored tubers of different potato varieties

Plate 6. Photograph of the chips made from ambient stored tubers of different potato varieties

Scores with regard to taste in tubers stored under ZECC ranged between 3.40 (Kufri Ashoka) to 2.50 (Kufri Sutlej), whereas under ambient condition it ranged between 3.21 (Kufri Jawahar) to 2.81 (Kufri Sutlej).

Overall acceptability for chips produced from ZECC stored potato tubers was recorded higher in cv. Kufri Chandramukhi (3.25) followed by Kufri Jyoti (3.15) and lower in Kufri Sutlej (2.40), whereas Kufri Jawahar scored higher (3.14) and Kufri Chandramukhi recorded lower (2.71) under ambient condition.

Interaction effect of storage condition and variety was non-significant for texture and flavour of potato chips.

4.1.13 Sugar content (mg/100 g fresh weight)

Data on sugar content of potato tubers stored under different storage conditions are presented in table 11.

4.1.13.1 Reducing sugar

Reducing sugars content of potato ranged between 220 mg (Kufri Chandramukhi) to 330 mg (Kufri Sutlej) before storage. However, reducing sugars content increased during storage and the accumulation of reducing sugars was faster in tubers stored under ZECC as compared to ambient stored one.

Mean value of reducing sugars among cultivars was recorded higher in cv. Kufri Pukhraj and Kufri Sutlej (385.0 mg both), whereas lower value was recorded in Kufri Jyoti (282.50 mg) after storage period of two

Table 11. Sugar content (mg/100 g fresh weight) of potato cultivars during storage under different storage conditions

Treatment	Storage period (month)					
	0		2		4	
	RS	TS	RS	TS	RS	TS
Storage condition (S)						
S_1			373.33	614.91	498.58	719.75
S_2			310.41	566.58	349.66	599.75
S.Em±			5.958	9.77	6.87	5.78
CD (1%)			25.46	42.28	29.75	25.01
Variety (V)						
V_1	260.0	390.0	335.0	602.0	436.25	688.50
V_2	300.0	450.0	385.0	635.0	471.25	714.50
V_3	290.0	475.0	375.0	628.5	443.75	702.25
V_4	225.0	350.0	282.50	550.25	360.50	603.75
V_5	330.0	450.0	385.0	617.25	470.50	681.0
V_6	220.0	330.0	288.75	511.50	360.50	568.5
S.Em±			10.32	16.92	11.91	10.0
CD (1%)			44.69	73.22	51.57	43.27
S_1 X V_1			360.0	625.0	515.0	761.0
S_1 X V_2			430.0	675.0	582.50	805.5
S_1 X V_3			420.0	654.0	540.0	768.5
S_1 X V_4			305.0	571.0	402.50	635.0
S_1 X V_5			410.0	636.0	531.50	725.0
S_1 X V_6			315.0	527.50	420.0	623.5
S_2 X V_1			310.0	579.0	357.5	616.0
S_2 X V_2			340.0	595.0	360.0	623.50
S_2 X V_3			330.0	602.50	347.5	636.0
S_2 X V_4			260.0	529.50	318.5	572.5
S_2 X V_5			360.0	598.0	409.5	637.0
S_2 X V_6			262.5	495.50	301.0	513.
S.Em±			14.595	23.94	16.84	14.15
CD (1%)			NS	NS	72.92	NS

RS – Reducing sugar
TS – Total sugar

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

months. Kufri Chandramukhi also did not differ statistically with Kufri Jyoti for reducing sugars content after two months of storage.

Interaction effect of storage condition and variety was found non-significant for reducing sugar content after two months of storage. After four months of storage, higher content of reducing sugars was recorded 471.25 mg in cv. Kufri Pukhraj and tubers of Kufri Jyoti followed by Kufri Chandramukhi recorded lower values (360.25 and 360.5 mg respectively).

Interaction effect of storage condition and variety was found significant for reducing sugar content after storage period of four months. Tubers of Kufri Pukhraj recorded higher reducing sugars (582.5 mg) followed by Kufri Jawahar (540.0 mg) and Kufri Jyoti recorded lower value (402.5 mg) under ZECC. Whereas higher reducing sugars content was recorded in potato tubers cv. Kufri Sutlej (409.5) followed Kufri Pukhraj (360.0) and lower in Kufri Chandramukhi (301) followed by Kufri Jyoti (318.5) after storage period of four months under ambient condition.

4.1.13.2 Total sugar

Total sugars content of tubers at harvest ranged from 330 (Kufri Chandramukhi) to 475 mg (Kufri Jawahar). During storage there was gradual increase in total sugar content. However, potatoes stored under ZECC showed higher total sugar content ranging from 623.5 mg (Kufri Chandramukhi) to 805.5 mg (Kufri Pukhraj) after storage period of four months. Total sugars content in tubers stored under ambient condition ranged from 513.5 mg (Kufri Chandramukhi) to 636.0 mg (Kufri Jawahar) after four months of storage. But the interaction of storage condition and

variety was non-significant. Mean total sugar content of potato cultivars ranged from 568.5 mg (Kufri Chandramukhi) to 714.50 mg (Kufri Pukhraj) after four months of storage.

4.1.14 Ascorbic acid content (mg/100 g fresh weight)

Ascorbic acid content varied from 22 (Kufri Sutlej) to 36 mg/100 g F.W. (Kufri Chandramukhi) at harvest. However, it decreased during storage and the decline was faster under ambient condition.

Tubers stored under ZECC retained significantly higher ascorbic acid (13.27 and 11.47 mg) as compared to those stored under ambient condition (11.43 and 9.62 mg) after two and four months of storage.

Among the varieties, tubers of Kufri Jyoti recorded higher ascorbic acid content (14.25 and 12.76 mg) and lower values (10.62 and 8.71 mg) were recorded in cv. Kufri Sutlej after two and four months of storage.

Interaction effect of storage condition and variety was found non-significant for ascorbic acid content during storage.

4.1.15 Amylase activity (µg maltose/15 min/mg protein)

Among the different varieties analysed, amylase activity was detected in tubers of Kufri Sutlej and Kufri Chandramukhi at harvest (Table 13 and Figure 3).

Amylase activity was recorded higher in tubers stored under ZECC as compared to tubers stored under ambient condition after two months of storage.

Table 12. Ascorbic acid content (mg/100 g fresh weight) of potato cultivars during storage under different storage conditions

Treatment	Storage period (month)		
	0	2	4
Storage condition (S)			
S_1		13.27	11.47
S_2		11.43	9.62
S.Em±		0.173	0.150
CD (1%)		0.75	0.65
Variety (V)			
V_1	29.0	11.11	10.13
V_2	26.0	11.85	9.87
V_3	32.5	12.48	10.63
V_4	34.0	14.25	12.76
V_5	22.0	10.62	8.71
V_6	36.0	13.80	11.17
S.Em±		0.299	0.260
CD (1%)		1.29	1.12
S_1 X V_1		12.20	11.25
S_1 X V_2		12.60	11.35
S_1 X V_3		13.50	11.32
S_1 X V_4		15.00	13.42
S_1 X V_5		11.75	9.08
S_1 X V_6		14.60	12.40
S_2 X V_1		10.02	9.01
S_2 X V_2		11.10	8.39
S_2 X V_3		11.47	9.95
S_2 X V_4		13.50	12.10
S_2 X V_5		9.50	8.35
S_2 X V_6		13.00	9.95
S.Em±		0.423	0.368
CD (1%)		NS	NS

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

Table 13. Amylase activity (μg maltose /15 min/mg protein) in tubers of different potato cultivars during storage under different storage conditions

Treatment	Storage period (month)		
	0	2	4
$S_1 X V_1$	Nil	35.41	189.30
$S_1 X V_2$	Nil	466.35	27.17
$S_1 X V_3$	1.65	337.15	6.28
$S_1 X V_4$	Nil	151.02	Nil
$S_1 X V_5$	155.94	630.80	Nil
$S_1 X V_6$	115.10	126.61	Nil
$S_2 X V_1$	Nil	298.87	412.9
$S_2 X V_2$	Nil	208.89	78.35
$S_2 X V_3$	1.65	184.30	61.67
$S_2 X V_4$	Nil	141.30	64.16
$S_2 X V_5$	155.94	278.11	Nil
$S_2 X V_6$	115.10	52.72	Nil

Data not analysed statistically.

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
V_1 – Kufri Ashoka, V_2 – Kufri Pukhraj, V_3 – Kufri Jawahar, V_4 – Kufri Jyoti, V_5 – Kufri Sutlej, V_6 – Kufri Chandramukhi

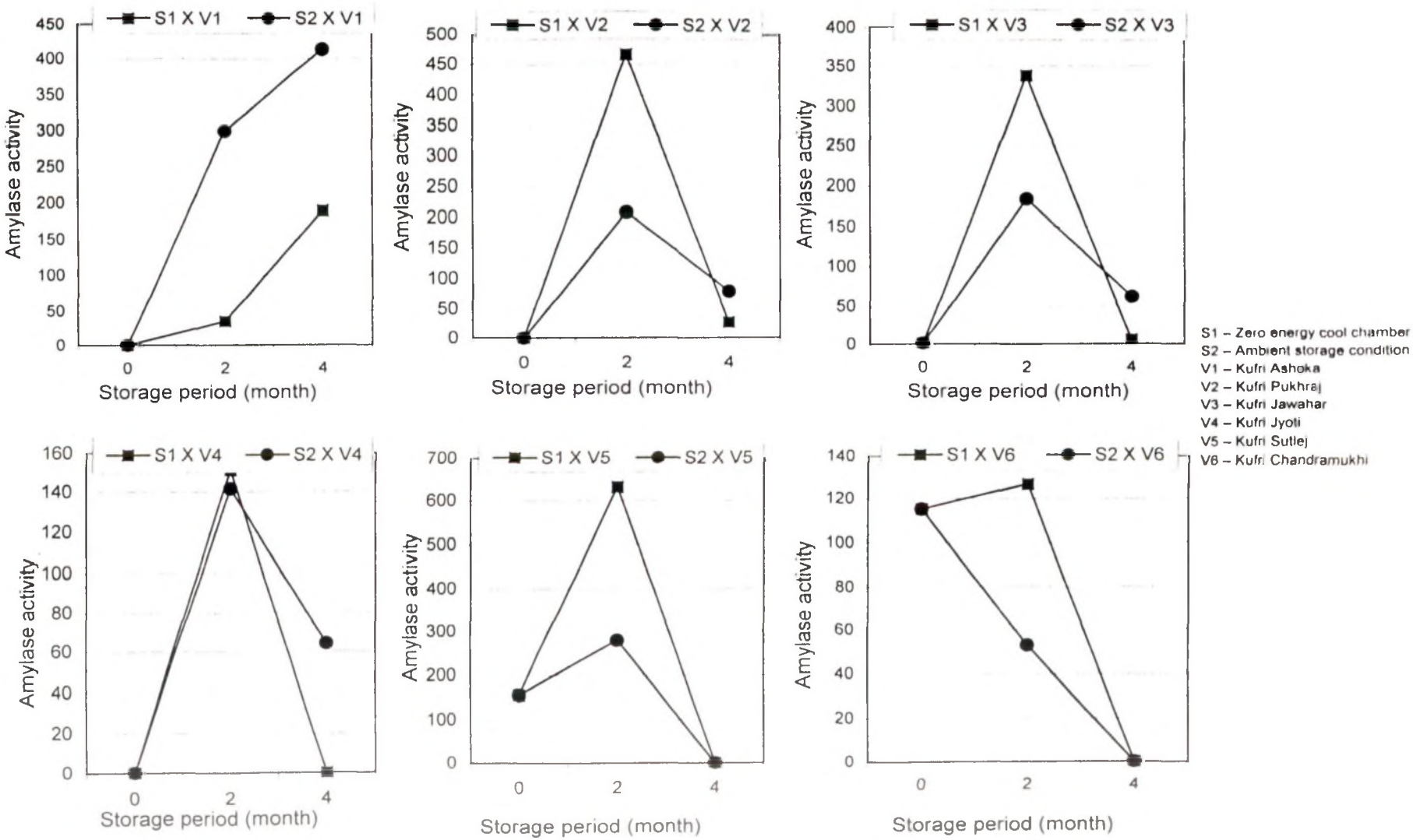

Fig. 3. Amylase activity (μg maltose /15 min/mg protein) in tubers of different potato cultivars during storage under different storage conditions

Among the different varieties, higher activity of amylase under ZECC was recorded in Kufri Sutlej (630.8) and lower in Kufri Ashoka (35.41), whereas under ambient condition, the activity was recorded higher in Kufri Ashoka (298.87) and lower in Kufri Chandramukhi (52.72) after two months of storage.

The activity of amylase gradually declined in tubers of most of the varieties except in Kufri Ashoka, which showed incline as the storage period progressed.

Amylase activity could not be detected in tubers of cv. Kufri Jyoti, Kufri Sutlej and Kufri Chandramukhi under ZECC and in Kufri Sutlej and Kufri Chandramukhi under ambient condition after storage period of four months.

4.1.16 Correlation studies

Correlation coefficients between various characters of potato tubers after four months of storage as influenced by storage condition and variety are presented in Table 14. From the table, it is clear that sprout weight had highly significant positive correlation with number of sprout (0.784) and length of sprout (0.859). Dry matter content was negatively correlated with sprout weight (-0.749). Reducing sugar had positive correlation (0.730) with sprout weight and negative correlation (-0.582) with dry matter content.

Table 14. Correlation coefficients between various characters of potato tubers after four months of storage as influenced by storage condition and variety

Sl. No.	X	Y	Correlation coefficient (r)
1.	Sprout weight	Number of sprout	0.784**
2.	Sprout weight	Length of sprout	0.859**
3.	Dry matter content	Sprout weight	-0.749**
4.	Dry matter content	PLW%	0.008
5.	Overall acceptability of chips	Dry matter content	0.217
6.	Overall acceptability of chips	Sprout weight	-0.314
7.	Overall acceptability of chips	Reducing sugar	-0.325
8.	Overall acceptability of chips	PLW%	-0.039
9.	Overall acceptability of cooked tubers	PLW%	-0.209
10.	Reducing sugar	Sprout weight	0.730**
11.	Reducing sugar	Dry matter content	-0.582*

* - Significant at 5% level
** - Significant of 1% level

4.2 EFFECT OF CHEMICAL TREATMENT ON STORAGE BEHAVIOUR OF POTATO CV. KUFRI PUKHRAJ

4.2.1 Physiological loss in weight (PLW%)

PLW (%) increased with increasing storage period irrespective of storage condition and chemical treatment (Table 15). However tubers stored under ZECC maintained significantly lower values of PLW (%) throughout the storage period and it was recorded 6.09 after storage period of four months as compared to 14.27 under ambient condition.

Differences in PLW (%) due to chemical treatment was found non-significant during first month, whereas tubers treated with MH recorded significantly lower PLW (9.34%) after storage period of four months followed by tubers treated with SNA (9.67%) and higher value was recorded in untreated tubers (10.96%).

Interaction of storage condition and chemical treatment was found significant with respect to PLW (%) during storage. However, difference in PLW (%) among treatments under ZECC was found non-significant during the first month of storage and recorded significantly lower in tubers treated with CIPC (5.0) followed by tubers treated with SNA (5.5) and higher in untreated tubers (7.17) after four months of storage. Under ambient storage, difference in PLW (%) due to chemical treatment was found non-significant during first month, whereas tubers treated with MH maintained significantly lower value (12.0) and it was recorded higher (16.5) in tubers treated with CIPC followed by untreated tubers (14.75) after storage period of four months.

