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Influence of sprout inhibiting treatments and packaging methods on storage performance of Kufri Chipsona 4 potato

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ABSTRACT

Effect of sprout inhibiting treatments viz., hot water dip treatment (57.5±0.1°C for 20 min), isopropyl N-(3 chlorophenyl) carbamate (CIPC) treatment on Kufri Chipsona 4 variety of potato during storage was investigated. The control and treated potato tubers were packed in net bag packaging (nylon mesh bags), MAP (Modified atmosphere packaging) and vacuum packaging and stored for four months (120 days) at low temperature (12±1°C) conditions. During the study, it was observed that with increasing the storage period of tubers, there was a overall progressive increase in sprouting (49.7%), physiological loss in weight (PLW) (7.2%), decay loss (67.3%) and decrease in firmness (8.8 kg/cm^2) of potato tubers at 120th day of storage. The CIPC treatment recorded no sprouting, lowest PLW of 6.1% and decay loss (53.2%) and; higher firmness (10.2 kg/cm^2) compared with the other sprouting inhibiting treatments at 120th day of storage. In all packaging methods, the PLW of tubers was significantly lower (2.0%) in vacuum packaging, whereas, the maximum tuber weight loss (16.6%) was observed in net bag packaging while the lowest severity of decay (19.6%) was recorded in net bag packaging followed by MAP (89.8%) and vacuum packaging (92.6%) at 120th day of storage. The sprouting % was signifantly lower (47.4%) in vacuum packaging followed by net bag packaging (49.2%) and highest in MAP (52.5%). Among the interaction effect, the CIPC treated tubers showed no sprouting when packed in any of the used packaging method. The PLW of CIPC treated tubers was lower (1.2%) under vacuum packaging whereas, the lowest decay loss (12.5%) was recorded when CIPC treated tubers were packed in net bag.

Keywords: CIPC, hot water dip, sprouting, packaging.

INTRODUCTION

Potato is considred as one of the most important food in the world. In India, Indo-Gangetic plains contribute around 87% of the total potential production area and the tubers are harvested once in a year during Feb-March which coincides with an abrupt increase in temperature in the region. Therefore, storage becomes the necessity to ensure ample balanced supplies of this perishable commodity until the next harvest (Lu *et al*., 7; Mehta *et al*., 8). Inadequate, expensive and unevenly distributed refrigerated storage facilities lead to oversupply of tuber in the market, causing sizeable economic loss to the farmers as well as wastage of this food product. The root crops' shelf life and realistic usability is said to be impacted by variety, storage temperature, humidity and packaging (Clark *et al*., 2). In the absence of suitabale storage, the potatoes start deteriorating due to biochemical changes in the tuber. The dormancy period can be extended by several storage methods (Lu *et al*., 7). The proper storage of potatoes is essential for fresh consumption as well as for processing industries. The processing industries mainly depend on stored potatoes due to unavailbilty of fresh potatoes for long period. Physiological loss in weight, spoilage, sprouting and quality deteriorations in potatoes were minimized by good storage conditions. Prolonged potato tuber storage also requires sprout inhibition either by sprout inhibitor chlorpropham (CIPC) treatment (Ezekiel *et al*., 4; Lu *et al*., 7; Mehta *et al*., 8), using hot water treatment (Ranganna *et al*., 11; Kyriacou *et al*., 6; Hu *et al*., 5) or packaging methods (Clark *et al*., 2; Beltran *et al*.,1). Hu *et al*. (5) observed that sweet potato storage combined with HWT resulted in to less sprouting and also prevented the decay loss. Mehta *et al*. (8) successfully reduced sprouting of potato tubers by using CIPC formulation based on methanol. The potato shelf life may also be extended by various packaging methods like MAP (Modified atmosphere packaging), vacuum packaging systems (Shetty *et al*., 14; Rocha *et al*., 12) and refrigerated storage. These treatments, besides affecting the physiology of tubers also alter the properties of various biochemical constituents. Very limited information is available on the combined study of sprout inhibiting treatments and packaging methods.

Currently the new potato variety Kufri Chipsona 4 is being promoted due to its suitability for chips making and high dry matter content. Since there was

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no systematic information available in the literature on the variations in potatoes subjected to various storage treatments along with various packaging methods, therefore, the present study was carried out to track the combine effect of pre-storage treatment and packaging methods on the storage performance of potato variety Kufri Chipsona 4.

