Storability and Chips Quality of Chemical Treated Potatoes under Ordinary Condition

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Abstract: Storage experiments were conducted under ordinary room conditions in the mid hill, Khumaltar (1350 masl ; meter above sea level) and high hills, Daman (2200 masl) of Nepal during the summer season of 2011 to find out the effect of chemical treatments and their time of applications on storability and chips qualities of potato cv. Kufri Jyoti. Chemicals treatments were; CIPC (Isopropyl N (3 chlorophenyl) carbamate), hydrogen peroxide and calcium chloride, which were applied as a single dose (before storage) and double dose (before and at 45 days in storage). Ordinary water treated potatoes served as control. The treatments were replicated thrice. Apparently healthy tubers > 60 gram weight after different chemical treatments were stored in bamboo racks and wooden tray, respectively at Kumaltar and Daman for 120 days. Observations were recorded on weight loss percentage (WLP), sprouting percentage, numbers and weight of sprouts and quality parameters for chips. Double fumigation with CIPC was effective for inhibition of sprouting and reduction of postharvest loss up to 120 days in both the locations. On the other hand the better colour of the chips was produced by two times hydrogen peroxide treated potatoes.

Keywords: Post-harvest treatment, CIPC, hydrogen peroxide, calcium chloride, potato storage, sprouting, chips processing.

INTRODUCTION

Potato (*Solanum tuberosum* L.) production in Nepal has increased from 420,160 million tons in 1984/85 to 2,508,044 million tons in 2010/11 [1]. Due to inadequate facility and infrastructure for storage, marketing and utilization of potato for processing, the excess production often result in market gluts and heavy price reduction during the main harvesting months. In hills of Nepal, potatoes are harvested at the beginning of hot summer and rainy season. The high temperature and shortage of time for processing farmers compel to sale their product at minimum immediately after harvesting. The semi perishable and bulky nature of potato tubers are subjected to continuous weight loss and sprouting during storage. At harvesting time, the price of potato is very low, i.e. US$ 113.6 $ ton^{-1} and it gradually increased and reached maximum US$ 272.20 ton^{-1} (from Sep. 15 to Nov. 15) in Kalimati whole sale market, Kathmandu [2]. For storing potatoes, cold store is ideal for holding long period. But this is not possible in Nepalese situation due to the lack of sufficient cold stores, separate compartments for storing different purpose potatoes and high storage charge. At present, there are only 41 cold stores with storage capacity of 80,400 tons potato [3], which is not sufficient even for seed tubers. Furthermore, the storage of potato at low temperature causes excessive accumulation of reducing sugars and making them unsuitable for processing. Chips and French fries prepared from cold stored potatoes turn dark brown colours during frying at high temperature due to Millard's reaction [4-6]. These situation clearly indicates that there is urgent need to develop suitable technology for storing potatoes for short term especially from April/ May to October/November.

Indigenous methods of potato storage (spreading tubers under floor, storing in bins and hanging in bamboo baskets etc) are most cost effective and accepted by Nepalese farmers for short term storage to fetch better price. However, sprouting and weight loss are major problems in these methods due to higher temperature [8]. Sprouting causes great weight loss and reduces tuber quality. Khairgoli [7] reported 42-53 % storage losses in different varieties of potato at Khumaltar (1350 masl) during six months storage period (from 3rd week of May to 3rd week of November). Weight losses due to sprouting and rotting have been estimated from 10-40 % under on-farm storage condition in India [8]. The sprouting of potato itself and intensive evaporation of water from the sprout surface causes great weight loss, which exhibits softening and shrinkage. These potatoes are not

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suitable even for table purpose due to difficult for peeling and cutting.