Table 15. Physiological weight loss (PLW%) * of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	1.96	3.42	3.83	6.09	3.83
	(8.14)	(10.61)	(11.23)	(14.23)	(11.00)
S_2	2.62	5.77	9.36	14.27	8.0
	(9.28)	(13.72)	(17.75)	(22.16)	(15.72)
Chemical (C)					
C_1	2.0	4.42	6.92	10.75	6.02
	(8.05)	(11.93)	(14.68)	(18.44)	(13.27)
C_2	2.34	3.67	5.42	9.34	5.19
	(8.72)	(11.01)	(13.22)	(17.61)	(12.64)
C_3	2.50	4.84	7.09	9.67	6.03
	(9.03)	(12.43)	(15.16)	(17.68)	(13.57)
C_4	2.34	5.46	6.96	10.96	6.13
	(8.66)	(13.28)	(14.89)	(19.05)	(13.97)
$S_1 \times C_1$	1.67	2.83	3.33	5.0	3.21
	(7.36)	(9.63)	(10.46)	(12.92)	(10.09)
$S_1 \times C_2$	2.0	3.33	3.5	6.67	3.88
	(8.06)	(10.53)	(10.75)	(14.96)	(11.07)
$S_1 \times C_3$	2.0	4.0	4.5	5.5	4.0
	(8.10)	(11.53)	(12.22)	(13.53)	(11.34)
$S_1 \times C_4$	2.17	3.5	4.0	7.17	4.21
	(8.36)	(10.75)	(11.47)	(15.51)	(11.52)
$S_2 \times C_1$	2.33	6.0	10.5	16.5	8.83
	(8.73)	(14.23)	(18.90)	(23.96)	(16.45)
$S_2 \times C_2$	2.67	4.0	7.33	12.0	6.50
	(9.39)	(11.50)	(15.69)	(20.26)	(14.21)
$S_2 \times C_3$	3.0	5.67	9.67	13.83	8.04
	(9.96)	(13.33)	(18.09)	(21.83)	(15.80)
$S_2 \times C_4$	2.5	7.42	9.92	14.75	8.64
	(9.05)	(15.81)	(18.32)	(22.59)	(16.94)
Mean	2.29	4.60	6.60	10.28	5.92
	(8.61)	(12.16)	(14.49)	(18.19)	(13.36)

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.1269	0.1795	0.2538	0.1795	0.2538	0.3590	0.5077
CD (5%)	0.36	0.51	0.72	0.51	0.72	1.02	1.44

* Initial weight- 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

4.2.2 Per cent weight loss due to rottage

Per cent weight loss due to rottage increased with increasing storage period (Table 16). However, ZECC stored tubers recorded lower weight loss due to rottage throughout the storage period and it was 4.54 per cent compared to 19.53 per cent under ambient condition after storage period of four months.

Untreated tubers recorded lower value of mean weight loss due to rottage (5.54%) followed by tubers with MH treatment (5.70%) and tubers treated with CIPC recorded higher value (7.15%). However interaction of chemical treatment and storage period was non-significant.

Per cent cumulative weight loss due to rottage under ZECC after storage period of four months was recorded lower in untreated tubers (3.33) followed by tubers with MH treatment (3.67) and higher in tubers treated with SNA (5.83). Whereas under ambient condition, difference in per cent weight loss due to rottage between chemical treated tubers and untreated tubers was non-significant.

4.2.3 Per cent total weight loss

There was gradual increase in total weight loss irrespective of storage condition and chemical treatments (Table 17 and Figure 4). However, the tubers stored under ZECC recorded significantly lower value throughout the storage period and it was only 10.62 per cent under ZECC as compared to 33.85 per cent under ambient condition after storage period of four months.

Table 16. Per cent weight loss * due to rottage of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	1.98	2.76	3.58	4.54	3.22
	(7.98)	(9.47)	(10.65)	(12.21)	(10.08)
S_2	1.82	5.45	10.66	19.53	9.36
	(7.75)	(13.47)	(19.04)	(26.04)	(16.62)
Chemical (C)					
C_1	2.34	4.93	8.33	13.0	7.15
	(8.73)	(12.69)	(16.50)	(20.19)	(14.53)
C_2	1.50	3.60	6.27	11.44	5.70
	(6.96)	(10.70)	(13.61)	(18.51)	(12.34)
C_3	2.17	4.50	7.83	12.58	6.77
	(8.64)	(12.13)	(15.95)	(20.02)	(14.18)
C_4	1.59	3.39	6.05	11.13	5.54
	(7.14)	(10.36)	(13.32)	(18.18)	(12.25)
$S_1 \times C_1$	2.0	3.53	5.33	5.33	4.15
	(8.07)	(10.81)	(13.34)	(13.34)	(11.39)
$S_1 \times C_2$	1.33	2.17	2.17	3.67	2.34
	(6.53)	(8.45)	(8.45)	(11.03)	(8.61)
$S_1 \times C_3$	2.57	3.33	4.83	5.83	4.14
	(9.21)	(10.51)	(12.68)	(13.97)	(11.59)
$S_1 \times C_4$	2.0	2.0	2.0	3.33	2.33
	(8.13)	(8.13)	(8.13)	(10.49)	(8.71)
$S_2 \times C_1$	2.67	6.33	11.33	20.67	10.25
	(9.39)	(14.57)	(19.67)	(27.03)	(17.66)
$S_2 \times C_2$	1.67	5.03	10.37	19.2	9.07
	(7.38)	(12.96)	(18.78)	(25.98)	(16.27)
$S_2 \times C_3$	1.77	5.67	10.83	19.33	9.40
	(8.06)	(13.76)	(19.21)	(26.08)	(16.78)
$S_2 \times C_4$	1.17	4.77	10.10	18.93	8.74
	(6.17)	(12.60)	(18.51)	(25.86)	(15.78)
Mean	1.90	4.11	7.12	12.04	6.29
	(7.87)	(11.47)	(14.85)	(19.22)	(13.35)

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.1103	0.1560	0.2206	0.1560	0.2206	0.3120	0.4413
CD (5%)	0.31	0.44	0.62	0.44	0.62	NS	1.24

* Initial weight – 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Table 17. Per cent total weight loss * of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	3.98	6.18	7.42	10.62	7.05
	(11.50)	(14.34)	(15.69)	(19.01)	(15.14)
S_2	4.44	11.22	20.02	33.85	17.38
	(11.88)	(19.46)	(26.47)	(35.56)	(23.34)
Chemical (C)					
C_1	4.34	9.35	15.25	23.75	13.17
	(11.78)	(17.56)	(22.47)	(28.15)	(19.99)
C_2	3.83	7.27	11.69	20.85	10.91
	(11.22)	(15.52)	(19.15)	(26.40)	(18.07)
C_3	4.67	9.33	14.92	22.25	12.79
	(12.41)	(17.53)	(22.35)	(27.41)	(19.92)
C_4	3.92	8.85	13.02	22.10	11.97
	(11.36)	(16.99)	(20.36)	(27.19)	(18.98)
S_1 X C_1	3.67	6.37	8.67	10.33	7.26
	(11.0)	(14.57)	(17.10)	(18.74)	(15.35)
S_1 X C_2	3.33	5.5	5.67	10.33	6.2
	(10.44)	(13.55)	(13.76)	(18.75)	(14.12)
S_1 X C_3	4.57	7.33	9.33	11.33	8.14
	(12.34)	(15.69)	(17.78)	(19.66)	(16.37)
S_1 X C_4	4.17	5.5	6.0	10.50	6.54
	(12.33)	(13.55)	(14.14)	(18.89)	(14.70)
S_2 X C_1	5.0	12.33	21.83	37.17	19.08
	(12.56)	(20.55)	(27.85)	(37.56)	(24.63)
S_2 X C_2	4.33	9.03	17.70	31.37	15.61
	(12.0)	(17.49)	(24.55)	(34.06)	(22.02)
S_2 X C_3	4.77	11.34	20.50	33.17	17.44
	(12.48)	(19.36)	(26.91)	(35.16)	(23.48)
S_2 X C_4	3.67	12.20	20.03	33.70	17.42
	(10.49)	(24.44)	(26.58)	(35.48)	(23.25)
Mean	4.19	8.66	13.72	22.24	12.20
	(11.69)	(16.90)	(21.08)	(27.29)	(19.24)

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.1171	0.1656	0.2342	0.1656	0.2342	0.3312	0.4683
CD (5%)	0.33	0.47	0.66	0.47	0.66	0.93	1.32

* Initial weight – 2 kg

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Among different chemical treatments, tubers treated with MH recorded lower values and tubers with SNA as well as CIPC treatment recorded higher values of per cent total weigh loss throughout the storage period. But weight loss in tubers with MH (20.85%) and SNA treatment (22.25%) did not differ statistically with untreated tubers (22.10%) after storage period of four months.

There was no statistical difference in total weight loss between chemical treated and untreated tubers stored under ZECC after storage period of four months. Whereas tubers with MH and CIPC treatment recorded lower and higher values (31.37 and 37.17%, respectively) as compared to untreated tubers (33.70%) under ambient condition.

4.2.4 Per cent decay loss

Data on per cent decay loss during storage are presented in Table 18. Per cent decay loss increased with increasing storage period irrespective of storage condition and chemical treatment. However, tubers under ZECC recorded lower (4.96%) decay loss as compared to 19.85 per cent under ambient condition after storage period of four months.

Among the treatments, decay loss was higher in chemical treated tubers as compared to untreated tubers during storage, but the interaction of chemical treatment with storage period was found non-significant.

The interaction effect of storage condition, chemical treatment and storage period was found significant with respect to per cent decay loss.

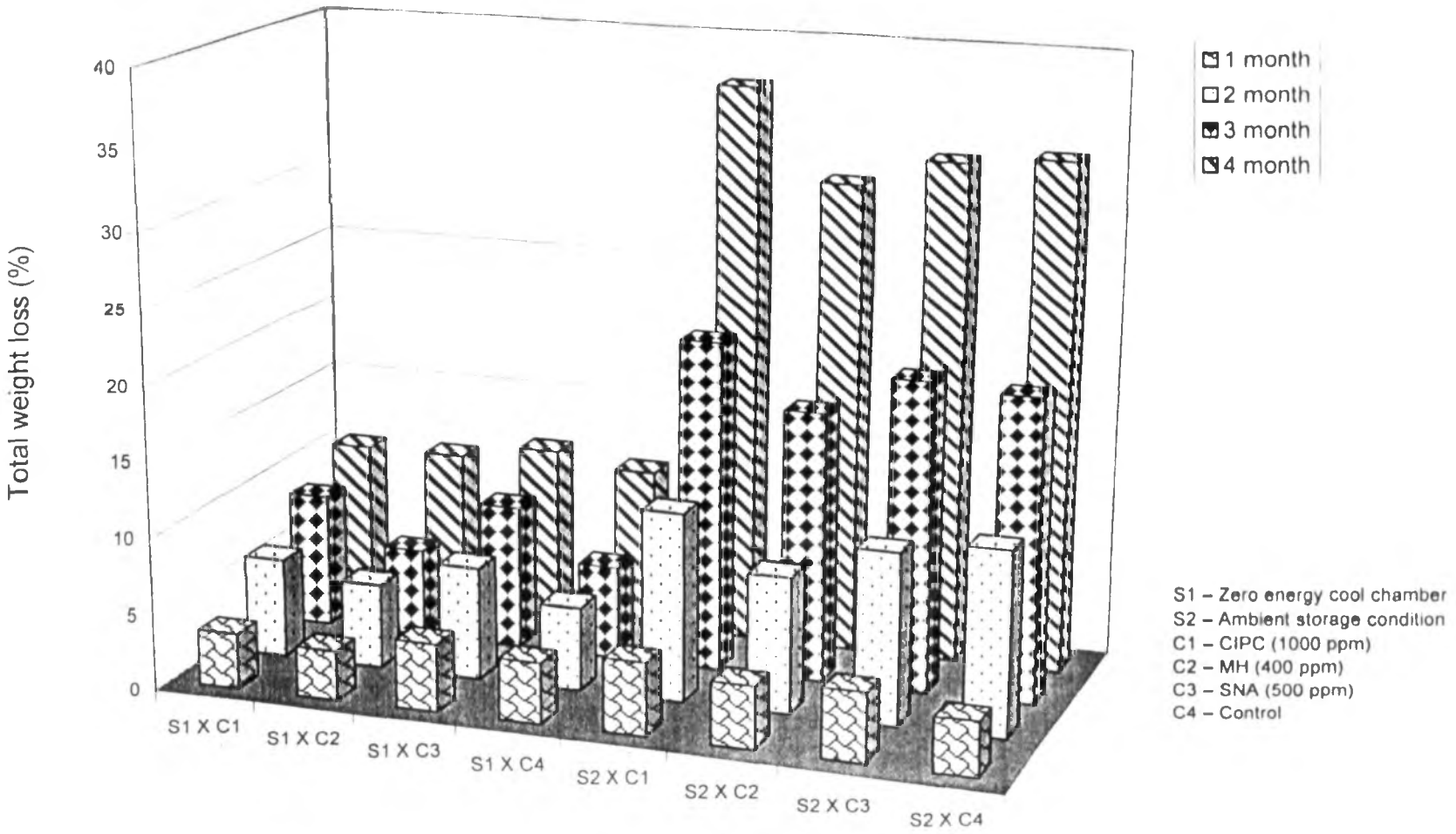

Fig. 4. Per cent total weight loss of sprout inhibitor treated potato cv. Kufri Pukhraj during storage under different storage conditions

Table 18. Losses due to decay (%) of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	2.26	3.03	3.92	4.96	3.54
	(8.53)	(9.97)	(11.22)	(12.79)	(10.63)
S_2	2.55	5.93	11.33	19.85	9.92
	(9.17)	(14.04)	(19.65)	(26.44)	(17.32)
Chemical (C)					
C_1	2.67	5.09	9.0	13.29	7.51
	(9.25)	(12.78)	(17.15)	(20.48)	(14.91)
C_2	1.94	4.22	7.84	11.17	6.29
	(7.92)	(11.63)	(14.06)	(18.35)	(12.99)
C_3	2.92	4.85	8.42	13.34	7.38
	(9.81)	(12.64)	(16.47)	(20.60)	(14.88)
C_4	2.09	3.75	6.59	11.83	6.07
	(8.41)	(10.97)	(14.05)	(19.03)	(13.11)
$S_1 \times C_1$	2.17	3.17	5.67	5.67	4.17
	(8.27)	(10.24)	(13.76)	(13.76)	(11.50)
$S_1 \times C_2$	1.70	2.67	2.67	3.83	2.72
	(7.40)	(9.39)	(9.39)	(11.25)	(9.35)
$S_1 \times C_3$	2.67	3.77	4.83	6.0	4.32
	(9.39)	(11.18)	(12.67)	(14.17)	(11.85)
$S_1 \times C_4$	2.5	2.5	2.5	4.33	2.96
	(9.06)	(9.06)	(9.06)	(12.0)	(9.80)
$S_2 \times C_1$	3.17	7.0	12.33	20.90	10.85
	(10.24)	(15.33)	(20.54)	(27.20)	(18.33)
$S_2 \times C_2$	2.17	5.77	10.33	18.50	9.19
	(8.45)	(13.88)	(18.74)	(25.46)	(16.63)
$S_2 \times C_3$	3.17	5.93	12.0	20.67	10.44
	(10.24)	(14.09)	(20.27)	(27.03)	(17.91)
$S_2 \times C_4$	1.67	5.0	10.67	19.33	9.17
	(7.76)	(12.88)	(19.04)	(26.06)	(16.43)
Mean	2.41	4.48	7.63	12.41	6.73
	(8.85)	(12.00)	(15.43)	(19.61)	(13.97)

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.1288	0.1822	0.2577	0.1822	0.2577	0.3644	0.5153
CD (5%)	0.36	0.51	NS	0.51	0.73	NS	1.45

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Plate 7. Photograph of the potato tubers cv. Kufri Pukhraj treated with sprout inhibitors after four months of storage under ZECC

Plate 8. Photograph of the potato tubers cv. Kufri Pukhraj treated with sprout inhibitors after four months of storage under ambient storage condition

Per cent decay loss after four months of storage under ZECC was recorded higher in tubers with SNA treatment (6.0) followed by CIPC treatment (5.67) and lower in tubers with MH treatment (3.83) followed by untreated tubers (4.33). However, under ambient condition, lower value was recorded in tubers with MH treatment (18.50%) and higher in CIPC treated tubers (20.90%) with no statistical difference between chemical treated and untreated tubers.