MATERIALS AND METHODS

The present research work was conducted at Centre of Food Science and Technology, CCS HAU, Hisar. The tubers *Solanum tuberosum* L. Kufri Chipsona-4 were procured from Vegetable Farm, CCS HAU, Hisar. For this study, the cured potato tubers of Kufri Chipsona-4 were subjected to hot water dip, CIPC treatment along with control (untreated) and packed in different packaging material (i.e. nylon mesh bags, MAP and vacuum packaging) and placed in corrugated fiber board (CFB) boxes and stored for 4 months at low temperature (12±1°C) conditions in B.O.D. incubator. For hot water (dip treatment), cured potato tubers were washed to remove soil particles, patted dry and eight tubers per sample were taken. Tubers were immersed for 20 min in a water bath (45 L) maintained at temperature 57.5±0.1°C. Immediately after hot water dip treatment tubers were cooled in distilled water at ambient temperature for 10 min and then moisture was removed by air drying. For CIPC treatment, sprout inhibitor (CIPC) is available as a commercial product (Oorja of United Phosphorus Limited, an ISO 14001 Company, Mumbai). 12.5 ml Oorja (50% active ingredient) dissolved in 1.4 litre of methanol (pure) and stirred well for 5 min. Single layer of cured potatoes were spread on the ground and 14 ml of above solution was sprayed uniformly on 2.5 kg potatoes with the help of hand sprayer and air dried the surface moisture. A batch of hot water treated, CIPC treated and control (untreated) potatoes were packed in net bags (length 41.4 cm, width 29.6 cm), LDPE bags 400 gauge (size 31.5" × 25.5") sealed with sealing machine (MAP) and LDPE bags with a vacuum multivac machine (1 mBar for 10 s) (Vacuum Packaging) respectively. There were 8 potatoes tubers (weighing~1 Kg) packed per treatment (Plate 1) and three replicates per treatment per sampling. The tubers were subjected to the following observations at 30 days intervals. The stored potatoes with buds (eyes more than 0.5 mm length) were selected as sprouted potatoes. The sprouting (%) was counted using the following formula:

$$\text{Sprouting (\%)} = \frac{\text{No of sprouted potatoes}}{\text{Initial number of healthy potatoes}} \times 100$$

For PLW%, initial tuber weight was measured at the start, i.e. at 0 day of storage. The final tuber weight was measured on every day and used in calculation of that particular day. The percent PLW was calculated at 30 days interval up to 120 days using the following formula:

$$\text{Physiological loss in weight (\%)} = \frac{\text{Intial tuber weight-Final tuber weight}}{\text{Intial tuber weight}} \times 100$$

For decay loss %, fresh potato tubers selected for storage at 0 day were counted. On every 30 days interval, the decayed potatoes, if any, were counted and decay loss (%) was calculated by below formula.

$$\text{Decay loss (\%)} = \frac{\text{Number of decayed potatoes}}{\text{Total No. of potatoes at initial}} \times 100$$

Hand held fruit pressure tester (TR Agricoli, Italy; Model FT 327) was used for flesh firmness measurement of potato from the equatorial region on

a: Potatoes packed in nylon net bags | b: Potatoes packed in polyethylene bags (MAP) | c: Potatoes packed under vacuum

Plate 1: Potato tubers subjected to different packaging treatments.

scale of 13 kg/cm^2 with cylindrical plunger of 8 mm diameter. The thick peel (1mm) of potato tuber was removed by hand peeler before measurement. The OPStat software developed by CCSHAU, Hisar was used for statistical analysis of variance (ANOVA). Means were separated by critical difference (CD) at the 5 % level of significance. For experiment three factorial CRD was used for analysis.