To overcome sprouting and higher weight loss a large number of chemicals such as ethylene, nonanol, chlorprophan, maleic hydrazide (MH), carvone,abscisic acid, indole acetic acid, clove oil, mint oils, hydrogen peroxide maleic hydrazide, (MH) have been tested and used in many countries since long time ago [9,23]. Among them the use of CIPC hold commercial important in world for sprout suppression and better quality maintenance. Kleinkopf *et al.,* [9] reported that, CIPC has been used successfully for more than 40 years in America. In India it was registered in 1998 and is being used on table and processing potatoes since then [10]. Single treatment with CIPC @ 40 - 60 ml t^{-1} of potato was effective for suppressed sprout growth and reduced storage loss up to 90 days under heap (18-32 º C and 52-88 % R.H) and pit storage (19-27 º C and 69-92 % R.H.) [11]. However, its effectiveness on field stress potato, fluctuating temperature and humidity in storage may cause failure of sprout inhibition [9]. Many essential oils (Spearmint oil, Peppermint oil, Mint oil, Clove oil etc) extracted from plant materials showed good alternative to CIPC for sprouts suppression. These oils have been certified and are being used for organic potato production [12]. Frazier and Kleinkopf [12] also reported that hydrogen peroxide and its derivatives were found environment friendly and are allowed by the federal organic standards. These alternative compounds are not true “sprout inhibitors” but damage the developing sprouts and suppress sprout elongation [9]. Research on storage of potatoes in Nepal by using chemicals in ordinary stores is lacking. This study was conducted with the objective to find out the effect of different chemicals and their times of post-harvest applications on storability and processing of potato into chips.

MATERIALS AND METHODS

Storage experiments were conducted during 2011 in mid hill at National Potato Research Programme (NPRP) at Khumaltar (1350 m asl) and high hill at Temperate Horticulture Nursery Farm (THNF) at Daman (2200 masl). The widely cultivated and adopted potato variety Kufri Jyoti grown in respective sites was used for experimentation. Potato tubers more than 60 gram weight, free from wound and diseases were selected and cured for 15 days by spreading at ordinary room before imposing the treatments. The experiments were laid out in Completely Randomized Design (CRD) with three replications. The treatments were:

1. Fumigation with CIPC @ 40 ml ton^{-1} potato before storage.
2. Fumigation with CIPC @ 40 ml ton^{-1} potato before storage and 45 days after storage.
3. Fumigation with hydrogen peroxide @ 40 ml ton^{-1} potato before storage.
4. Fumigation with hydrogen peroxide @ 40 ml^{-1} to^{-1}n potato before storage and 45 days after storage.
5. Fumigation with calcium chloride @ 40 ml^{-1} ton $potato^{-1}$ before storage.
6. Fumigation with calcium chloride @ 40 ml ton^{-1} potato before storage and 45 days after storage.
7. Control (Fumigation with fresh water @ 40 ml ton^{-1} potato before storage

Required amount of each chemical was first mixed with methanol @ 40 ml $liter^{-1}$ ton $potato^{-1}$. Five kg potato of each treatment were fumigated inside close plastic chamber by the given chemicals with the help of small hand operated fumigators and hold air-tied for 48 hours. After 48 hours treated tubers were placed in bamboo racks at Khumaltar and wooden trays at Daman for 120 days storage i.e. from 20 June to 18 October at Khumaltar and 8 July to 5 November at Daman at ambient room temperature under dark condition. First sets of observations were recorded on temperature, relative humidity only at Khumaltar during storage period. Temperature was recorded at half an hour’s interval by using temperature data logger (Hobo). Relative humidity was calculated by using temperature recorded on wet and dry bulb thermometer of storage room daily at 9.30 AM. Cumulative weight loss percentage was calculated at every 30 days intervals. Second sets of observations were made on dry matter, specific gravity and reducing sugars and fresh chips qualities in both locations.

Sprouting Percentage

Third sets of observations were recorded on sprouting percentage, numbers of sprouts per tuber, sprout weight (g kg^{-1} tubers) at 30 days intervals after emergence of sprouts. A tuber was considered sprouted when it had at least one sprout measuring ≥ 5 mm in length.

Quality Parameters

Dry Matter Percentage

The fourth set of observations on dry matter percentage, specific gravity and reducing sugars were recorded before and after storage. Dry matter content was determined by chopping and mixing of tubers in to small pieces and drying of 100 gram sample in hot air oven at 80° C for first six hours and then at 65° C till constant weight was obtained [13].