4.2.5 Sprouting percentage

Sprouting percentage of tubers increased with increasing storage period (Table 19 and Figure 5). However, mean sprouting percentage was recorded lower in tubers stored under ZECC throughout the storage period.

Mean per cent sprouting in tubers treated with all chemical was recorded significantly lower value upto three months of storage as compared to untreated one and tubers with CIPC and MH treatment recorded lower sprouting (83.98 and 88.75%, respectively) even after storage period of four months. Whereas 100 per cent sprouting was recorded in tubers with SNA treatment and untreated one.

Interaction of storage condition, chemical treatment and storage period was found significant for sprouting percentage. All chemicals except CIPC treatment under ambient condition recorded lower values of sprouting as compared to untreated control upto three months under both storage conditions. Sprouting under ZECC was less than 40 per cent

Table 19. Sprouting percentage of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditionS

Treatment	Storage period in month (P)				Mean
	1	2	3	4	
Storage condition (S)					
S_1	4.88	27.09	67.25	86.36	46.40
	(12.43)	(29.29)	(60.07)	(74.30)	(44.02)
S_2	5.10	35.55	91.25	100	57.98
	(12.80)	(36.01)	(73.26)	(90.0)	(53.02)
Chemical (C)					
C_1	4.43	24.59	66.56	83.98	44.89
	(11.70)	(27.06)	(57.68)	(72.76)	(42.30)
C_2	5.05	18.25	63.51	88.75	43.89
	(12.94)	(24.76)	(54.13)	(75.84)	(41.92)
C_3	3.41	28.91	89.41	100	55.43
	(10.41)	(32.29)	(71.23)	(90.0)	(50.99)
C_4	7.10	53.54	97.54	100	64.55
	(15.39)	(46.48)	(83.61)	(90.0)	(58.87)
$S_1 \times C_1$	2.18	4.57	37.95	67.95	28.16
	(8.44)	(12.33)	(38.03)	(55.53)	(28.58)
$S_1 \times C_2$	4.42	10.51	39.74	77.50	33.04
	(12.14)	(18.87)	(39.09)	(61.69)	(32.95)
$S_1 \times C_3$	4.60	32.27	91.32	100	57.05
	(12.37)	(34.58)	(73.15)	(90.0)	(52.52)
$S_1 \times C_4$	8.35	61.02	100	100	67.34
	(16.77)	(51.37)	(90.00)	(90.0)	(62.04)
$S_2 \times C_1$	6.67	44.61	95.17	100	61.61
	(14.96)	(41.80)	(77.32)	(90.0)	(56.02)
$S_2 \times C_2$	5.67	25.99	87.27	100	54.73
	(13.73)	(30.64)	(69.17)	(90.0)	(50.88)
$S_2 \times C_3$	2.22	25.55	87.5	100	53.82
	(8.53)	(30.01)	(69.32)	(90.0)	(49.46)
$S_2 \times C_4$	5.84	46.06	95.07	100	61.74
	(14.01)	(41.59)	(77.22)	(90.0)	(55.71)
Mean	5.0	31.32	79.25	93.18	52.19
	(12.62)	(32.65)	(66.66)	(82.15)	(48.52)

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.1796	0.2540	0.3592	0.2540	0.3592	0.5079	0.7183
CD (5%)	0.51	0.72	1.01	0.72	1.01	1.43	2.03

(Figures in parentheses indicates angular transformed values)

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

in tubers treated with CIPC and MH upto three months and it was 67.95 and 77.50 per cent respectively after four months of storage. Whereas all other treatments along with untreated tubers recorded 100 per cent sprouting.

4.2.6 Number of sprout per tuber

Data on number of sprout per sprouted tuber recorded after three and four months of storage are presented in Table 20. There was general increase in number of sprout over increasing storage period. However, storage condition, storage condition X storage period and chemical treatment X storage period interaction on number of sprout was found non-significant. Mean number of sprout was recorded lower in tubers treated with CIPC (1.70) and higher in untreated tubers (2.95).

Mean number of sprouts under ZECC was recorded lower in tubers treated with CIPC (1.23) and higher in untreated tubers (3.13) followed by tubers with SNA treatment (3.12). Whereas under ambient condition, mean sprout number was recorded lower in tubers with SNA treatment (2.05) followed by CIPC treatment (2.18) and higher value was recorded in untreated tubers (2.76).

4.2.7 Length of longest sprout (cm)

Data on longest sprout length of tubers recorded after three and four months of storage under different storage condition are presented in Table 21. Length of sprout increased with increasing storage period.

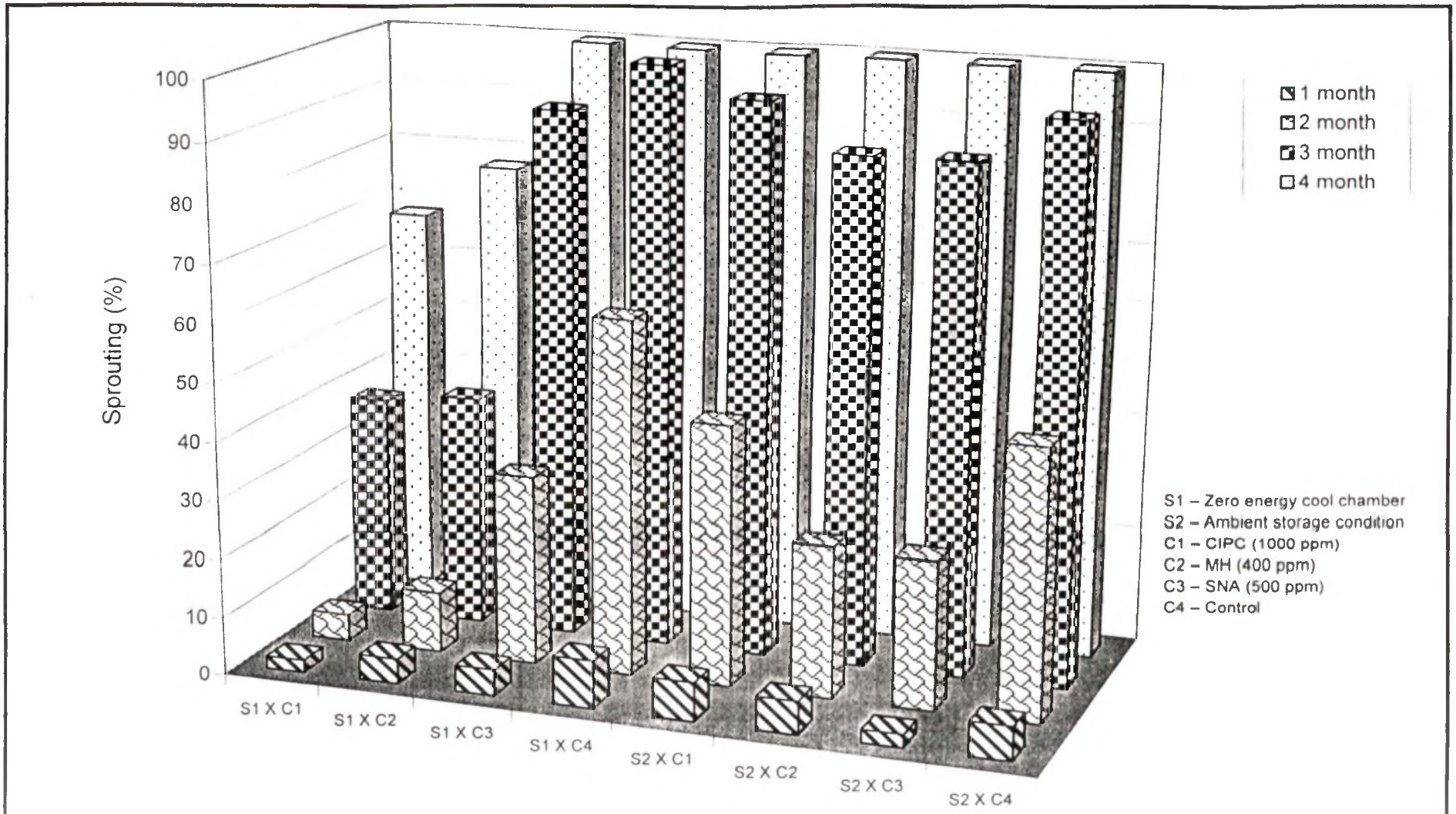

Fig. 5. Sprouting percentage of sprout inhibitor treated potato cv. Kufri Pukhraj during storage under different storage conditions

Table 20. Number of sprout per tuber in tubers of cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)		Mean
	3	4	
Storage condition (S)			
S_1	2.30	2.51	2.41
S_2	2.26	2.51	2.39
Chemical (C)			
C_1	1.55	1.86	1.70
C_2	2.27	2.43	2.35
C_3	2.51	2.66	2.58
C_4	2.80	3.10	2.95
$S_1 \times C_1$	1.0	1.46	1.23
$S_1 \times C_2$	2.06	2.23	2.15
$S_1 \times C_3$	3.06	3.18	3.12
$S_1 \times C_4$	3.06	3.20	3.13
$S_2 \times C_1$	2.10	2.26	2.18
$S_2 \times C_2$	2.47	2.63	2.55
$S_2 \times C_3$	1.96	2.14	2.05
$S_2 \times C_4$	2.53	3.00	2.76
Mean	2.28	2.51	2.40

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.0209	0.0295	0.0417	0.0209	0.0295	0.0417	0.059
CD (5%)	NS	0.08	0.12	0.06	NS	NS	0.17

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Table 21. Length of longest sprout (cm) in tubers of cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

Treatment	Storage period in month (P)		Mean
	3	4	
Storage condition (S)			
S_1	1.95	2.36	2.15
S_2	1.14	1.94	1.54
Chemical (C)			
C_1	1.11	1.69	1.40
C_2	1.35	1.93	1.64
C_3	1.70	2.39	2.04
C_4	2.01	2.60	2.30
S_1 X C_1	0.93	1.33	1.13
S_1 X C_2	1.89	1.92	1.91
S_1 X C_3	2.24	2.99	2.62
S_1 X C_4	2.74	3.20	2.97
S_2 X C_1	1.30	2.04	1.67
S_2 X C_2	0.82	1.95	1.38
S_2 X C_3	1.15	1.79	1.47
S_2 X C_4	1.29	2.00	1.64
Mean	1.54	2.15	1.85

	Storage condition (S)	Chemical (C)	S X C	Storage period (P)	S X P	C X P	S X C X P
S.Em±	0.009	0.013	0.018	0.009	0.013	0.018	0.025
CD (5%)	0.03	0.04	0.05	0.03	0.04	0.05	0.07

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

However, tubers stored under ZECC recorded longer mean sprout length (1.95 and 2.36 respectively) during both observation period against 1.14 and 1.94 cm under ambient condition.

Among the treatments imposed tubers treated with chemicals recorded shorter sprout length during both observation period with lower mean length in tubers treated with CIPC (1.40) and higher in untreated one (2.30).

Interaction effect of storage condition, chemical treatment and storage period was found significant for length of longest sprout. Mean length of longest sprout was recorded lower in CIPC treated tubers (1.13) and higher in untreated tubers (2.97) under ZECC, whereas under ambient condition, lower mean length was recorded in tubers treated with MH (1.38) followed by SNA treatment (1.47) and higher in tubers with CIPC treatment (1.67) followed by untreated one (1.64). However, the values in untreated and CIPC treated tubers were statistically on par under ambient storage condition.

4.28 Sprout weight

Data on sprout weight (g/500 g tuber) and per cent sprout weight after storage period of four months are presented in table 22.

Sprout weight per 500 g tuber was marginally higher (8.40 g) under ZECC compared to tubers stored under ambient condition (8.25 g). However these values were statistically non-significant.

Among the chemical treatments, tubers with MH treatment recorded less sprout weight per 500 g tuber (6.28 g) followed by tubers with CIPC treatment (6.47 g) and higher value was recorded in untreated tubers (10.54 g) followed by tubers with SNA treatment (10.01 g).

Interaction of storage condition and chemical treatment was significant for sprout weight. Tubers with CIPC treatment recorded low sprout weight (4.36 g) under ZECC followed by MH treated one (5.72 g) and SNA treated tubers (12.16 g) did not differ with untreated one (11.36 g). Under ambient condition, tubers with MH treatment recorded low sprout weight (6.84 g) and higher value was recorded in untreated one (9.71 g).

Per cent sprout weight in tubers stored under ZECC ranged between 0.87 (CIPC treatment) to 2.43 (SNA treatment). Whereas under ambient condition, it ranged between 1.40 (MH treatment) to 1.94 (Untreated tubers).

4.2.9 Dry matter content

Data on dry matter content of tubers after storage period of four months are presented in Table 22.

Dry matter content of tubers decreased during storage period. However, tubers stored under ambient condition retained higher dry matter content (19.52%) as compared to those stored under ZECC (17.44%).

Table 22. Dry matter content, sprout weight (g/500 of tuber) and per cent sprout weight of tubers cv. Kufri Pukhraj after 4 months of storage under different storage conditions

Treatment	Dry matter (%)		Sprout wt g/500g tuber	Percentage of sprout weight to tuber weight
	Initial	After 4 months		
Storage condition (S)				
S_1		17.44	8.40	1.68
S_2		19.52	8.25	1.66
S.Em±		0.414	0.1600	0.0295
CD (5%)		1.23	NS	NS
Chemical (C)				
C_1	20.90	18.86	6.47	1.29
C_2	20.12	18.44	6.28	1.27
C_3	20.90	17.83	10.01	2.0
C_4	20.90	18.78	10.54	2.10
S.Em±		0.5818	0.2263	0.0417
CD (5%)		NS	0.68	0.12
S_1 X C_1		18.81	4.36	0.87
S_1 X C_2		17.92	5.72	1.14
S_1 X C_3		16.22	12.16	2.43
S_1 X C_4		16.79	11.36	2.27
S_2 X C_1		18.92	8.57	1.71
S_2 X C_2		18.96	6.84	1.40
S_2 X C_3		19.43	7.87	1.57
S_2 X C_4		20.67	9.71	1.94
S.Em±		0.8328	0.32	0.059
CD (5%)		NS	0.96	0.18

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Among the treatments imposed, dry matter content of tubers ranged between 17.83 per cent (SNA treatment) to 18.86 per cent (CIPC treatment), but these values were statistically on par with dry matter content of untreated tubers (18.78%).