RESULTS AND DISCUSSION

The effects of various sprout inhibiting treatments and packaging methods on sprouting (%) of stored potatoes are presented in Table 1. There was progressive increase in overall sprouting with increasing storage periods of tubers. There was no sprouting on 0 day, which increased to 49.7% at 120th day of storage. In the absence of chemical control, sprouting generally increases with storage time. Among various sprout inhibiting treatments, the complete inhibition of sprouting was observed by CIPC treatment, while mean sprouting was 12.1% in hot water dip treated tubers and 66.2% in untreated tubers during the storage period. This may indicate higher physiological activity of untreated tubers compared to CIPC and hot water treated tubers. CIPC acts as a mitotic inhibitor by interfering the process of spindle formation during the cell division in the G2/M-phase (Cell Cycle phase) of the cell cycle (Paul *et al*., 10). In sweet potato, hot water dip treatment (nonchemical method) have been described as one of the potential method for reducing sprouting as well as root growth (Kyriacou *et al*., 6; Sheibani *et al*.,13). The heat from hot water transfered from tuber surface up to the center has the advantages due to high heat transfer rates and decreased the sprouting by inactivating cell division (Ranganna *et al*., 11). Similar lowest percentage of sprouting by CIPC-treatment and HWT during storage of potato tubers at LT has been reported by Kyriacou *et al*. (6). Among various packaging methods for tubers,

Table 1. Effect of sprout inhibiting treatments and packaging methods on sprouting (%) of stored potatoes at low temperature.

Period of Storage (days)	Treatments												Overall mean
	Control				Hot Water Dip				CIPC				
	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)
30	27.5 (31.5)	31.2 (33.7)	27.2 (31.4)	28.6 (32.2)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	9.5 (12.6)
60	89.0 (73.6)	100 (87.1)	87.5 (67.9)	92.0 (76.2)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	30.7 (27.3)
90	100.0 (87.1)	100.0 (87.1)	100.0 (87.1)	100.0 (87.1)	26.7 (31.1)	35.2 (36.4)	12.5 (20.6)	24.8 (29.4)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	41.6 (39.8)
120	100.0 (87.1)	100.0 (87.1)	100.0 (87.1)	100.0 (87.1)	47.5 (43.7)	57.4 (49.5)	42.2 (40.6)	49.0 (44.6)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	49.7 (44.9)
Mean				66.2 (57.1)				12.1 (16.5)				0.0 (2.9)	

Period of Storage (days)	Packaging methods			Overall Mean
	Net Bag	MAP	Vacuum	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)
30	9.2 (12.4)	10.4 (13.2)	9.1 (12.4)	9.5 (12.6)
60	29.7 (26.5)	33.2 (30.9)	29.2 (24.6)	30.7 (27.3)
90	42.2 (40.4)	45.1 (42.1)	37.5 (36.8)	41.6 (39.8)
120	49.2 (44.5)	52.5 (46.5)	47.4 (43.5)	49.7 (44.9)
Mean	25.9 (25.3)	28.0 (27.1)	24.5 (24.0)	

(Values in the parenthesis are angular transformed values; NS – non significant)
CD at 5 %: Storage (S) = 1.69; Treatment (T) = 1.31; Packaging methods (P) = 1.31; SxT = 2.93; SxP= NS; TxP = 2.27; SxTxP = 5.08

minimum mean sprouting (24.5%) was observed under vacuum packaging due to non-availability of gases which required during sprouting followed by net bag packaging (25.9%), while it was maximum (28.0%) in modified atmosphere packaging during the storage period. Same results also observed by Clark *et al*. (2); Beltran *et al*. (1). The interactions between storage, sprout inhibiting treatments and packaging methods were found to be significant. Among the interaction effect, the CIPC treated tubers showed no sprouting when packed in any of the used packaging method. This showed that the CIPC is an effective chemical to retard potato tuber sprouting under different packaging.

There was a progressive increase in physiological loss in weight (%) with increasing storage periods of tubers (Table 2). There was no physiological loss in weight on 0 day, which increased to 7.2% by the 120th day of storage. It was observed that the varieties having long dormancy period, low tuber sprouting percentage and slower growth rate of sprout are also exhibited lower weight loss during storage (Pande *et al*., 9). Among various sprout inhibiting treatments, significantly lower mean weight loss (3.1%) was observed by CIPC, followed by 3.9% in hot water dip treated tubers and maximum (4.3%) in untreated tubers. Untreated tubers had higher sprouting and thus exhibited higher weight loss because of higher respiratory rates and utilization of reserved food material. The tuber weight loss started from the beginning in all treatments but it was increasing fairly slow in CIPC treated tubers and recorded significantly lower PLW of 6.1%, compared with the HWT (7.2%) and control (8.3%) at 120th day of storage. In the present investigation, no sprouting was observed in stored tubers treated with CIPC, thus exhibiting low weight loss due to lower metabolic rate in tubers. Sprouting is always accompanied by rapid respiration and weight loss so it resulted in a rapid increase in physiological weight loss of stored tubers (Sheibani