Specific Gravity

Specific gravity was determined by weighing of randomly selected 10 tubers in Kern electric balance (0.1-6000 g) in air and water) before and after storage by using following formula:

$$Specific\ gravity = \frac{Weight\ in\ air}{Weight\ in\ air - Weight\ in\ water} \times Sp.grav\ of\ water\ at\ the\ lab\ temp.$$

Reducing Sugars

Reducing sugars was determined by using di-nitrosalicyclic colorimetric method [14] by recording the absorbance reading in spectrophotometer at 575 nm. To calculate the milligram reducing sugars per 100 gram fresh weight of potato, a standard curve was plotted with different concentration of glucose (0.00125, 0.0025, 0.05, 0.01, 0.02, and 0.04 mg glucose^{-1}ml water on X-axis and absorbent reading on Y-axis. The absorbent reading of samples were recorded and calibrated on the basis of standard curve and presented as milligram reducing sugars per 100 gram fresh weight of potato.

Chips Qualities

The fifth sets of observation were recorded on chips qualities as chips colour, crispness, taste and overall acceptability of chips. For determination of chips qualities, randomly selected 10 potato tubers were peeled and cut into slices of 1.4 mm thickness with a hand operated slicer. Good and undamaged slices were washed thoroughly in cold water to remove the surface starch and sugars. These slices were spread in paper towel to remove surface water and then fried immediately in palm oil at 180° C till stopping of the bubbles. Chips qualities were evaluated on the basis of hedonic rating by group of scientists for colour, taste and overall acceptability using 1- 9 scale and crispness; 1-3 scale (higher the number better the colour, taste and acceptability). Data were statistically analyzed using Genstat-3.2, while MSTAT C was used to separate treatment means.

RESULTS

Storage Environment

The maximum and minimum temperature ranged from 23.7 to 29.6 ^{o}C, and 21.9 to 28.6 ^{o}C, respectively. The average temperature ranged from 22.8 to 29.1 ^{o}C during the storage period in mid hill at Khumaltar. The relative humidity on storage remained consistently high (78.8 to 88 %). Both temperature and Relative humidity declined at later stage of storage (Figure **1** and **2**). The decline in temperature and relative humidity was associated with the fluctuation in the outer environment. Generally there is lowering of temperature and relative humidity after second week of September.

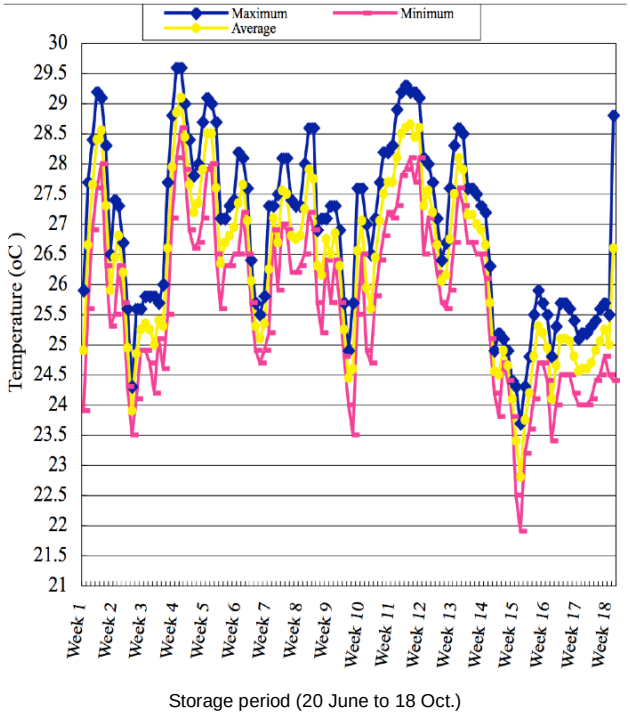

Figure1: Maximum, minimum and average temperature of storage room in mid hill at Khumaltar, 2011.