The interaction effect of storage condition and chemical treatment on dry matter content after storage period of four months was found non-significant.

4.2.10 Cooking quality

Data on sensory characteristics of cooked potatoes after four months of storage under different storage condition are presented in Table 23.

Tubers stored under ZECC scored significantly higher value for all sensory characteristics *viz.*, appearance, taste, texture, flavour and overall acceptability (3.40, 3.32, 3.89, 3.17 and 3.22, respectively) as compared to those stored under ambient storage (2.41, 2.49, 3.62, 2.73 and 2.46, respectively).

Sensory score of tubers due to different chemicals were non-significant with regard to appearance, taste, texture and flavour. However, score pertaining to overall acceptability was significantly higher in untreated tubers (3.20) followed by tubers with MH treatment (2.92) and lower value was recorded in tubers with SNA treatment (2.54).

The interaction effect of storage condition and chemical treatment was non-significant for sensory characteristics of cooked potato.

Table 23. Cooking quality * of tubers of cv. Kufri Pukhraj treated with sprout inhibitors after 4 months of storage under different storage conditions

Treatment	Appearance	Taste	Texture	Flavour	Overall acceptability
Storage condition (S)					
S_1	3.40	3.32	3.89	3.17	3.22
S_2	2.41	2.49	3.62	2.73	2.46
S.Em±	0.1003	0.1088	0.0694	0.0958	0.0847
CD (5%)	0.33	0.36	0.23	0.31	0.28
Chemical (C)					
C_1	2.74	2.75	3.76	2.93	2.70
C_2	2.85	3.03	3.76	2.94	2.92
C_3	2.71	2.78	3.63	2.94	2.54
C_4	3.32	3.05	3.86	2.99	3.20
S.Em±	0.1418	0.1538	0.0982	0.1355	0.1197
CD (5%)	NS	NS	NS	NS	0.39
S_1 X C_1	3.19	3.25	4.0	3.0	3.14
S_1 X C_2	3.50	3.67	4.0	3.4	3.57
S_1 X C_3	3.13	2.98	3.58	3.1	2.77
S_1 X C_4	3.80	3.37	4.0	3.2	3.41
S_2 X C_1	2.30	2.26	3.53	2.87	2.26
S_2 X C_2	2.20	2.39	3.53	2.49	2.27
S_2 X C_3	2.30	2.58	3.69	2.79	2.32
S_2 X C_4	2.85	2.73	3.73	2.79	2.99
S.Em±	0.2006	0.2175	0.1388	0.1917	0.1693
CD (5%)	NS	NS	NS	NS	NS

* Scored on 4 point hedonic scale

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

4.2.11 Frying quality

No statistical difference in sensory characteristics could be observed between chips prepared from tubers stored under ZECC and ambient condition after storage period of four months (Table 24).

Among the chemical treatments, tubers treated with MH scored higher value for appearance (3.17) followed by CIPC (3.13) and SNA treatment (3.04), whereas lower value was scored by untreated tubers (2.62). Chips prepared from chemical treated tubers did not differ statistically for taste, texture, flavour and overall acceptability.

Tubers treated with CIPC stored under ZECC scored higher value (3.47) for appearance followed by SNA treatment (3.23) and lower value was recorded in untreated tubers (2.55). However, under ambient storage condition, tubers treated with MH scored higher (3.43) and rest of the treatment were statistically on par with untreated tubers (2.70).

4.2.12 Sugar content (mg/100 g fresh weight)

Data on sugar content of chemical treated potato tuber during storage are presented in Table 25.

4.2.12.1 Reducing sugar

Reducing sugar content increased with increasing storage period irrespective of storage condition and chemical treatment. However, accumulation of reducing sugar was higher under ZECC after two and

Table 24. Chipping quality * of tubers of cv. Kufri Pukhraj treated with sprout inhibitors after 4 months of storage under different storage conditions

Treatment	Appearance	Taste	Texture	Flavour	Overall acceptability
Storage condition (S)					
S_1	3.04	2.97	3.95	3.14	2.98
S_2	2.94	3.13	3.91	3.19	2.87
S.Em±	0.0613	0.0837	0.0280	0.07	0.663
CD (5%)	NS	NS	NS	NS	NS
Chemical (C)					
C_1	3.13	2.16	4.0	3.21	3.05
C_2	3.17	2.95	3.97	3.13	2.84
C_3	3.04	3.13	4.0	3.27	3.11
C_4	2.62	2.97	3.87	3.05	2.72
S.Em±	0.0867	0.1183	0.0395	0.099	0.0938
CD (5%)	0.28	NS	NS	NS	NS
S_1 X C_1	3.47	3.30	4.0	3.35	3.30
S_1 X C_2	2.91	2.72	3.95	2.96	2.80
S_1 X C_3	3.23	3.13	4.0	3.30	3.25
S_1 X C_4	2.55	2.75	3.85	2.95	2.60
S_2 X C_1	2.80	3.03	4.0	3.07	2.80
S_2 X C_2	3.43	3.18	4.0	3.30	2.88
S_2 X C_3	2.85	3.13	4.0	3.25	2.97
S_2 X C_4	2.70	3.20	3.90	3.15	2.85
S.Em±	0.1226	0.1673	0.0559	0.14	0.1327
CD (5%)	0.40	NS	NS	NS	NS

* Scored on 4 point hedonic scale

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

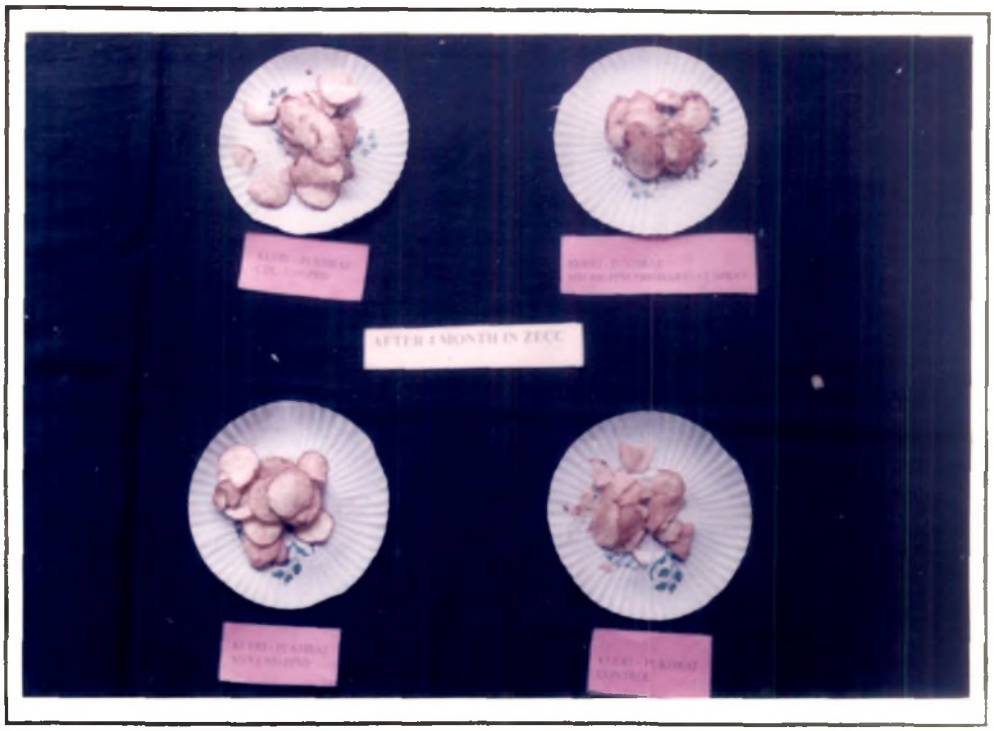

Plate 9. Photograph of the chips made from sprout inhibitor treated potato tubers (cv. Kufri Pukhraj) after four months of storage under ZECC

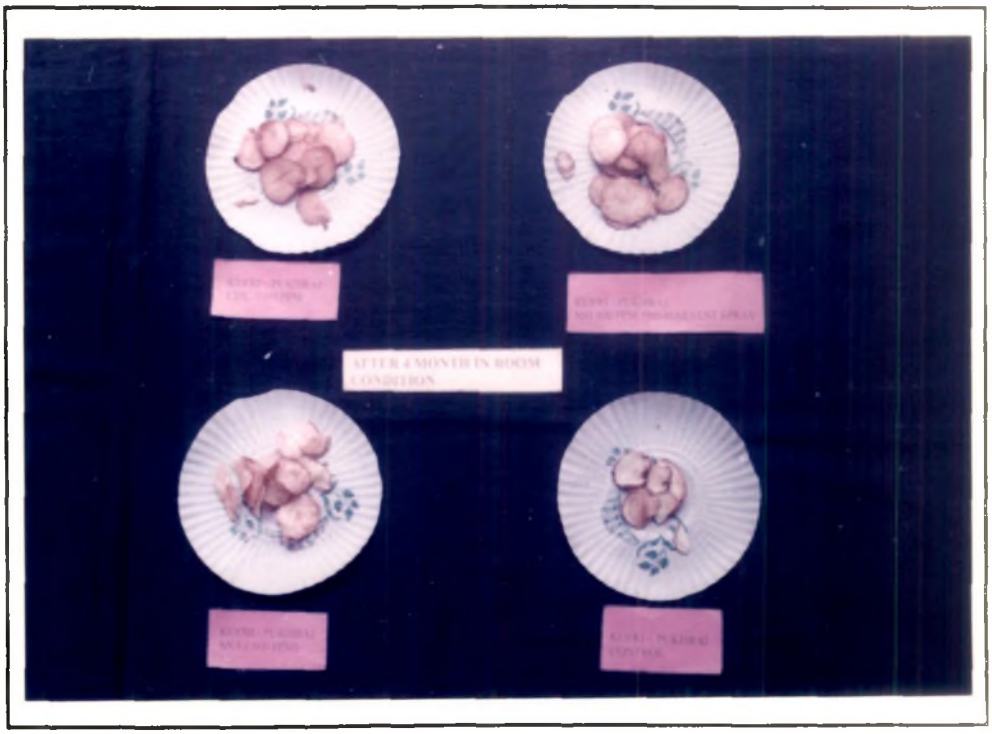

Plate 10. Photograph of the chips made from sprout inhibitor treated potato tubers (cv. Kufri Pukhraj) after four months of storage under ambient storage condition

four months of storage (377.37 and 588.12 mg, respectively) as compared to tubers stored under ambient condition (333.75 and 382.50 mg, respectively).

Reducing sugar content of chemical treated tubers was non-significant at the end of second month, whereas it was significantly higher in tubers with SNA treatment (523.75 mg) and lower in tubers with CIPC treatment (451.25 mg) followed by untreated on (482.50 mg) after storage period of four months.

Interaction effect of storage condition and chemical treatment was found non-significant for reducing sugar content after two months of storage. Tubers treated with CIPC and stored under ZECC for a period of four months recorded significantly lower reducing sugar content (515.0 mg) and higher value was recorded in tubers with SNA treatment (642.5 mg) as compared to untreated tubers (585.0 mg), whereas effect due to chemical treatment was statistically non-significant for reducing sugar content after four months of storage under ambient condition.

4.2.12.2 Total sugar

Accumulation of total sugar in chemical treated tubers was observed during storage and higher value was recorded in tubers stored under ZECC after two and four months of storage (621.62 and 811.25 mg respectively) as compared to ambient storage (583.50 and 618.25 mg respectively). But value recorded after two months were statistically non-significant.

Table 25. Sugar content (mg/100 g fresh weight) of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage condition

Treatment	Storage period (months)					
	0		2		4	
	RS	TS	RS	TS	RS	TS
Storage condition (S)						
S_1			377.37	621.62	588.12	811.25
S_2			333.75	583.50	382.50	618.25
S.Em±			7.61	8.63	5.97	7.53
CD (1%)			36.16	NS	28.37	35.78
Chemical (C)						
C_1	300.0	450.0	333.75	574.75	451.25	676.50
C_2	290.0	460.0	345.0	601.75	483.75	725.50
C_3	300.0	450.0	383.75	625.25	523.75	742.0
C_4	300.0	450.0	359.75	608.50	482.50	715.0
S.Em±			10.76	12.20	8.45	10.66
CD (1%)			NS	NS	40.15	NS
S_1 X C_1			327.50	565.0	515.0	732.50
S_1 X C_2			385.00	640.0	610.0	849.0
S_1 X C_3			417.50	657.50	642.5	855.0
S_1 X C_4			379.50	624.0	585.0	808.50
S_2 X C_1			340.0	584.50	387.5	620.50
S_2 X C_2			305.0	563.50	357.5	602.0
S_2 X C_3			350.0	593.0	405.0	629.0
S_2 X C_4			340.0	593.0	380.0	621.5
S.Em±			15.22	17.26	11.95	15.07
CD (1%)			NS	NS	56.78	71.61

RS – Reducing sugar
TS – Total sugar
S_1 – Zero energy cool chamber, S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Effect of chemical treatment on total content was found non-significant during both observation periods.

Interaction effect of storage condition and chemical treatment was found non-significant for total sugar content after two months. However, tubers treated with CIPC and stored under ZECC recorded significantly lower value of total sugar (732.50 mg) and rest of treatments did not differ with untreated tubers (808.50 mg) after four months of storage.

4.2.13 Ascorbic acid content (mg/100 g f.w.)

Ascorbic acid content of tubers decreased during storage period irrespective of storage condition and treatment imposed (Table 26).

Ascorbic acid content of tubers with chemical treatment did not differ significantly with untreated tubers during storage. However, tubers stored under ZECC retained significantly higher ascorbic acid (12.38 and 10.99 mg respectively) after two and four months of storage as compared to tubers under ambient condition (11.0 and 8.90 mg respectively).

Interaction effect of storage condition and chemical treatment was found non-significant for ascorbic acid content during storage.

4.2.14 Amylase activity (μg maltose/15 min/mg protein)

The activity of amylase could not be detected in tubers treated with CIPC and MH and it was recorded higher (466.35) in untreated tubers after storage period of two months under ZECC, whereas activity of amylase was recorded higher (208.89) in untreated tubers and lower in tubers with SNA treatment (51.59) under ambient condition (Table 27).