Table 2. Effect of sprout inhibiting treatments and packaging methods on physiological loss in weight (PLW) (%) of stored potatoes at low temperature.

Period of Storage (days)	Treatments												Overall mean
	Control				Hot Water Dip				CIPC				
	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)
30	7.4 (16.0)	0.6 (4.9)	0.5 (4.6)	2.8 (8.5)	6.9 (15.4)	0.5 (4.6)	0.3 (4.0)	2.6 (8.0)	5.4 (13.6)	0.3 (3.9)	0.3 (3.7)	2.0 (7.1)	2.5 (7.8)
60	11.2 (19.7)	1.3 (6.9)	0.8 (5.6)	4.4 (10.7)	10.1 (18.6)	0.9 (5.9)	0.7 (5.4)	3.9 (10.0)	8.9 (17.5)	0.4 (4.3)	0.4 (4.1)	3.2 (8.7)	3.8 (9.8)
90	13.5 (21.7)	2.3 (9.0)	1.6 (7.7)	5.8 (12.8)	13.9 (21.9)	1.9 (8.3)	1.3 (7.1)	5.7 (12.4)	12.0 (20.4)	0.7 (5.4)	0.5 (4.8)	4.4 (10.2)	5.3 (11.8)
120	19.0 (25.9)	3.7 (11.3)	2.3 (9.0)	8.3 (15.4)	15.9 (23.6)	3.3 (10.7)	2.5 (9.3)	7.2 (14.5)	14.9 (22.8)	2.4 (9.1)	1.2 (6.6)	6.1 (12.8)	7.2 (14.3)
Mean				4.3 (10.1)				3.9 (9.6)				3.1 (8.3)	

Period of Storage (days)	Packaging methods			Overall Mean
	Net Bag	MAP	Vacuum	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.8)
30	6.6 (15.0)	0.4 (4.4)	0.3 (4.1)	2.5 (7.8)
60	10.1 (18.6)	0.9 (5.7)	0.6 (5.1)	3.8 (9.8)
90	13.1 (21.3)	1.6 (7.5)	1.2 (6.5)	5.3 (11.8)
120	16.6 (24.1)	3.1 (10.4)	2.0 (8.3)	7.2 (14.3)
Mean	9.4 (16.4)	1.1 (6.2)	0.8 (5.3)	

(Values in the parenthesis are angular transformed values; NS – non significant)
CD at 5 %: Storage (S) = 0.48; Treatment (T) = 0.38; Packaging methods (P) = 0.38; SxT = 0.84; SxP= 0.84; TxP = NS; SxTxP = NS

et al., 13; Paul *et al*., 10). CIPC treated tubers had a lower tuber respiration rate, and thus lesser weight loss was observed than untreated tubers (Ezekiel *et al*., 3). Hu *et al*. (5) reported that HWT of sweet potato resulted in to inactivation of the protein and tissue from surface flesh. This process also protecting the tuber from spoilage by retarding the evaporation of water from the skin. HWT treated tubers had lower sprouted, so weight loss was also lower. Among various packaging methods for tubers, significantly lower mean weight loss (0.8%) was observed under vacuum packaging followed by MAP (1.1%), while maximum (9.4%) was observed in net bag packaging. The PLW of tubers was significantly lower (2.0%) in vacuum packaging, followed by MAP (3.1%) whereas, the maximum tuber weight loss (16.6%) was observed in net bag packaging at 120th day of storage. The reduced PLW in MAP and vacuum packed potatoes can be attributed to lower moisture loss because of low permeability of polythene to water vapours and due to reduced respiratory rates of tubers due to creation of modified atmosphere (Beltran *et al*., 1). Among the interaction, the PLW of CIPC treated tubers was significantly lowest (1.2%) under vacuum packaging at 120th day of storage which may be attributed due to sprout inhibition action and lower tuber respiration rate by CIPC treatment with supplemented by lower moisture loss due to vacuum packaging.