Weight Loss Percentage

There was no significant variation on the weight loss of the potatoes up to 30 days by the effect of chemical treatments. At 60 days of storage, control treatment had the highest weight loss percentage (13.22 %) at Khumaltar while there was no variation on weight loss at Daman (Table **1**). At 90 days of storage, treatments differed significantly on weight loss percentage at both

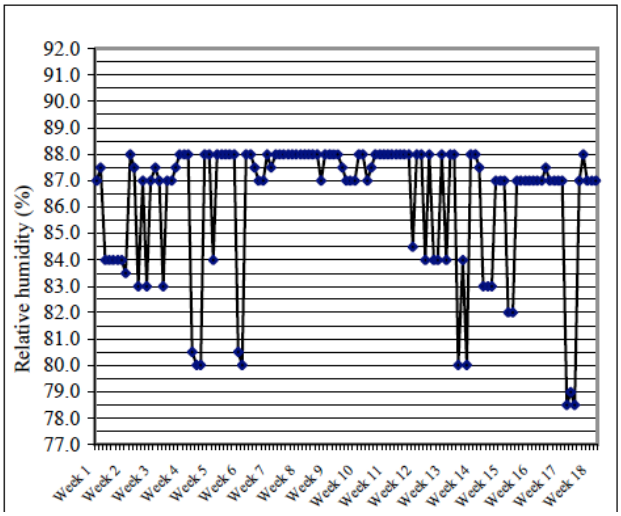

Figure 2: Relative humidity of storage room in mid hills at Khumaltar, 2011.

locations. The maximum weight loss percentage of 16.56 % and 5.98 % was recorded on control treatment at Khumaltar and Daman, respectively. After 120 days of storage, weight loss percentage significantly differed among the treatments in both locations. At Khumaltar, the maximum WLP (22.89 %) was on control treatment and it was at par with one time fumigation with CIPC (20.15%) and the minimum (9.40%) on one time fumigation with hydrogen peroxide (H_2O_2) treatment, which was at par with two times fumigation with CIPC (10.94%). At Daman, the maximum WLP (8.77 %) was also observed on control treatment and it was at par with two times fumigation with H_2O_2 (8.01%) and the minimum (4.49 %) on one and two times fumigation with CIPC (5.62 %).

Sprouting and Sprout Weight

The sprouting was noticed after 60 days of storage at Khumaltar and after 90 days at Daman. Treatments differed significantly on sprouting percentage at 60, 90 and 120 days after storage in mid hill i.e., at Khumaltar (Figure **3**). At 60 days, control treatment had the maximum sprouting (52.9 %) while there was no sprouting on other treatments. At 90 days the maximum sprouting percentage (59.50 %) was also observed on control treatment and it was the minimum (2.60%) on two times fumigation with CIPC. At 120 days of storage, sprouting percentage differed significantly among the treatments at Khumaltar. At Daman, sprouting was significantly differed at 90 and 120 days of storage. The maximum sprouting was observed 45% and 100 % on control treatment at 90 and 120 days of storage, respectively. Control treatments had the maximum sprouting (96.07%) and (100 %) at Khumaltar and Daman, respectively. The minimum sprouting percentage (8.03 %) and no

Table 1: Effect of post Harvest Chemicals Treatment on Weight Loss Percentage of Potato on Different Days After Storage at Khumaltar and Daman, 2011

Treatments	At Khumaltar				At Daman			
	Days after storage				Days after storage			
	30	60	90	120	30	60	90	120
One time fumg. with CIPC	2.55	7.81 *b*	14.12*ab*	20.15 *ab*	1.68	2.98	4.34 *bc*	5.62 *cd*
Two times fumg. with CIPC	2.51	5.16 *b*	7.88 *b*	10.94 *cd*	1.43	2.67	3.45 *c*	4.49 *d*
One time fumg. with H_2O_2	2.47	4.43 *b*	7.83 *b*	9.40 *d*	1.86	2.95	4.50 *bc*	6.33 *bc*
Two times fumg. with H_2O_2	2.99	5.41 *b*	8.35 *b*	13.59 *bcd*	2.02	3.62	4.41 *bc*	7.24 *abc*
One time fumg. with $CaCl_2$	1.66	7.33 *b*	11.21 *ab*	17.40 *abc*	1.60	2.68	3.77 *c*	7.12 *abc*
Two times fumg. with $CaCl_2$	3.77	7.84 *b*	8.50 *b*	14.43*bcd*	1.61	3.62	5.36 *ab*	8.01 *ab*
Control	2.97	13.2 *a*	16.56 *a*	22.89 *a*	2.0	3.79	5.98 *a*	8.77 *a*
Mean	2.70	7. 31	10.64	15.54	1.47	3.19	4.54	6.80
F-test	NS	*	*	**	NS	NS	**	**
LSD	-	4.557	6.094	6.598	-	-	1.248	1.667