Table 26. Ascorbic acid content (mg/100 g fresh weight) of tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage condition

Treatment	Storage period (months)		
	0	2	4
Storage condition (S)			
S_1		12.38	10.99
S_2		11.0	8.90
S.Em±		0.279	0.118
CD (1%)		1.32	0.56
Chemical (C)			
C_1	26.0	12.38	10.17
C_2	26.9	11.02	10.10
C_3	26.0	11.68	9.57
C_4	26.0	11.67	9.95
S.Em±		0.395	0.166
CD (1%)		NS	NS
S_1 X C_1		13.17	11.25
S_1 X C_2		12.10	11.27
S_1 X C_3		12.0	10.19
S_1 X C_4		12.25	11.25
S_2 X C_1		11.60	9.10
S_2 X C_2		9.94	8.93
S_2 X C_3		11.37	8.95
S_2 X C_4		11.10	8.65
S.Em±		0.559	0.235
CD (1%)		NS	NS

S_1 – Zero energy cool chamber. S_2 – Ambient storage condition
C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

Table 27. Amylase activity (μg maltose / 15 min / mg protein) in tubers cv. Kufri Pukhraj treated with sprout inhibitors during storage under different storage condition

Treatment	Storage period in month		
	0	2 month	4 month
S_1 X C_1	Nil	Nil	190.80
S_1 X C_2	Nil	Nil	397.22
S_1 X C_3	Nil	181.18	Nil
S_1 X C_4	Nil	466.35	27.17
S_2 X C_1	Nil	151.53	Nil
S_2 X C_2	Nil	76.23	Nil
S_2 X C_3	Nil	51.59	Nil
S_2 X C_4	Nil	208.89	78.35

Data not analysed statistically

S_1 – Zero energy cool chamber, S_2 – Ambient storage condition

C_1 – CIPC (1000 ppm), C_2 – MH (400 ppm), C_3 – SNA (500 ppm), C_4 – Control

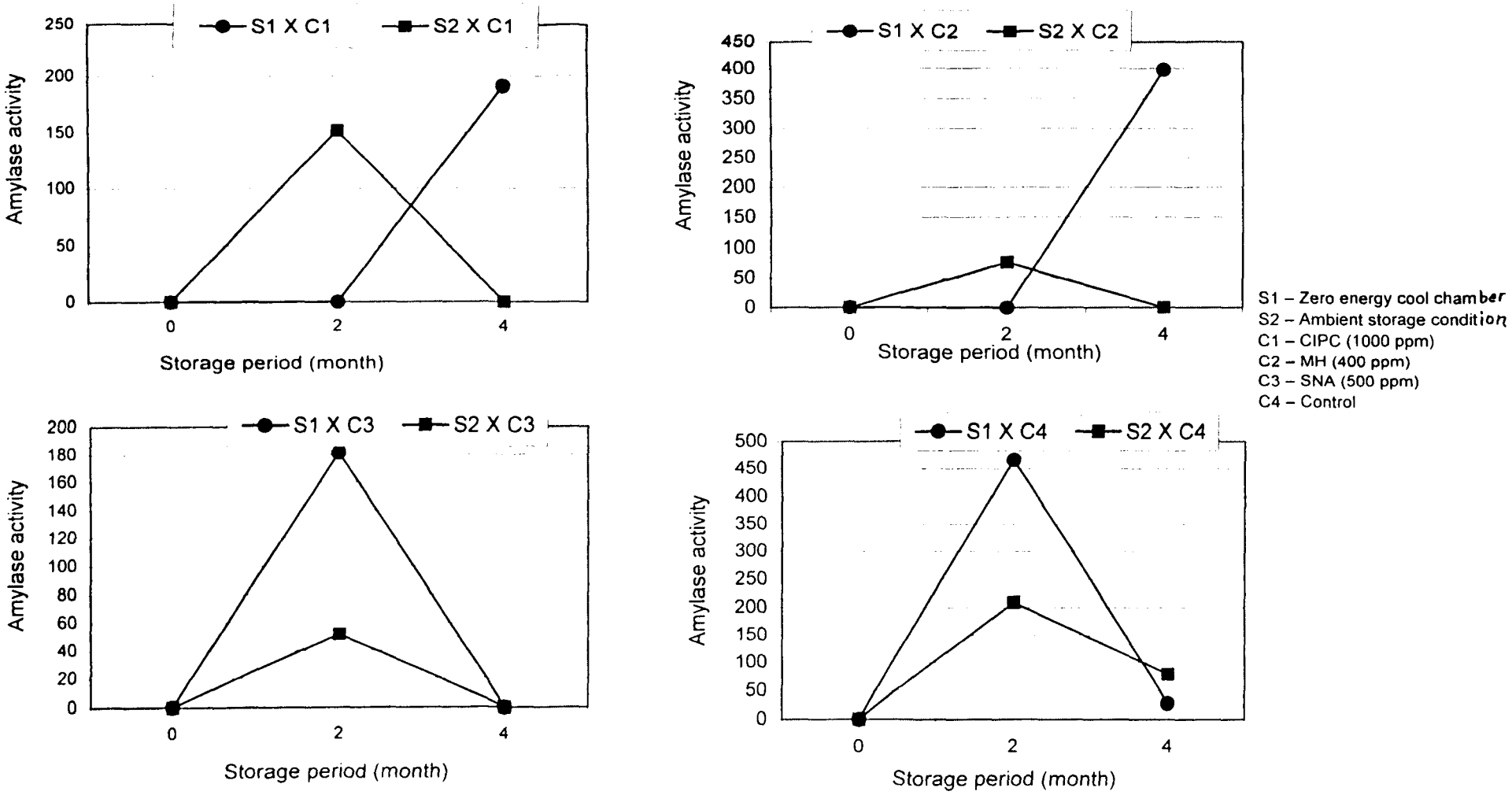

Fig. 6. Amylase activity (μg maltose /15 min/mg protein) in tubers of Kufri Pukhraj treated with sprout inhibitors during storage under different storage conditions

However, amylase activity was not observed in tubers with SNA treatment and observed in tubers with other treatments under ZECC and tubers with chemical treatment did not show any activity of amylase under ambient condition after four months of storage.

4.2.15 Correlation studies

Correlation coefficients between various characters of potato tubers after four months of storage as influenced by storage condition and chemical treatment are presented in Table 28. It was observed that sprout weight had highly significant positive correlation with number of sprout (0.897) and length of sprout (0.890). Dry matter had significant positive correlation with PLW% (0.714). Whereas reducing sugar content was negatively correlated with dry matter content (-0.850).

Table 28. Correlation coefficients between various characters of potato after four months of storage as influenced by storage condition and chemical treatment

Sl. No	X	Y	Correlation coefficient (r)
1.	Sprout weight	Number of sprout	0.897**
2.	Sprout weight	Length of sprout	0.890**
3.	Dry matter content	Sprout weight	-0.428
4.	Dry matter content	PLW%	0.714*
5.	Overall acceptability of chips	Dry matter content	-0.079
6.	Overall acceptability of chips	Sprout weight	-0.224
7.	Overall acceptability of chips	Reducing sugar	0.189
8.	Overall acceptability of chips	PLW%	-0.407
9.	Overall acceptability of cooked tubers	PLW%	-0.681
10.	Reducing sugar	Sprout weight	0.228
11.	Reducing sugar	Dry matter content	-0.850**

* - Significant at 5% level
** - Significant of 1% level

Discussion

V. DISCUSSION

The results obtained in respect of various parameters of potato as influenced by storage condition, cultivars and chemical treatment during the period of investigation are discussed here under.

5.1 EXPERIMENT I: STUDIES ON STORAGE BEHAVIOUR OF POTATO CULTIVARS UNDER DIFFERENT STORAGE CONDITIONS

5.1.1 Weight loss (%)

Physiological losses in weight of potato tubers are low as long as they remain dormant and increase due to sprout growth after dormancy is over. Weight loss during storage is mainly due to physiological processes like transpiration and respiration and due to rotting by decay causing organisms. Physiological losses can be reduced by increasing the relative humidity and reducing the temperature of the storage atmosphere (Kaul and Mehta, 1999).

In the present investigation, per cent PLW as well as total weight loss were recorded lower (8.54 and 12.83%) in tubers stored under zero energy cool chamber (ZECC) against 14.0 and 27.38 per cent under ambient storage condition (ASC) after storage period of four months (Table 1 to 3). Similar results were obtained by Ilangantileke *et al.* (1996) and Mangal *et al.* (1999) under evaporatively cooled potato stores (ECPS). Less weight loss under ZECC was probably due to less transpiration and respiration due to low temperature and high relative humidity (Kaul and

Mehta, 1999) and less aggravated microbial growth under such condition (Rama *et al*, 1990).

Cultivar Kufri Chandramukhi and Kufri Sutlej respectively recorded lower (6.83 and 8.67%) and higher (11.25 and 17.67%) PLW under both ZECC and ASC. Total weight loss due to combined effect of PLW and rotting was lower in cv. Kufri Chandramukhi under both storage conditions (9.75 under ZECC and 18.17% under ASC) and higher in Kufri Sutlej (23.58%) under ZECC and Kufri Ashoka (33.84%) under ASC. However, tubers of cv. Kufri Ashoka (10.34), Kufri Pukhraj (10.84) and Kufri Jyoti (10.91) under ZECC and Kufri Jyoti (18.83) under ASC were statistically on par with Kufri Chandramukhi with respect to per cent total weight loss after four months of storage. cv. Kufri Pukhraj and Kufri Sutlej, which recorded higher (33.67 and 33.25%, respectively) total weight loss were on par with Kufri Ashoka under ASC. Similar results were obtained by Kang and Jai Gopal (1993) and Kaul and Mehta (1993). Differences in weight loss among the potato cultivars have also been reported by Verma and Jha (1990), Khurana *et al.* (1994), Kumar *et al.* (1995), Mehta and Kaul (1997), Mangal *et al.* (1999), Naik and Basavaraj (1999) and Singh and Raghav (1999), which can be attributed to the difference in respiration and transpiration rate (Mehta and Kaul, 1997). In the present investigation, difference in sprouting behaviour among cultivars (Table 5 to 8) might have contributed to difference in PLW (%). Mehta and Kaul (1994) and Mehta *et al.* (1997) indicated positive correlation between dormancy period, skin and periderm thickness, wound induced suberization, calcium content in peels and the keeping quality of tubers.

Sprouting does not normally occur in freshly harvested potato tubers eventhough they are kept under favourable environmental condition because of their dormancy period and it varies from variety to variety. Excessive weight loss and shrinkage due to sprouting becomes major reasons for deterioration of quality of potatoes stored without refrigeration (Rastovski, 1981).

In the present investigation, higher sprouting percentage was observed in tubers stored under ZECC at the initial months of storage (Table 5). Kaul and Mehta (1988), Kaul and Mehta (1994) and Mangal *et al.* (1999) also made similar observations and opined that higher sprouting might be due to higher relative humidity inside the evaporative cooling chamber (Appendix II). Varietal differences was observed for sprouting and all cultivars under storage started sprouting within a month. Per cent sprouting was more than 50 per cent under ZECC within 2 months except in cv.Kufri Chandramukhi. More than 90 per cent sprouting was observed within 3 months under both storage condition except in cv. Kufri Chandramukhi under ASC (74.69%). Varietal difference in sprouting have also been reported by Kaul and Mehta (1988), Kaul and Mehta (1993), Kumar *et al.* (1995) and Naik and Basavaraja (1999), which might be due to difference in dormancy period.

Higher number of sprout was recorded in tubers stored under ZECC, which might be due to early breaking of dormancy due to high

relative humidity (Kaul and Mehta, 1998). Among the cultivars studied, Kufri Jawahar under ZECC and Kufri Jyoti in ASC recorded higher number of sprouts and Kufri Chandramukhi recorded lower value under both storage conditions. Length of longest sprout was observed higher in tubers stored under ZECC irrespective of cultivars, that might be due to dark condition prevailed inside ZECC (Garg *et al.*, 1999). cv. Kufri Chandramukhi and Kufri Sutlej respectively recorded shorter and longer sprout length under both storage conditions, which can be attributed to the varietal difference. Per cent sprout weight to tuber weight at 120th day of storage was observed lower (1.75) in ASC and higher (2.34) in ZECC (Table 8). Higher sprout weight in ZECC stored tubers was due to higher sprouting intensity and vigorous sprout growth due to low temperature and high relative humidity inside the chamber. This corresponded to the results obtained by Kaul and Mehta (1988), Garg *et al.* (1999) and Mangal *et al.* (1999). Among the cultivars evaluated, per cent sprout weight varied from 1.18 (Kufri Chandramukhi) to 2.92 (Kufri Sutlej) under ZECC and 1.16 (Kufri Chandramukhi) to 2.16 (Kufri Sutlej) in ASC. Differences in sprout weight among varieties in this experiment can be attributed to the difference in number of sprouts, sprout length and growth behaviour of sprouts in cultivars under study, as there was highly significant positive correlation of sprout weight with number and length of sprouts (Table 14). Similar differences in sprout weight among genotypes have also been reported by Kaul and Mehta (1988), Kaul and Mehta (1993) and Mangal *et al.* (1999).

5.1.3 Quality of stored potato tubers

5.1.3.1 Dry matter

Dry matter content declined as the storage period progressed during the investigation which corresponded to the result obtained by Kumar *et al.* (1999). Tubers stored under ASC retained higher dry matter (18.56%) as compared to those under ZECC (17.41%) after storage period of four months. Highly significant negative correlation was observed between dry matter content and spout weight (Table 14). Hence, higher loss of dry matter in tubers under ZECC can be attributed to the utilization of carbohydrate for sprout growth (Beukema and Van Der Zaag, 1990) and higher water loss might have increased the ratio of dry matter to fresh weight under ASC (Doreyappa Gowda and Krishnappa, 1985).

Tubers of cv. Kufri Chandramukhi retained maximum dry matter under both storage conditions (20.34% under ZECC and 20.53% under ASC). Whereas cv. Kufri Jyoti under ZECC and Kufri Jawahar under ASC showed minimum dry matter (16.28 and 17.5%, respectively). Maximum dry matter retention in cv. Kufri Chandramukhi was due to less utilization of carbohydrates because of low intensity of sprouting and low sprout weight (Beukema and Van Der Zaag, 1990).

5.1.3.2 Cooking quality

The objectionable properties in cooked potatoes are proneness to the development of a grey discoloration after cooking or to disintegration

during cooking or possession of soggy, wet or sticky texture. The flavour is sometimes unpleasant due to high content of solanine. The change in texture caused by cooking together with gelatinization of starch is regarded as the fundamental changes, which render a potato normally edible (Burton, 1989).

In the present investigation, tubers stored under ZECC recorded higher scores for all sensory characters though taste was statistically non-significant. Lower scores for sensory characteristics under ASC might be due to greater water losses, leading to greater peeling losses and reduction of culinary qualities as opined by Rastovski (1981). Potato cvs. Kufri Jawahar, Kufri Pukhraj, Kufri Ashoka and Kufri Jyoti performed fairly good for all sensory characteristics under both storage conditions. Whereas tubers of Kufri Chandramukhi and Kufri Sutlej scored low for all sensory characteristics. According to Burton (1989), the overall tendency to a particular texture, colour and other characteristics of cooked potato tuber is a heritable varietal character, though it is influenced by differential environmental condition.