The per cent decay loss was progressively increased with the increasing storage period of tubers (Table 3). There was no decay loss on 0 day, which overall increased to 67.3% by the 120th day of storage. Among various sprout inhibiting treatments, significantly lower mean decay loss (12.9%) was observed under CIPC treatment, while it was 19.8% in hot water dip treated tubers and maximum (25.4%) in untreated tubers. Sprouted potatoes were more prone to decay due to microbial invasion, so higher the sprouting more is the decay loss. Hu *et al*. (5)

Table 3. Effect of sprout inhibiting treatments and packaging methods on decay loss (%) of stored potatoes at low temperature.

Period of Storage (days)	Treatments												Overall mean
	Control				Hot Water Dip				CIPC				
	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)
30	0.0 (2.9)	4.2 (12.1)	8.3 (16.9)	4.2 (10.6)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	1.4 (5.5)
60	0.0 (2.9)	22.5 (28.3)	28.5 (32.3)	17.0 (21.2)	0.0 (2.9)	12.5 (20.8)	16.7 (24.2)	9.7 (15.9)	0.0 (2.9)	4.2 (12.1)	8.3 (16.9)	4.2 (10.6)	10.3 (15.9)
90	8.3 (17.0)	46.6 (43.1)	52.9 (46.8)	35.9 (35.7)	8.3 (17.0)	29.2 (32.7)	33.3 (35.3)	23.6 (28.3)	4.2 (12.1)	16.7 (24.2)	35.9 (36.7)	18.9 (24.3)	26.2 (29.4)
120	25.5 (30.3)	100.0 (87.1)	100.0 (87.1)	75.2 (68.1)	20.8 (27.3)	100.0 (87.1)	100.0 (87.1)	73.6 (67.2)	12.5 (20.9)	69.4 (57.4)	77.8 (64.8)	53.2 (47.4)	67.3 (61.0)
Mean				25.4 (27.7)				19.8 (23.4)				12.9 (17.7)	

Period of Storage (days)	Packaging methods			Overall Mean
	Net Bag	MAP	Vacuum	
0	0.0 (2.9)	0.0 (2.9)	0.0 (2.9)	0.0(2.9)
30	0.0 (2.9)	1.4 (5.9)	2.8 (7.6)	1.4 (5.5)
60	0.0 (2.9)	13.0 (20.4)	17.8 (24.5)	10.3 (15.9)
90	6.9 (15.2)	30.8 (33.3)	40.7 (39.6)	26.2 (29.4)
120	19.6 (26.2)	89.8 (77.2)	92.6 (79.7)	67.3 (61.0)
Mean	4.6 (10.0)	24.0 (27.9)	29.5 (30.8)	

(Values in the parenthesis are angular transformed values; NS – non significant)

CD at 5 %: Storage (S) = 2.29; Treatment (T) = 1.77; Packaging methods (P) = 1.77; SxT = 3.96; SxP= 3.96; TxP = 3.07; SxTxP = 6.87

reported that the potato decay by micro-organisms infection is generally the most serious cause of postharvest losses and found that HWT significantly inhibited the sprouting and decay of sweet potato during the storage period. Ezekiel *et al*. (3) also reported that thermal treatment supplied a lethal dose of heat to surface pathogens and cauterized eyes (buds) without damaging the nutritional quality of sweet potatoes. Ranganna *et al*. (11) found that hot water treated potato can be stored for at least 12 weeks at either 8 or 18°C without sprouting or spoilage due to *E. carotovora* or *F. solani*. Among various packaging methods for tubers, significantly lower mean decay loss (4.6%) was observed under net bag packaging followed by MAP (24.0%), while it was maximum (29.5%) in vacuum packaging. There was no decay loss up to 60 days of storage under net bag packaging and which slowly reached up to 19.6% while MAP and vacuum packaging resulted 89.8% and 92.6% decay loss, respectively at 120th day of storage. The absence of air in vacuum packaging may favour the growth of anaerobic pathogens, such as *Clostridium botulinum* (Beltran *et al*., 1). Shetty *et al*. (14) and Rocha *et al*. (12) had also observed that vacuum packed fresh-cut potatoes stored at room temperature became brown after 2 days and after 4 days they had deteriorated to the point they were inedible. The interactions between storage, sprout inhibiting treatments and packaging methods were found to be significant. The CIPC treated potato tuber along with net bag packaging resulted in to no decay loss up to 60 days of storage and at 120th day of storage it was 12.5% only. CIPC treated tubers showed no sprouting in the present investigation and at the same time the net bag packaging provide good air circulation, so lower decay loss was observed in the interaction.