NS = Not significantly different, * and ** significant at 0.05 and highly significant at 0.01 levels, respectively. [+] Same small letters are not significantly different by DMRT at 0.05 levels.

sprouting (0 %) was observed on two times fumigation with CIPC at Khumaltar and Daman, respectively.

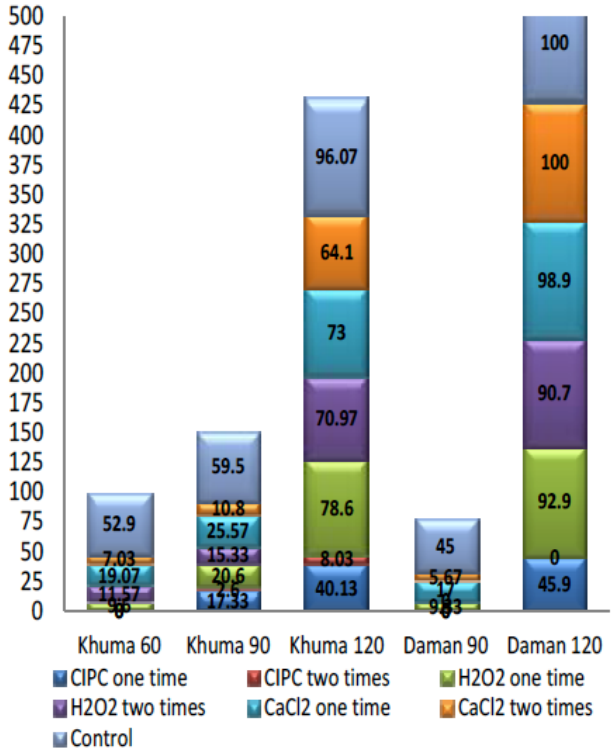

Figure 3: Effect of chemical on sprouting percentage of potato at different DOS at Khumaltar and Daman, 2011.

Weight of sprout recorded at 120 days of storage in both locations differed significantly among the treatments (Figure **4**). The maximum weight of sprouts (24.72 g kg $^{-1}$ tuber) was produced by control tubers at Khumaltar. In Daman the maximum weight of sprouts (9.77 g $^{-1}$ kg tuber) was recorded on one time fumigation with calcium chloride against no sprouting on T_2 treatment. The delay sprouting and minimum weight of sprouts at Daman was due to due to low temperature than Khumaltar.

Quality Parameters

There was increased in dry matter percentage, specific gravity and reducing sugars during storage (Table **2**). The mean increment of dry matter, specific gravity and reducing sugars was 4.04%, 0.26 % and 26.57 % in mid hill at Khumaltar and 8.72%, 0.018% and 57.66 % in high hill at Daman, respectively after 120 days storage. However, the level of change varied among the treatments in both locations. Control treatment had highest dry matter percentage (19.47 %) and specific gravity (1.0706) than other treatments at Khumaltar, whereas no difference was observed on dry matter at Daman. There was no variation on reducing