5.1.3.3 Frying quality

The colour is one of the most important characters of processed potato and is determined by the amount of reducing sugar present in the tuber. High reducing sugars yield dark brown chips due to Maillard reaction between sugars and free amino acids (Habib and Brown, 1957). In the present investigation, no statistical difference could be observed

between tubers stored under ZECC and ASC eventhough score on appearance, taste and overall acceptability in tubers under ASC and texture and flavour under ZECC were marginally higher. Although the reducing sugars content was higher in tubers stored under ZECC (Table 11), blanching treatment and water washing before frying might have brought down phenolics, reducing sugar and free amino acids and inhibited enzymes nullifying the effect of excess reducing sugars (Misra and Premchand, 1988). Storage condition and cultivar interaction was observed significant for appearance, taste and overall acceptability. Tubers of cv. Kufri Chandramukhi, Kufri Jyoti and Kufri Ashoka, which contained lower reducing sugars scored higher for most of sensory characteristics under ZECC. These results are in confirmation with the results obtained by Pant and Kulshrestha (1994). However, under ASC cv. Kufri Jawahar, Kufri Ashoka and Kufri Pukhraj performed fairly good for most of sensory characteristics though they contain slightly higher reducing sugars, which might be due to variation in other participants of the Maillard reaction (Burton, 1989).

4.1.3.4 Chemical composition

Potato tuber being a living entity undergoes various biochemical and physiological changes during storage. In the present investigation, both reducing and total sugars content of tubers increased during storage irrespective of storage condition. But increase was faster in tubers under ZECC as compared to those under ambient condition. Reducing sugars content was positively correlated with sprout weight and negatively with

dry matter content (Table 14). Hence, higher sugar content under ZECC stored tuber can be attributed to the higher break down of starch for sprout growth as evidenced by loss of dry matter (Table 8) and low utilization of sugars due to low respiration rate because of temperature and high humidity. Similar results were obtained by Mehta and Kaul (1988) under ECPS. Among the cultivars tubers of cv. Kufri Jyoti and Kufri Chandramukhi, maintained low reducing and total sugars content under both storage conditions (Table 11). Varietal differences in sugar content was also reported by Verma *et al.* (1974), Mehta and Kaul (1988), Uppal (1995) and Kumar *et al.* (1999).

Ascorbic acid content of tubers decreased during storage and the decrease was faster under ASC than ZECC, which corresponded to the observation made by Burton (1989) and Azarang and Shahidi (1994). Among the cultivars Kufri Jyoti and Kufri Sutlej recorded higher and lower ascorbic acid content respectively during storage (Table 12). Desai (1992) also reported cultivar differences in ascorbic acid content. The general decrease in ascorbic acid content during storage might be due to oxidative destruction of ascorbic acid in presence of molecular oxygen by enzyme ascorbic acid oxidase (Mapson, 1970).

5.1.4 Enzyme activity

Low temperature storage has been reported to result in increased activity of both α and β-amylase (Cottrel *et al.*, 1993). Anon.(1991) reported that amylase activity increased after harvest and reached peak

within 2 weeks at 4°C, whereas similar peak was noticed at 17°C only after 4 weeks. Kumar and Baijal (1978) found progressive increase in amylase activity at 5°C and decrease at room temperature (30±2°C). In the present investigation, no clear relationship could be observed between amylase activity and sprouting percentage, tuber rotting and sugar accumulation, though sprouting percentage and sugar accumulation was higher in tubers stored under ZECC. Activity of amylase increased after harvest and increase was faster in tubers stored under ZECC except in Kufri Ashoka and declined after reaching peak. Bailey *et al.* (1978) also found a general increase in enzyme activity at the time of sprouting of tubers followed by a general decline. But the activity of their enzyme could not be correlated with the observed level of sugars. The activity of enzyme seems to depend on varietal characteristic and unusual high amylase activity in tubers of Kufri Ashoka under ASC could be the reason for higher tuber rotting of this cultivar under ASC (Table 2).

5.2 EXPERIMENT II: STUDIES ON EFFECT OF DIFFERENT CHEMICAL TREATMENTS ON STORAGE LIFE OF POTATO CV. KUFRI PUKHRAJ

An important aspect in storage of ware potatoes is sprout inhibition as sprouting is always associated with higher weight losses and softening of tubers (Buitelaar, 1981). In the present investigation, different sprout inhibitors were tried to know their effect on storability of potato tubers cv. Kufri Pukhraj under different storage conditions.

5.2.1 Storability of potato as influenced by CIPC treatment

Use of CIPC as sprout inhibitor to extend the storability of potato has been reported by Liu *et al.* (1990), Wessel and Wustman (1990), Kumar *et al.* (1994) and Liu *et al.* (1994). Irrespective of storage conditions, mean PLW per cent in tubers treated with CIPC was marginally lower (10.75), but weight loss due to rottage and total weight loss were higher (13.0 and 23.75%) than those of untreated one (10.96, 11.13 and 22.10%, respectively) after storage period of four months (Table 15 to 17). However, the same CIPC treated tubers maintained significantly low PLW (5.0%) as compared to 7.17 per cent in untreated tubers under ZECC, which might have been due to low respiration and transpiration rate. This reduction in PLW is in line with the results obtained by Maini *et al.* (1984), Khurana *et al.* (1986) and Kumar *et al.* (1994). Weight loss due to rottage was increased by CIPC treatment under by both storage conditions, which was due to aggravation of microbial growth due to chemical treatment. Similar observation was made by Rama *et al.* (1990) and Kumar *et al.* (1994). Total weight loss in tubers with CIPC treatment stored under ASC was higher (37.17%) as compared to 33.70 per cent in untreated tubers. But it was not affected by CIPC treatment under ZECC.

Irrespective of storage conditions, sprouting of tubers treated with CIPC was 24.59, 66.56 and 83.98 per cent as compared to 53.54, 97.54 and 100 per cent in untreated tubers after 2, 3 and four months of storage respectively. However, the CIPC treated tubers stored under ZECC showed only 4.57, 37.95 and 67.95 per cent sprouting against 46.06,

95.07 and 100 per cent in untreated tubers under ASC after 2, 3 and four months of storage respectively (Table 19). But sprouting was not suppressed by the CIPC under ASC. Similar results of better efficiency of CIPC under low temperature condition have been reported by Rama and Narasimham (1987), Wessel and Wustman (1990) and Anon. (1998).

Irrespective of storage condition and storage period, mean sprout number in tubers with CIPC treatment was 1.70 as compared to 2.95 in untreated tubers. However, mean number of sprouts per tuber in CIPC treated tubers stored under ZECC was only 1.23 and it was 3.13 and 2.77 in untreated tubers under ZECC and ASC respectively (Table 20). Length of longest sprout was inhibited by CIPC treatment under ZECC. Whereas no such inhibition was found under ASC (Table 21). Wessel and Wustman (1990) opined that the low efficiency of CIPC under higher temperature condition is due to the increased evaporation of compound resulting to reduced presence and activity in the stored tubers. According to Nowak (1977), sprout inhibiting effect of CIPC is mainly due to inhibition of protein synthesis. CIPC treatment reduced the sprout weight by 38.61 per cent over control irrespective of storage condition at the end of four months of storage (Table 21). However, reduction of sprout weight due to CIPC treatment under ZECC was 61.62 per cent as compared to untreated tubers under ZECC and it was 55.1 per cent as compared to untreated tubers under ASC. Reduction in sprout weight by CIPC treatment has also been reported by Kumar *et al.* (1994). Reduction of sprout weight due to CIPC treatment under ZECC in this experiment can

be attributed to the less sprouting percentage, less number of sprouts and shorter sprout length (Table 19-22), as there was highly significant positive correlation between sprout weight and number as well as length of sprout (Table 28). Effect of CIPC treatment alone or interaction with storage condition was non-significant on dry matter content after storage period of four months. However, CIPC treated tuber stored under ZECC retained maximum dry matter (18.86%) as compared to 16.79 per cent in untreated tubers, which may be attributed to the less utilization of carbohydrate due to low sprout intensity in this treatment (Beukema and Van Der Zaag, 1990).

Irrespective of storage conditions, organoleptic score of cooked tubers was significantly lower (2.70) due to CIPC treatment as compared to 3.20 in untreated tubers for overall acceptability and non-significant for other sensory characteristics. However, CIPC treated tubers under ZECC scored fairly good (3.14) for overall acceptability though it was lower than untreated tubers (3.41). Burton (1989) opined that cooking quality of potato is a heritable varietal character, although it is influenced by external environmental condition. Effect of CIPC on organoleptic score of fried potato was significant only for appearance (Table 24). Appearance of chips prepared from tubers with CIPC treatment was better (3.13) as compared to untreated tubers (2.62) irrespective of storage condition and its effect was more pronounced under ZECC, in which tubers scored 3.47 as compared to 2.55 in untreated tubers. Better appearance of chips from tubers with CIPC treatment was due to low reducing sugar content in

tubers with this treatment (Table 25). Low reducing sugars content in this treatment was due to low breakdown of starch, as there was significant negative correlation between reducing sugar and dry matter content (Table 28). Similar results have been reported by Khurana and Randhawa (1985) and Anon. (1998). Ascorbic acid content decreased during storage. But neither CIPC treatment nor interaction with storage condition was significant. Only storage condition was significant for ascorbic acid content during storage (Table 26). General decline in ascorbic acid content was due to oxidation of ascorbic acid by enzyme ascorbic acid oxidase in presence of molecular oxygen (Mapson, 1970).

Amylase activity was not detected in CIPC treated tubers under ZECC after two months of storage. That might be the reason of lower sprouting and lower sugar accumulation in these tubers. Similar observations were made by Khurana and Randhawa (1985). General trend of amylase activity was in similar line as observed by Bailey *et al.* (1978) (Figure 6).

5.2.2 Storability of potato as influenced by MH treatment

Irrespective of storage conditions tubers with MH treatment recorded lower PLW (9.34%) as compared to untreated tubers (10.96%) after four months of storage and the reduction of PLW was observed under both storage conditions. It might be due to low respiration and transpiration rate in MH treated tubers because of less sprout growth (Kaul and Mehta, 1994). Rotting increased slightly in MH treated tubers

irrespective of storage condition (Table 16). Similar results have been reported by Kumar and Mukherjee (1989), Mehta and Kaul (1991) and Kaul and Mehta (1994). Rama *et al.* (1990) opined that increased rotting in chemical treated tubers is due to aggravated microbial growth. But the total weight loss due to combined effect of PLW and rotting was not affected significantly by MH treatment irrespective of storage condition (Table 17).

Irrespective of storage conditions, sprouting percentage in MH treated tubers was recorded 18.25, 63.51 and 88.75 per cent at the end of 2, 3 and four months of storage as compared to 53.54, 97.54 and 100 per cent in untreated tubers (Table 19). However, it was only 4.57, 37.25 and 67.95 per cent respectively in MH treated tubers stored under ZECC. Similar results have been reported by Kaul and Mehta (1991), Mehta and Kaul (1991) and Kaul and Mehta (1994). Better sprout inhibition due to MH treatment under ZECC was due to reduced temperature under such condition, which corresponded to the findings of Rama and Narasimham (1987). Number of sprouts per tuber as well as the length of longest sprout in tuber were reduced by MH treatment under both storage conditions (Table 20 and 21). But the efficiency was better under ZECC, which again corresponded to the observation of above workers. Number of sprouts was more in MH treated tubers than CIPC treated tubers under ASC, but the sprout length was comparatively shorter. This indicates, though sprout initiation was not inhibited completely, sprout growth in tubers was checked by MH treatment. This corresponded to the findings

of Kumar and Mukherjee (1989). Reduction in sprout weight due to MH treatment was 40.42% irrespective of storage condition, which was higher than CIPC treatment indicating better efficiency of MH under ASC. Reduction in sprout weight in MH treated tubers stored under ZECC was 49.65 per cent over untreated tubers under ZECC, and it was 38.56 per cent lower than untreated tubers under ASC. MH treatment reduced the sprout weight by 29.56 per cent over untreated tubers under ASC. Similar observation of reduction in sprout weight by MH treatment was recorded by Kumar and Mukherjee (1989) and Kaul and Mehta (1994). According to Mueller and Mondy (1977), sprout inhibition by MH is due to interference in various stages of hormone metabolism or the lipid composition.

Dry matter content of tubers after four months of storage was not affected by MH treatment, though it decreased during storage. Decrease in dry matter is due to utilization of Carbohydrates for sprout growth (Beukema and Van Der Zaag, 1990). All the sensory characteristics of cooked tubers were lower in MH treated as compared to untreated one irrespective of storage condition. But they were statistically on par indicating the fact that cooking quality varies mainly in accordance with varietal character (Burton, 1989).

Irrespective of storage condition, appearance of chip was superior in tubers treated with MH (3.17) over untreated one (2.62) (Table 24). Chips from MH treated tubers stored in ASC were superior in appearance (3.43) over untreated one (2.70) and no difference could be observed due to MH treatment over control under ZECC. It was due to low content of reducing

sugars in MH treated tubers under ASC (Table 25). Similar relationship between reducing sugars and chip appearance was observed by Pant and Kulshreshtha (1994) and Uppal (1999).

Ascorbic acid content of tubers declined during storage, but MH treatment did not affect its content under both storage conditions. General decline was probably due to the oxidation of ascorbic acid by enzyme ascorbic acid oxidase (Mapson, 1970). Amylase activity was detected only after four months of storage under ZECC, and that might be the reason in low sprouting during initial months. The trend of amylase activity during storage was similar to that observed by Bailey *et al.* (1978).

5.2.3 Storability of potato as influenced by SNA treatment

α-NAA as well as its sodium salt (SNA) and methylene ester (MENA) are used to inhibit sprouting in storage (Rama and Narasimham, 1987; Liu *et al.* 1989 and Rama and Narasimham, 1989).

In the present investigation per cent PLW and total weight loss in SNA treated tubers did not differ statistically with untreated tubers irrespective of storage conditions (Table 15 and 17). Per cent PLW was lower (5.5) in SNA treated tubers under ZECC as compared to 7.17 per cent in untreated tubers, whereas per cent PLW in treated tuber was statistically on par with untreated tubers under ASC. However, weight loss due to rottage in SNA treated tubers was higher under both storage conditions (5.83 under ZECC and 19.33% under ASC) as compared to 3.33 and 18.93 per cent respectively in untreated tubers. Similar

observations of low PLW and high spoilage have been recorded by Rama and Narasimham (1987 and 1989). Total weight loss due to SNA treatment was marginally higher (11.33%) under ZECC and lower (33.17%) under ASC as compared to 10.50 and 33.70 per cent in untreated tubers. But values were statistically non significant.

Tubers treated with SNA showed less sprouting under both storage conditions (32.27 under ZECC and 25.55 % under ASC) as compared to 61.02 and 46.06 per cent respectively in untreated tubers after two months of storage (Table 19). But the per cent sprouting was 91.32 and 87.5 per cent after three month of storage under ZECC and ASC respectively. Similar observation of better sprout inhibition by SNA under room condition has been made by Rama and Narasimham (1987). Number of sprout per tuber was not influenced by SNA treatment under ZECC, but length of sprout was inhibited by this treatment. (Table 20 and 21). There was no reduction in sprout weight by SNA treatment after four months of storage under ZECC, but it was 18.95 per cent in ASC over control, which again corresponded to the findings of Rama and Narasimham (1987). These findings suggest that SNA can not inhibit sprouting for longer period. Dry matter content wasn't affected by SNA treatment (Table 22). Overall acceptability of SNA treated tubers after cooking was inferior than control irrespective of storage condition (Table 23). But the appearance of chip made from SNA treated tuber was better than untreated one (Table 24) though reducing sugar content was higher in these tubers (Table 25). This can be explained as the outcome of

the variation in participants of maillard reaction other than reducing sugar (Burton, 1989).