The potato tuber firmness was 13.0 kg/cm^2 at 0 day of storage, which progressively decreased to 8.8 kg/cm^2 by the 120th day of storage (Table 4). The loss of moisture from the surface resulted in to decrease in firmness during storage, particularly for vegetables. This also lead to loose turgidity and breakdown of pectin resulted in to the degradative changes in cell wall structure as well as composition. Hu *et al*. (5) reported that sprouting increased evapotranspiration and thus there was loss of turgor pressure leading to decreased firmness. Ezekiel *et al*. (4) observed that potato varieties with minimum total weight loss retain the tuber firmness and fetches good market

Table 4. Effect of sprout inhibiting treatments and packaging methods on firmness (kg/cm^2) of stored potatoes at low temperature.

Period of Storage (days)	Treatments												Overall mean
	Control				Hot Water Dip				CIPC				
	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	Net Bag	MAP	Vacuum	Mean	
0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
30	12.2	11.8	11.6	11.9	12.1	11.9	11.7	11.9	12.5	12.3	12.2	12.3	12.0
60	10.7	10.5	10.3	10.5	11.0	10.8	10.6	10.8	11.9	11.7	11.5	11.7	11.0
90	10.0	9.9	8.8	9.6	10.6	10.0	9.8	10.1	11.4	11.2	10.7	11.1	10.3
120	8.0	7.6	(8.1)*	7.9	8.6	8.2	7.9	8.2	10.8	10.2	9.6	10.2	8.8
Mean				10.6				10.8				11.7	

Period of Storage (days)	Packaging methods			Overall Mean
	Net Bag	MAP	Vacuum	
0	13.0	13.0	13.0	13.0
30	12.3	12.0	11.8	12.0
60	11.2	11.0	10.8	11.0
90	10.7	10.4	9.8	10.3
120	9.1	8.7	8.5	8.8
Mean	11.3	11.1	10.8	

(*Treatment was terminated due to spoilage of the tubers. Values in the parenthesis are assumed values equivalent to the values at the last day before termination of the treatment. The values have been taken for the purpose of ANOVA only).

CD at 5 %: Storage (S) = 0.42; Treatment (T) = 0.33; Packaging methods (P) = 0.33; SxT = 0.73; SxP= NS; TxP = NS; SxTxP = NS prices for a longer period of time. Among various sprout inhibiting treatments, significantly higher mean firmness (11.7 kg/cm^2) was retained in CIPC treated tubers followed by 10.9 kg/cm^2 in hot water dip treated tubers and minimum (10.6 kg/cm^2) in untreated tubers. The CIPC treated tubers recorded higher firmness (10.2 kg/cm^2) as compared with the other sprouting inhibiting treatments at 120th day of storage. CIPC is known to inhibit sprouting completely along with suppression of transpiration and respiration, thereby retained higher firmness at lower temperature (Mehta *et al*., 8; Paul *et al*., 10). HWT treated tubers had lower sprouting, weight loss than untreated tubers so had higher firmness than untreated (Hu *et al*., 5). The interactions between storage, sprout inhibiting treatments and packaging methods were found to be nonsignificant except the interaction of storage × treatment.

There was a progressive increase in sprouting, PLW and decay loss and, decrease in firmness of potato tubers observed during storage. CIPC was more effective sprout inhibiting treatment than HWT. Among various packaging methods, net bag tubers had significantly lower decay loss, while maximum decay loss was observed in vacuum packaged packaging. In terms of decay loss the CIPC treated and net bag packed tubers showed promising result and it will be effective for long term storage of potato tubers of Kufri Chipsona-4.

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