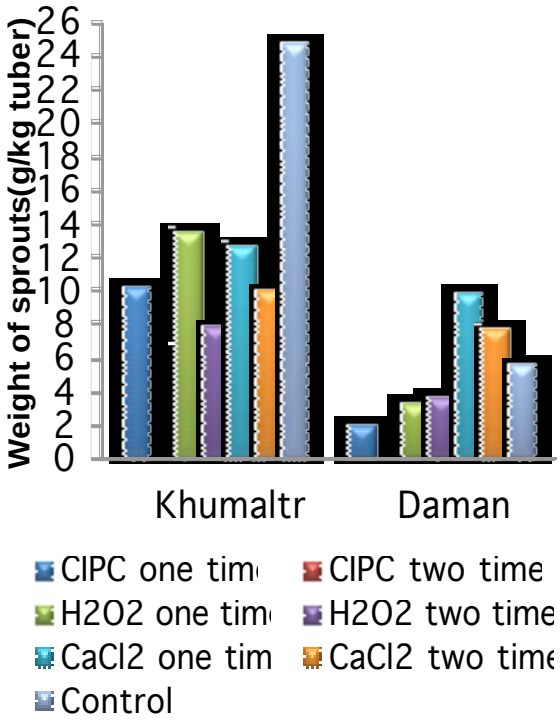

Figure 4: Effect of chemical on sprouting weight (g/kg tuber) at 120 DOS at Khumaltar and Daman, 2011.

sugars among various treatments at Khumaltar, while it was significantly different at Daman. The highest RS (88.6 mg 100^{-1} g fresh wt. of potato) was observed on one time calcium chloride fumigated potatoes followed by (78.3 mg 100^{-1} g) one time fumigated with CIPC and the lowest 34.4 mg 100^{-1} g) on control treatment. Despite of some differences, all treatments in both locations had the acceptable limit of reducing sugars for chips making.

Chips Qualities

Chips colour of two times hydrogen peroxide fumigation potatoes stored at Khumaltar differed significantly with other treatments and had the highest chips colour scores of 7.25 scales (Table **3**). However, crispness, taste and overall acceptability did not vary among the treatments. In high hill at Daman, colour 7.43 and overall acceptability 7.57 had the highest scores on one time fumigated with hydrogen peroxide potatoes (Table **4** and Figure **6**). No variation was observed on crispness and taste among the treatments.

DISCUSSION

No difference on weight loss percentage due to chemical treatments was observed up to 30 days after

Table 2: Effect of Post Harvest Chemicals Treatment on Dry Matter, Specific Gravity and Reducing Sugars of Potato at 120 DAS at Khumaltar and Daman, 2011

Treatments	At Khumaltar			At Daman		
	Dry Matter (%)	Specific gravity	R. sugars (mg 100^{-1} g. f. wt.)	Dry Matter (%)	Specific gravity	R. sugars (mg 100^{-1} g. f. wt.)
Before storage	15.83	1.0587	35.0	16.85	1.0648	35.33
One time fumigation with CIPC	16.37 *b*	1.0612 *c*	45.7	18.87	1.0657	39.2 *bc*
Two times fumigation with CIPC	16.53 *b*	1.0581 *f*	36.0	17.90	1.0638	78.3 *a*
One time fumigation with H_2O_2	14.77 *b*	1.0603 *d*	43.0	16.50	1.0614	47.4 *bc*
Two times fumigation with H_2O_2	16.03 *b*	1.0585 *e*	39.7	19.33	1.0678	44.4 *bc*
One time fumigation with $CaCl_2$	15.90 *b*	1.0628 *b*	47.7	19.87	1.0673	88.6 *a*
Two times fumigation with $CaCl_2$	16.23 *b*	1.0594 *a*	53.0	17.87	1.0644	57.7 *bc*
Control	19.47 a	1.0706 *a*	45.3	17.90	1.0643	34.4 *c*
Mean	16.47	1.06154	44.3	18.32	1.0650	55.7
F-test	*	**	NS	NS	NS	***
LSD	2.184	0.005206	-	-	-	18.24
CV (%)	7.6	0. 3	13.9	8.5	0.2	18.7

NS = Not significantly different, * and ** significant at 0.05 and highly significant at 0.01 levels, respectively. [+] Same small letters in a column are not significantly different by DMRT at 0.05 levels.