Ascorbic acid content was not affected by SNA treatment under both storage conditions, though it declined during storage (Table 26). Decline in ascorbic acid content of tuber during storage was due to the oxidation of ascorbic acid by enzyme ascorbic acid oxidase (Mapson, 1970).

The activity of amylase in tuber was detected low in ASC as compared to ZECC after two months of storage (Table 27), which might have contributed to better sprout inhibition under ASC (Khurana and Randhawa 1985). Activity of amylase declined after two months of storage (Figure 6), which was similar to the trend of amylase activity observed by Bailey *et al.* (1978).

PRACTICAL UTILITY

1. Zero energy cool chamber which works on principle of evaporative cooling, can be successfully utilized for short-term storage of potatoes minimizing shrinkage and total weight loss during storage.

2. Chemicals such as CIPC and MH can be used effectively to prevent sprouting of ware potato stored under ZECC.

FUTURE LINE OF WORK

1. Alternative low cost indigenous storage technologies involving low cost cooling systems need to be explored.

2. There is a scope for indepth study on naturally occurring volatiles/ organic oils as alternative to the present sprout inhibitors.

3. There is a need to develop cultivars which have a good keeping quality to reduce dependence on energy intensive refrigerated storage.

4. Low cost indigenous storage structure like ZECC can be tried to store potatoes harvested during *rabi* season for possible use as seed materials for *kharif* crop.

Summary

VI. SUMMARY

An investigation on storability of potato was carried out in the Department of Horticulture, College of Agriculture, Dharwad during the year 1999-2000. The highlights of the experimental findings are summarized below.

Zero energy cool chamber (ZECC), which is a storage structure working on the principle of evaporative cooling maintained low temperature and high humidity as compared to ambient storage condition (ASC) during the investigation period. Tubers stored under ZECC recorded significantly lower values of per cent PLW (8.54) and total weight loss (12.83) as compared to those under ASC (14.0 and 27.38 respectively) after storage period of four months. Sprouting percentage was recorded higher in the tubers of all the varieties stored under ZECC upto three months. But 100 per cent sprouting was recorded after four months of storage under both storage conditions. Sprout weight after 4 months of storage was higher (2.34%) in tubers stored under ZECC as compared to those under ASC (1.75%). Tubers stored under ASC retained more dry matter (18.56%) as compared to those under ZECC (17.41). Scores for all sensory characteristics of cooked potato was higher in tubers under ZECC than those under ASC. But the sensory characteristics of fried potato was not affected by storage conditions though the sugar content was higher in tubers under ZECC. Tubers under ZECC retained higher ascorbic acid content (10.99 mg/100 g F.W.) after storage period of four months as compared to those under ASC (8.90 mg/100 g F.W.).

Performance of cv. Kufri Chandramukhi was better under both storage conditions showing 6.83 and 8.67 per cent PLW and total weight loss respectively under ZECC and 9.75 and 18.17 per cent, respectively under ASC. However, cvs Kufri Ashoka, Kufri Pukhraj and Kufri Jyoti under ZECC and Kufri Jyoti under ASC were statistically on par with cv. Kufri Chandramukhi with respect to total weight loss after storage period of four months. Potato cultivars differed in sprouting percentage during initial months, but 100 per cent sprouting was observed in all cultivars after storage period of four months. Tubers of cv. Kufri Chandramukhi recorded lower (1.81% under ZECC and 1.16 per cent under ASC) sprout weight and Kufri Sutlej recorded higher (2.92 and 2.16%, under ZECC & ASC, respectively) after storage period of four months. Tubers of cv. Kufri Chandramukhi retained maximum dry matter (20.34% under ZECC and 20.53% under ASC) among the cultivars evaluated after four months of storage.

With respect to cooking quality, Kufri Jawahar was the best followed by Kufri Pukhraj and Kufri Ashoka after the storage period of four months. Overall acceptability of chips was higher in tubers of cv. Kufri Chandramukhi (3.25) followed by Kufri Ashoka (3.15) and Kufri Jyoti (3.0) under ZECC and in cv. Kufri Jawahar (3.14) followed by Kufri Ashoka (2.85) and Kufri Pukhraj (2.85) under ASC. Tubers of cvs. Kufri Chandramukhi and Kufri Jyoti accumulated less sugar during storage. Ascorbic acid content in tuber was retained maximum in cv. Kufri Jyoti (12.76) followed by Kufri Chandramukhi (11.17) and minimum in Kufri

Sutlej (8.71 mg/100 g F.W.) after storage period of 4 months. Activity of amylase was recorded higher in ZECC stored tubers of most of the varieties after two months of storage.

All chemical treatments increased rotting during storage. The total weight loss after storage period of four months in chemical treated tubers were statistically on par with untreated tubers (10.50%) under ZECC. Whereas under ASC, tubers with CIPC treatment recorded higher (37.17%) and MH treatment with lower (31.37%) total weight loss as compared untreated tubers (33.70%). Post harvest treatment of tubers with CIPC (1000 ppm) and pre-harvest foliar spray of MH (400 ppm) inhibited sprouting by over 62 and 60 per cent respectively after three months and by 32 and 22 per cent respectively after four months of storage under ZECC. The reduction in sprout weight over control was 61.62 and 49.65 per cent, respectively in tubers with CIPC and MH treatment under ZECC after four months of storage. SNA treatment could not inhibit the sprouting for more than two months during storage under both storage conditions. Dry matter content of tubers was not influenced significantly by chemical treatment. Scores pertaining to overall acceptability of cooked tubers was reduced significantly by chemical treatment. Chemical treatment did not influence on most of the sensory characteristics of fried potato. Tubers with CIPC treatment under ZECC and MH treatment under ASC accumulated less sugar during storage as compared to untreated one. But the ascorbic acid content was not influenced by chemical treatment. Activity of amylase in tubers with CIPC and MH treatment under ZECC was detected only after storage period of four months.

References

VII. REFERENCES

ANONYMOUS, 1991, *Annual Report* 1990-91, Central Potato Research Institute, Shimla, p.32.

ANONYMOUS, 1998, *Annual Report 1997-98*, Central Potato Research Institute, Shimla, pp.98-99.

ANONYMOUS, 1999a, *Annual Report 1998-99*, Central Potato Research Institute, Shimla, pp.60-64.

ANONYMOUS, 1999b, *Production Year Book*, Food and Agriculture Organization of United Nation, Rome.

*AZARANG, H.P. AND SHAHIDI, H.M., 1994, The variation of nutritional value in two khorasan endemic potato varieties under different storage condition. *Agricultural Science and Technology*, **8**(1): 3-18.

BAILEY, K.M., PHILIPS, I.D.J. AND PIH, D., 1978, The role of buds and gibberellin in dormancy and the mobilization of reserve materials in potato tubers. *Annals of Botany (London)*, **42**: 649-657.

BEUKEMA, H.P. AND VAN DER ZAAG, D.E., 1990, *Introduction to potato production*, Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen. pp. 139-154

BIST, B.S. AND SHARMA, H.C., 1997, *Potato statistics (India and the World)* Technical Bulletin No 40. Central Potato Research Institute, Shimla.

BUITELAAR, N., 1981, Sprout inhibition in ware potato storage. In: *Storage of Potatoes Post-harvest Behaviour, Store Design, Storage Practice and Handling* (eds. Rastovski *et al.*), Centre for agricultural publishing and documentation, Wageningen, pp.344-356.

BURTON, W.E., 1989, *The Potato* (Third Edition), Longman Scientific and Technical, England. pp. 391-422 and 447-449.

*COTTREL, J.E., DUFFUS, C.M., PATERSON, L., MACKAY, G.R., ALLISON, M.J. AND BAIN, H., 1993, The effect of storage temperature on reducing sugar concentration and the activities of three amylolytic enzymes in tubers of the cultivated potato *Solanum tuberosum* L. *Potato Research*, **36**: 107-117.

DAHIYA, P.S. AND SHARMA, H.C., 1994, Potato marketing in India: Status, issues and outlook, Social Science Department, working paper No 1994-2, CIP, Lima, Peru.

DAHIYA, P.S. AND SHARMA, H.C., 1999, Recurrent potato gluts in India, issues and strategies. In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*), IPA, CPRI and ICAR, Delhi, p.73.

DESAI, S., 1992, Nutritive value of new potato cultures. *M.Sc.(Home Science) Thesis,* University of Agricultural Sciences, Dharwad.

DOREYAPPA GOWDA, I.N. AND KRISHNAPPA, K. S., 1985, Effect of preharvest application of MH on storage behaviour of potato stored at room temperature. *Madras Agricultural Journal*, **12**: 110-114.

FISHER, R.A. AND YATES, F., 1963, *Statistical tables for biological, agricultural and medical research*, Oliver and Boyd, Edinburgh, pp.74-75.

FUGLIE, K.O., KHATANA, V.S., ILANGANTILEKE, S.C., SINGH, J., KUMAR, D. AND SCOTT, G.J., 1997, *Economics of Potato Storage in Northern India.* CIP, Social Science Department, Working paper No. 1997-5.

GARG, V.K., SUKUMARAN, N.P. AND RAI, V.K., 1999, Effect of diffused light storage on sprouting behaviour and yield of three potato varieties in Shimla hills: In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.79.

GAUR, A. AND CHENULU, V.V., 1981, Two unrecorded storage disorders of *Citrus reticulata* L. and *Solanum tuberosum* L. *Current Science*, **50**: 322-323.

GHANEKAR, A.S., PADWAL DESAI, S.R. AND NADKARNI, G.B., 1984, Etiology of soft rot in stored potatoes. *Journal of Food Science and Technology*, **21**: 127-131.

*GICHOHI, E.G. AND PRITCHARD, M.K., 1995, Storage temperature and maleic hydrazide effects on sprouting, sugars and fry colour of shepody potatoes. *American Potato Journal*, **72**: 737-747.

HABIB, A.T. AND BROWN, H.D., 1957, Role of reducing sugars and amino-acids in the browning of potato chips. *Food Technology*, **11**: 85.

HILL, L.M., REIMHOLZ, R., SCHRODER, R., NIELSON, T.H., AND SMITT, M., 1996, The onset of sucrose accumulation in cold stored potato tubers is caused by an increased rate of sucrose synthesis and coincides with low levels of hexose phosphates, an activation of sucrose phosphate synthatase and in appearance of a new form of amylase. *Plant Cell and Environment*, **19**: 1223-1237.

ILANGANTILEKE, S.G., KHATANA, V.S., SINGH, J.P. AND KUMAR, D., 1996, Improved rustic storage in South Asia. CIP Programme Report 1995-96, International Potato Centre, Lima, Peru, pp.256-263.

*JEONG, J., KUENWOO, P. AND YANGJOON, Y., 1996, Effect of storage temperature and reconditioning o the processing quality of potato (*Solanum tuberosum* L.) tubers. *Journal of Korean Society for Horticultural Science*, **37**: 362-368.

KANG, G.S. AND JAI GOPAL, 1993, Differences among potato genotypes in storability at high temperature after different period of storage. *Journal of Indian Potato Association*, **20**(2): 105-110.

KASSIM, M.Y., 1986, Chemical control of post-harvest diseases of potatoes and tomatoes. *Indian Phytopathology*, **9**: 243-244.

KAUL, H.N. AND MEHTA, A., 1988, Evaluation of passive evaporative cooling for storage of potato (*Solanum tuberoxum*). *Indian Journal of Agricultural Sciences*, **58**: 928-931.

KAUL, H.N. AND MEHTA, A., 1991, A riskless sprout suppressant for ware potatoes: maleic hydrazide. *Indian Horticulture*, **36**: 10-13.

KAUL, H.N. AND MEHTA, A., 1993, Keeping quality of some advanced potato hybrids. *Journal of Indian Potato Association*, **20**: 85.

KAUL, H.N. AND MEHTA, A., 1994, Foliar application of maleic hydrazide for improving storability of potatoes under high temperature storage conditions. *Journal of Food Science and Technology*, **31**: 514-516.

KAUL, H.N. AND MEHTA, A., 1999, *Storage of Potatoes in India*, Technical Bulletin No.47, Central Potato Research Institute, Shimla.

KAUL, H.N., MEHTA, A. AND EZEKIEL, R., 1999, Storability of potatotes in pits and heaps - A feasibility study. In: *Abstracts of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.77.

KHATANA, V.S., KARNIK, K.S., ILANGANTILEKE, S.G., VAMAN, I.K., PATIL, M.G. AND SCOTT, G.J., 1997, *Farmers Storage Practices for Potatoes in Karnataka, India: Problems and Prospects*, CIP, Social Science Department, Working paper No.1997-8.

KHURANA, D.S., BAJAJ, K.H. AND RANDHAWA, K.S., 1986, Post-harvest storage behaiour of potatoes – A critical review. *Indian Food Packer*, **40**(4): 40-54.

KHURANA, D.S. AND RANDHAWA, K.S., 1985, Yield and quality of dehydrated chips prepared from sprout inhibitor treated potatoes stored under different conditions. *Journal of Food Science and Technology*, **22**: 433-435.

KHURANA, S.C., MEHTA, M.K., BHUTANI, R.D., SINGH, C.B. AND BHATIA, A.K., 1994, Evaluation of storage behaviour of potato under room temperature conditions. *Haryana Journal of Horticultural Science*, **23**: 159-163.

KUMAR, D., KAUL, H.N. AND SINGH, J., 1994, Effectiveness of CIPC (chloropropham) in improving keeping quality of potato stored under passive evaporative cooling. *Journal of Indian Potato Association*, **3-4**: 291-295.

KUMAR, D., KAUL, H. N. AND SINGH, S.V., 1995, Keeping quality in advanced potato selection during non-refrigerated storage. *Journal of Indian Potato Association*, **22**: 105-108.

KUMAR, D., SINGH, J. AND EZEKIEL, R., 1999, Potato stored at 10°C in relation to chipping quality. In: *Abstracts of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.77.

KUMAR, D., SINGH, J. AND SINGH, S.V., 1999, Changes in the sugar and dry matter in tubers of some Indian Potato cultivars and exotic hybrids stored at high temperature. In: *Abstracts of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.83.

KUMAR, P. AND BAIJAL, B.D., 1978, Changes in amylase activity and total sugars during storage in potatoes raised from growth regulator treated tubers. *Indian Journal of Experimental Biology*, **16**: 269-270.

KUMAR, R. AND MUKHERJEE, D., 1989, Sprouting and free amino-acid changes in potato tubers with pre-harvest maleic hydrazide treatment. *Indian Journal of Horticulture*, **46**: 66-72.

LIU, C., WANG, B., DING, F. AND HUANG, X., 1994, Experiment on sprout inhibition effects of CIPC treatment on germination of potato tubers. *Plant Protection*, **20**: 20-27.

LIU, M.S., CHEN, R.Y. AND TSAI, M.J., 1989, Potato storage in Taiwan. *Acta Horticulturae*, **258**: 555-564.

LIU, M.S., CHEN, R.Y. AND TSAI, M.J., 1990, Effect of low temperature storage, gamma irradiation and isopropyl – N – (3-chlorophenyl) carbamate treatment on the processing quality of potatoes. *Journal of the Science of Food and Agriculture*, **53**: 1-13.

MAINI, S.B., ANAND, J.C., KUMAR, R., CHANDAN, S.S. AND VISISHTH, S.C., 1984, Evaporative cooling system for storage of potatoes. *Indian Journal of Agricultural Sciences*, **54**: 193-195.