Table 3: Effect of Post Harvest Chemicals Treatment on Chips Qualities of Potato at 120 DOS at Khumaltar, 2011

Treatments	Colour (1-9 scale)	Crispness (1-3 scale)	Taste (1-9 scale)	Overall acceptability (1-9 scale)
One time fumigation with CIPC	6.25b *b*	1.90	6.08	6.17
Two times fumigation with CIPC	6.00 *b*	2.08	5.33	5.92
One time fumigation with H_2O_2	6.42 *b*	2.00	6.33	6.08
Two times fumigation with H_2O_2	7.25 *a*	2.08	6.83	7.33
One time fumigation with $CaCl_2$	6.42 *b*	2.12	6.67	6.50
Two times fumigation with $CaCl_2$	5.75 *b*	2.07	6.17	5.75
Control	6.25 *b*	2.0	6.00	5.75
Mean	6.33	2.036	6.20	6.21
F-test	*	NS	NS	NS
LSD	0.803	-	-	-
CV (%)	10.8	11.3	16.1	17.0

Color (1-9 scale): 1-6 none accepted, 7 accepted rather, 8 accepted & 9 accepted completely. Crispness (1-3 scales: 1 too crisp, 2 not crispy enough and 3 Ideal. Taste (1-9 scales): 1-3 poor, 4-5 moderate, 6-7 good, and 8-9 = V. good. Overall acceptability (1-9 scales): 1--3 poor, 4-5 moderate, 6-7 good, 8-9 V. good.
NS = No significantly different, * significant and ** highly significant at 0.05 and 0.01 levels respectively.
[+] Same small letters are not significantly different by DMRT at 0.05 levels.

storage in mid hill at Khumaltar and up to 60 days in high hill at Daman. At 120 days of storage, the highest weight loss percentage (22.89 % and 8.77 %) was observed on control treatments at Khumaltar and Daman, respectively. The maximum weight loss percentage at Khumaltar was as because of early harvesting and storage of potato than Daman. Moreover, the storage temperature was higher at Kumaltar. Among various chemical treatments two times (before and 45 DAS) CIPC fumigated and both one and/or two times hydrogen peroxide fumigated were found effective to reduce the weight loss in mid hill, while in high hill, CIPC performed better than other treatments for reduction of weight loss percentage.

Table 4: Effect of Post Harvest Chemicals Treatments on Chips Qualities of Potato at 120 DOS at Daman, 2011

Treatments	Colour (1-9 scale)	Crispness (1-3 scale)	Taste (1-9 scale)	Overall acceptability (1-9 scale)
One time fumigation with CIPC	6.21 *b*	2.03	6.86	6.36 *bc*
Two times fumigation with CIPC	5.86 *b*	2.00	6.29	6.14 *c*
One time fumigation with H_2O_2	6.36 *b*	2.07	6.93	7.14 *ab*
Two times fumigation with H_2O_2	7.43 *a*	1.87	7.29	7.57 *a*
One time fumigation with $CaCl_2$	5.86 *b*	2.06	6.0	6.07 *c*
Two times fumigation with $CaCl_2$	5.71 *b*	1.96	6.29	6.07 *c*
Control	6.21 *b*	2.00	6.14	6.21 *c*
Mean	6.23	1.998	6.54	6.51
F-test	*	NS	NS	**
LSD	1.054	-	-	0.891
CV (%)	15.7	10.3	17.1	12.7

Color (1-9 scale): 1-6 none accepted, 7 accepted rather, 8 accepted & 9 accepted completely. Crispness (1-3 scales: 1 too crisp, 2 not crispy enough and 3 Ideal. Taste (1-9 scales): 1-3 poor, 4-5 moderate, 6-7 good, and 8-9 = V. good. Overall acceptability (1-9 scales): 1--3 poor, 4-5 moderate, 6-7 good, 8-9 V. good.
NS = Not significantly different, * significant and ** highly significant at 0.05 and 0.01 levels respectively.
[+] Same small letters are not significantly different by DMRT at 0.05 levels.

(**a**)

(Figure 5). Continued.

(**b**)

Figure 5: (**a**) Effect of post harvest chemical treatments on sprouting of potato at 120 DAS in mid hills at Khumaltar. (**b**) Effect of post harvest chemical treatments on sprouting of potato at 120 DAS in high hills at Daman.

Figure 6: Effect of post harvest chemical treatments on chips colour at 120 DOS in high hills at Daman.

The minimum weight loss in CIPC treated tubers as compared to control is agreement with earlier findings [15, 16, and 17]. Mehta [15] reported that the single fog treatment of CIPC was sufficient to reduce sprouting index by 49 %, sprout weight by 93.3 % and total storage loss by 28.4 % up to 90 days of storage as compared to control. The residues of CIPC was reported quite low (0.24-0.87 mg $kg^{-1}$of fresh weight) in peeled tuber collected immediately after spray and these were well below the permissible limit defined by Environmental Protection Agency [16]. The effectiveness of hydrogen peroxide at mid hills is agreement with the finding of Khali [18] and Norikane [19]. Hydrogen peroxide has suppressed sprouting by physically damaging the developing sprouts or buds before they came emerge [10]. He also reported that hydrogen peroxide has some antimicrobial activity, which may be beneficial when applied to stored potato. Afek [20] has also reported that hydrogen peroxide plus (HPP) inhibit potato sprouting, is friendly to the environment, easy to implement and inexpensive. The minimum weight loss on calcium chloride treatment than control could be due to low respiration. Ismail [21] explained that $CaCl_2$ is hydroscopic (absorbs moisture), which is believed to be one of the reasons for its effectiveness in controlling weight loss.

Sprouting of tubers during storage resulted in considerable increase in total weight loss due to evaporation. Sprouts itself is the direct weight loss and higher permeability, higher surface area of sprouts and faster metabolic activities further increased loss of water from the potatoes. It was reported that the epidermis of sprouts are 100 -150 times more permeable to water than tuber surface [22]. In this experiment, CIPC is found most effective to control sprouting in both locations. This finding is agreement of earlier finding of Mehta [17]. He reported that application of CIPC reduced sprouting of potato in heap storage and no sprouting in pits. Moreover, the effect was more at higher altitude which was as because of the lower temperature. The higher dry matter and specific gravity on control treatment in this experiment could be due to evaporation of more water through sprouts. Dry matter percentage and specific gravity before and after storage irrespective of chemical treatments was higher in the potatoes which were grown in high hill. There was some variation in the level of reducing sugars with respect to storage condition. The potatoes which were storage in high altitude have higher level of reducing sugars. It could be due to increased in invertase activity under cool temperature prevailing during storage. The lower level of reducing sugar noticed in control potatoes after storage could be due to its utilization for spouting. The variation in reducing sugars in high altitude stored potatoes with respect to chemical treatments is inconsistent and not conclusive. It is to be noted that the level of reducing sugar in all treatments after storage is within acceptable limit for chip making but chips colour score is unacceptable on six of seven treatments.

The potato treated two times with hydrogen peroxide produced light chips color and higher acceptability both in mid and high hills compare to all other treatments. Moreover, all treatments had better chips color, crispness and overall acceptability than locally prepared chips by small cottage industries (Figure **6**), which share about 22 % of total chips in Nepalese markets (MOAC, 2011).

The results of present study concluded that post harvest treatment with different chemicals have positive role for reduction weight loss and sprouting than control treatment. However, two times fumigation with CIPC, before storage and 45 days after storage was the best for inhibition of sprouting and reduction post harvest losses up to 120 days storage than other treatments both in mid and high hills. Due to high temperature, the fumigation with CIPC one time before storage is not effective for reducing weight loss at Kumaltar as compared to Daman. In spite of more weight loss than CIPC, the two times hydrogen peroxide treated potatoes produced better chips colour after 120 days storage. The traceability of chemicals inside the potato tubers and and chips has not been calculated. All these chemicals are classified as "generally as Safe"(GRAS) by the U.S. Food and Drug administration. The USDA National organic program has approved non-synthetic GRAS compounds for application to certified organic crop [12].

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