MANGAL, J.L., SANDOJTA, J.K., BHUTANI, R.K. AND KHURANA, S.C., 1999, Comparative performance of seven potato cultivars in evaporative cool chamber and ambient condition. In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.91.

MANSAUR, S.A., 1984, Protection of stored potatoes from the larvae of potato tuber moth by coating tubers with a thin layer of insecticides. *Pesticides*, **18**(9): 40-42.

MAPSON, L.W., 1970, Vitamins in fruits: Stability of ascorbic acid. In: *Biotechnology of Fruits and Their Products*, Vol.1. (ed. Hulme, A.C.). Academic Press, London, pp.376-377.

MARWAHA, R.S., 1999, Processing quality of potatoes stored under high temperature conditions. In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*), IPA, CPRI and ICAR, Delhi, p.81.

MEHTA, A. AND KAUL, H. N., 1988, High temperature storage of potato (*Solanum tuberosum* L.) for processing – a feasibility study. *Plant Foods for Human Nutrition*, **38**: 263-268.

MEHTA, A. AND KAUL, H.N., 1991, Effect of sprout inhibitors on potato tubers (*Solanum tuberosum* L.) stored at ambient or reduced temperatures. *Potato Research*, **34**: 443-450.

MEHTA, A. AND KAUL, H.N., 1994, Wound healing in potato tuber tissue: cultivar variation. *Journal of Indian Potato Association,* **21**: 247-250.

MEHTA, A. AND KAUL, H.N., 1997, Physiological weight loss in potatoes under non-refrigerated storage: contribution of respiration and transpiration. *Journal of Indian Potato Association,* **24**: 106-113.

MEHTA, A., TREHAN, S.P.AND KAUL, H.N., 1997, Calcium content in potato tuber in relation to keeping quality. *Agricultural Science Digest,* **17**: 165-168.

MISHRA, D. AND RATH, R.C., 1986, Survey of post-harvest decay of vegetables caused by *Fusanum. Indian Phytopathology,* **9**: 273-274.

MISHRA, J.B. AND PREMCHAND, 1988, Improvement of chip colour by removal of colour reactants from potato tuber slices by water washing. *Journal of Food Science and Technology,* **25**: 99-100.

MUELLER, T.O. AND MONDY, N.I., 1977, Effect of sprout inhibition on the lipid composition of potatoes. *Journal of Food Science,* **42**: 618-621.

NAIK, K.R. AND BASAVARAJA, N., 1999, Studies on storability of potato genotypes. In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*), IPA, CPRI and ICAR, Delhi, p.98.

NIELSON, T.H., DEITING, V. AND SMITT, M., 1997, A β-amylase in potato tubers Is induced by storage at lower temperature. *Plant Physiology*, **113**: 503-510.

NIRMALA KUMARI AND MUKHERJEE, D., 1985, Influence of low temperatures on ascorbic acid changes in potatoes during storage. *Indian Journal of Horticulture*, **42**: 268-270.

NIRMALA KUMARI AND MUKHERJEE, D., 1986, The effect of storage temperature and humidity on the internal qualities of potato. *Indian Journal of Horticulture*, **43**: 112-117.

*NOWAK, J., 1977, Biochemical changes in stored potato tubers with different rest periods I. Influence of the storage temperature and isopropyl phenylcarbamates (IPC and CIPC) on protein changes. *Zpflanzenphysiol*, **81**: 113-124.

PANSE, V.G., AND SUKHATME, B.V., 1967, *Statistical methods for agricultural workers*. ICAR, New Delhi, pp.87-98 and 146-172.

PANT, S. AND KULSHRESTHA, K., 1994, Frying quality of six varieties of potato. *Journal of Food Science and Technology*, **31**: 428-429.

PATIL, R.B. AND PATIL, P.S., 1982, The influence of growth regulators on yield and storage life of potatoes (*Solanum tuberosum* L.). *Journal of Maharashtra Agricultural Universities*, **7**: 89-90.

PAUL, V., EZEKIEL, R., SINGH, J., SHEKHAWAT, G.S. AND SINGH, H., 1999, Evaluation of heap and pit methods of potato storage in Indo-Gangetic plains. In: *Abstracts of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.80.

PESHIN, A., 1999, Invertase activity and its relation to hexose accumulation in potato tubers. In: *Abstracts of Global Conference on Potato* held in Delhi, December 6-11, 1999 (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.97.

RAJ, B.T., 1991, *Potato Tuber Moth With Special Reference to India.* Technical Bulletin No. 16, Central Potato Research Institute, Shimla.

RAMA, M.V., KRISHNAMURTHY, H. AND NARASIMHAM, P., 1990, Evaporative cooling storage of potatoes in two model storage structures. *Journal of Food Science and Technology*, **27**: 19-21.

RAMA, M.V. AND NARASIMHAM, P., 1987, Comparative efficacies of chemical sprout inhibitors and vapour heat treatments on the control of sprouting in stored potatoes. *Journal of Food Science and Technology*, **24**: 40-42.

RAMA, M.V. AND NARASIMHAM, P., 1989, Control of potato (*Solanum tuberosum* L., cv. Kufri Jyoti) sprouting by sodium napthyl acetate during ambient storage. *Journal of Food Science and Technology*, **26**: 83-86.

RAMAVO, P. AND USHARANI, P., 1985, Post-harvest pathogen of potato (*Solanum tubersum*) with special reference to charcoal rot caused by *Macrophonina phaseolina* (Abstr). *Indian Phytopathology*, **38**: 605.

RASTOVSKI, A., 1981, Storage losses, In: *Storage of Potatoes; Post-harvest behaviour, Storage Design, Storage Practice and Handling* (eds. Rastovski *et al.*). Centre for Agricultural Publishing and Documentation, Wageningen, pp.169-172.

ROY, S.K, AND KHURDIYA, D.S., 1986, Studies on evaporatively cooled Zero energy cool chambers for storage of horticultural produce. *Indian foodpacker*, **40**(6): 26-31.

SADASIVAM, S. AND MANICHAM, A., 1992, *Biochemical Methods for Agricultural Sciences*. Wiley Eastern limited and Tamil Nadu Agricultural University, Coimbatore.

SAXENA, A.P., 1983, Pests of potato during storage and their control. *Seeds and Farms*, **9**(2-3): 41-42.

SHEKHAWAT, G.S., 1994, Future needs of potato crop. *Journal of Indian Potato Association*, **21**: 1-6.

SINGH, D. AND SINGH, A.K., 1991, Chemical control of storage rot of potato. *Indian Journal of Mycology and Plant Pathology*, **21**: 285-286.

SINGH, K.K., 1981, Cold storage of potatoes in India. *Punjab Horticultural Journal*, **21**: 9-16.

SINGH, N.P. AND RAGHAV, M., 1999, Studies on storage behaviour of potato cultivars under Terai conditions of Utter Pradesh. In: *Abstract of Global Conference in Potato* held in Delhi, December 6-11, 1999, (Eds. Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.96.

THIMMAIAH, S.K., 1989, *A Manual of Research Methods for Analysis of Agricultural Products (Vol I)*, University of Agricultural Sciences, Dharwad.

UPPAL, D.S., 1995, Free sugar and invertase activity in stored potato tubers. *Journal of Indian Potato Association*, **22**: 46-51.

UPPAL, D.S., 1999, Effect of storage environments on chip colour and sugar levels in tubers of potato cultivars. *Journal of Food Science and Technology*, **36**: 545-547.

UPPAL, D.S. AND EZEKIEL, R., 1999, Effect of traditional storage methods on sugar concentrations and chip quality of potatoes. In: *Abstract of Global Conference on Potato* held in Delhi, December 6-11, 1999, (Eds Khurana *et al.*) IPA, CPRI and ICAR, Delhi, p.82.

VERMA, S.C., SHARMA, T.R. AND VERMA, S.M., 1974, Effects of extended high temperature storage an weight losses and sugar content of potato tubers. *Indian Journal of Agricultural Sciences*, **44**: 702-706.

VERMA, V.S. AND JHA, V.B., 1990, Evaluation of potato genotypes for their storability under room temperature. *Journal of Indian Potato Association*, **17**: 152-161.

WESSEL, P.M.F. AND WUSTMAN, R., 1990, Sprout inhibiting effects of propham. chloropropham (IPC. CIPC) mixture and its residue pattern in ware potatoes stored under warm condition. *Tropical Agriculture* (Trinidad), **67**: 262-295.

*YUDA, R.Y., COFFIN, R.H., KEENAN, H.K., FIITS, M., DEFAULT, C. AND TAI, G.C.C., 1991, The effect of maleic hydrazide (Potassium salt) on potato yield, sugar content and chip colour of kennebec and norchip cultivars. *American Potato Journal*, **68**: 705-709.

*Originals not seen

Appendices

APPENDIX I

Mean monthly meteorological data for the year 1999 and average of past 50 years (1950-1999) recorded at Main Research Station, U.A.S., Dharwad

Month	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Maximum		Minimum			
	1999	1950-99	1999	1950-99	1999	1950-99	1999	1950-99
January	0.0	0.11	29.40	30.45	12.4	14.60	75.0	66.37
February	0.0	0.0	32.80	32.26	16.9	15.68	63.0	56.62
March	0.0	7.45	36.20	35.80	20.2	18.80	63.0	56.62
April	14.70	42.90	36.60	38.23	21.2	21.40	65	60.46
May	32.80	85.92	32.20	36.64	21.3	21.47	75	67.32
June	71.80	111.50	28.00	29.76	21.0	21.21	85	81.82
July	113.90	156.09	26.40	27.05	20.8	21.40	89	88.39
August	19.70	103.31	27.10	27.08	20.4	20.366	85	86.84
September	8.80	99.47	28.30	29.39	20.0	20.15	83	83.25
October	161.10	135.79	28.90	30.84	19.8	19.76	79	76.23
November	0.00	34.38	29.60	29.50	16.0	16.33	59	68.39
December	0.00	6.35	28.90	29.65	13.4	13.48	51	64.41
Total	422.80	783.29						
January 2000	0.00		34.38		15.08		48	
February 2000	0.00		32.19		16.33		52	

APPENDIX II

Temperature and relative humidity recorded at 8 am and 2 pm during investigation period

Date	ZECC				Room condition			
	Temperature (°C)		RH(%)		Temperature (°C)		RH(%)	
	8 am	2 pm	8 am	2 pm	8 am	2 pm	8 am	2 pm
5-11-1999	14	16	91	91	18	22	81	74
9-11-1999	15	16.5	87	81	17	22	75	61
13-11-1999	12	15.5	85	81	14	22.5	71	50
17-11-1999	16	16	82.5	75	18	22	60	55
21-11-1999	12	15	75	75	14	20	62	65
25-11-1999	13	17	83	75	17	22	71	60
29-11-1999	14	17	90	75	15	22	81	60
3-12-1999	11	15	80	62	13	23	65	74
7-12-1999	11	13	82	82	13	23	65	65
11-12-1999	11	13	83	83	14	19	67	56
15-12-1999	12	13	88	84	14	20	74	44
19-12-1999	10	14	81	85	14	19	57	45
23-12-1999	11	14	83	84	15.5	19	67	50
27-12-1999	12	14	85	83	15.5	19	67	61
31-12-1999	11.5	14.5	83	75	14	19	63	61
4-01-2000	11	13	85	85	14.5	20	67	59
8-01-2000	10.4	13.5	78	75	14.5	19	65	50
12-01-2000	13	15	87	87	17	21	71	71
16-01-2000	11.5	15	83	75	15	22	62	45
20-01-2000	13	17	85	80	16	22	65	57
24-01-2000	12	16	82	80	16	23	70	62
28-01-2000	12	16	80	80	16	23	65	57
02-02-2000	11	14	85	83	16	22	62	60
06-02-2000	10.5	12.5	90	82	14	22	70	59
10-02-2000	12.5	15	89	90	14	21	70	65
14.02-2000	11	13	85	85	17	21	69	57
18-02-2000	13	14.5	84	83	17	21	63	57
22-02-2000	11	14.5	88	84	15	20.5	66	64

APPENDIX III

Score card for evaluation of cooked potatoes

Name of Panel: Date:

Replication:

Characteristics		Codes											
		A	B	C	D	E	F	G	H	I	J	K	L
Appearance													
Highly attractive	4												
Moderately attractive	3												
Fairly attractive	2												
Unattractive	1												
Taste													
Like extremely	4												
Like moderately	3												
Like slightly	2												
Dislike	1												
Texture													
Well cooked and firm	4												
Mashy	3												
Semi cooked	2												
Uncooked	1												
Flavour													
Excellent	4												
Good	3												
Fair	2												
Poor	1												
Overall acceptability													
Highly acceptable	4												
Moderately acceptable	3												
Fairly acceptable	2												
Poorly acceptable	1												

Signature

Note: Kindly tick mark the score that you feel the best against the codes given.

APPENDIX IV

Score card for evaluation of fried potatoes

Name of Panel: Date:

Replication:

Characteristics		Codes											
		A	B	C	D	E	F	G	H	I	J	K	L
Appearance													
Highly attractive	4												
Moderately attractive	3												
Fairly attractive	2												
Unattractive	1												
Taste													
Like extremely	4												
Like moderately	3												
Like slightly	2												
Dislike	1												
Texture													
Crunchy	4												
Hard	3												
Rubbery	2												
Soggy	1												
Flavour													
Excellent	4												
Good	3												
Fair	2												
Poor	1												
Overall acceptability													
Highly acceptable	4												
Moderately acceptable	3												
Fairly acceptable	2												
Poorly acceptable	1												

Signature

Note: Kindly tick mark the score that you feel the best against the codes given.

STUDIES ON KEEPING QUALITY OF POTATO CULTIVARS

SALIL BHATTARAI 2000 Mr. K. RAMACHANDRA NAIK
Major Advisor

ABSTRACT

An investigation was carried out in the Department of Horticulture, College of Agriculture, Dharwad during the year 1999-2000 to study the effect of storage conditions and chemical treatments on storability of potato cultivars.

Tubers stored under zero energy cool chamber (ZECC) recorded significantly lower values of PLW (8.54%) and total weight loss (12.83%) as compared to 14.0% and 27.38 respectively under ambient storage condition (ASC) after storage period of four months. Sprout weight after four months of storage was higher (2.34%) in tubers stored under ZECC as compared to those under ASC (1.75%). Scores for sensory qualities of cooked potato was higher in tubers under ZECC. But the frying qualities were not affected by storage conditions.

Among the cultivars, Kufri Chandramukhi recorded lower values of PLW and total weight loss (6.83 & 8.67% and 9.75 & 18.17%, respectively under ZECC and ASC) after storage period of four months. Sprout weight after four months of storage was also lower in Kufri Chandramukhi (1.81% and 1.16%, respectively under ZECC and ASC). Difference was observed in cooking and frying qualities among the cultivars after four months of storage under different storage conditions.

The total weight loss after storage period of four months in chemical treated tubers were statistically on par with untreated tubers under ZECC storage. Post harvest treatment of tubers with CIPC (1000 ppm) and pre-harvest foliar spray of MH (400 ppm) inhibited sprouting considerably and the reduction in sprout weight over control was 61.62 and 49.65 per cent respectively in tubers with CIPC and MH treatment under ZECC after four months of storage. Though score pertaining to overall acceptability of cooked tubers was reduced by chemical treatment, frying quality was not significantly affected.