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On-farm storage of table and processing potatoes in heaps

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ABSTRACT

Heap storage of potatoes is commonly used in many states of India to avoid distress sale at harvest, but the losses in stored potatoes are generally enormous. Spray application of CIPC (isopropyl N-(3-chlorophenyl) carbamate) at the time of storage has been recommended to inhibit sprouting and reduce total losses in potatoes up to 90 days of storage in heaps. Sprouting in tubers was inhibited and total losses in potatoes were reduced (by 58.7%) up to 90 days of storage (temp. 19-31°C, 55-90% RH) during March to June. The farmers could market 6.5% more weight of CIPC treated potatoes (cv. Kufri Pukhraj) compared to the control (untreated) tubers due to reduced total losses and fetch 55.3% higher market price than the price at the time of harvest. In processing cultivar, Kufri Chipsona-1, reducing sugar concentrations decreased from 188.1 to 22.5 mg/100 g fresh weight during storage up to 90 days and chip colour improved significantly. Stored potatoes were found highly acceptable for processing by an industry collaborator (M/s Satnam Agri Products Ltd., Jalandhar) and were used in making good quality flakes and French fries. Findings established that the improved storage technology can beneficially be used to increase remunerations from potato cultivation and to preserve the quality of processing potatoes for three months at lower storage cost.

Key words: Potato, heap storage, sprout inhibition, storage losses, processing quality.

INTRODUCTION

Heap storage of potato (*Solanum tuberosum* L.) is commonly used in many states of India to avoid distress sale at harvest. Sprouting of potatoes is the main problem under heap storage where losses due to shrinkage, sprouting and attack by microorganisms are generally enormous (15-25%). Spray application of CIPC @ 20 mg a.i. kg^{-1} tuber weight in heaps was effective in reducing sprouting, sprout weight and total losses up to 90 days of storage in nine potato varieties varying widely in dormancy period and storability (Mehta *et al*., 7). An on-farm heap storage technology integrating essential pre- and post-harvest measures with the use of sprout inhibitor CIPC (isopropyl N-(3-chlorophenyl) carbamate) was developed for short-term storage of table and processing potatoes (Mehta *et al*., 8). Although the on-station trials provided broad guidelines for technology development, specific requirements needed to be devised in conjunction with the farmers and the potato industry by evaluating the improved technology in the climatic and physical conditions of beneficiaries farms and to monitor their experience in order to judge its acceptability. This investigation was, therefore, designed to evaluate on-farm storage in heaps at farmers' fields at four locations in Punjab during March to June, by determining losses in stored potatoes, their marketability as table potatoes and suitability for processing. Stored potatoes were also periodically tested by an industry collaborator to examine their suitability for processing into flakes and French fries.

MATERIALS AND METHODS

Farmers were randomly selected for the study. They were advised to follow essential pre harvest measures for raising the crop *viz*. tuber maturity and haulm cutting prior to harvest. The harvested tubers were kept in heaps covered with rice straw (*pural)* in their fields for 15-20 days to allow wound healing and curing of peel, prior to selecting undamaged and healthy tubers. Potatoes of cv. Kufri Pukhraj, a popular variety of the region, were stored for table purpose under the shade of trees in village Sultanpur (Jalandhar district) at three farms to determine storage losses and marketability of potatoes. Variety Kufri Chipsona-1 was stored in collaboration with the processing industry (M/s Satnam Agri Products Ltd., Pratapura, Jalandhar) under two storage conditions (high sheds made of asbestos sheets/shade of trees) in three villages of Punjab, *viz*. Badshahpur (Jalandhar district), Shamchaurassi (Hoshiarpur district) and Khatkar Kalan (Nawanshar district) to determine storage losses and the suitability of stored potatoes for processing.

Potatoes were treated with CIPC (20 mg a.i. kg^{-1} tuber weight) prior to storage and stored in heaps (Mehta *et al.*, 7) in tuber weight ranging between 20

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to 25 quintals at each place in the 1st week of March. Heaps of untreated control potatoes raised with all recommended pre- and post-harvest measures were laid nearby under the same storage environment. Ten kg of potatoes with three replications in each treatment packed in nylon bags were also placed in all heaps to record replicated data. Heaps laid in open were protected from rains during the storage period. Monitoring of tuber condition and processing quality evaluation of potatoes was done during storage and heaps were dismantled after 90 days of storage (DOS).

Temperatures and relative humidity was recorded daily at two locations, *i.e.* under the shade of trees and in the shed. Final observations on sprout weight (%), loss in weight due to tuber rotting and total weight loss (physiological + pathological + sprout loss) on fresh weight basis were recorded after storage. Tubers with slight evidence of decay were weighed to represent loss due to tuber rotting. Sprouting Index (SI) was recorded on 50 tubers per treatment after storage (Mehta *et al*., 7). At 0, 45 and 90 days of storage, tubers of only Kufri Chipsona-1 were analyzed for reducing sugars, sucrose and chip colour as per standard methods (Mehta and Singh, 6) as cv. Kufri Pukhraj is known for producing unacceptable colour chips due to higher reducing sugar contents (>250 mg/100 g fresh weight) in potatoes stored in heaps (Mehta *et al.*, 7). Chip colour was scored on 1-10 scale of increasing colour using the chip colour cards (Ezekiel *et al.*, 2). Chip colour score up to and including 5 was considered acceptable. Potatoes were also periodically tested for dry matter and sugar level (by strip test) and chip colour in laboratory of the industry. Data was statistically analyzed using MSTAT 4.0C software following the method of Gomez and Gomez (3).

RESULTS AND DISCUSSION

Storage in heap reduced the range of variation in temperature while maintaining a high relative humidity. Storage ambience did not affect the environment inside the heaps. The temperatures ranged between 19-31°C in the heaps laid under sheds or trees compared to the ambient (17 to 44°C) during March to June. Relative humidity inside the heap remained consistently high (55-90%) compared to a wider variation and lower levels (26-75%) under ambient conditions. Temperatures and humidity in the heap were in the same range as reported in our on-station trials conducted at Jalandhar (Mehta *et al.*, 7).

Untreated (control) tubers of both the cultivars had 100% sprouting with multiple sprouts at the end of storage period. The treatment of potatoes with CIPC resulted in significant reduction of sprouting at all the four locations resulting in lower sprout weight, sprouting index and total weight loss irrespective of location (Fig. 1). Sprout inhibition effect of CIPC

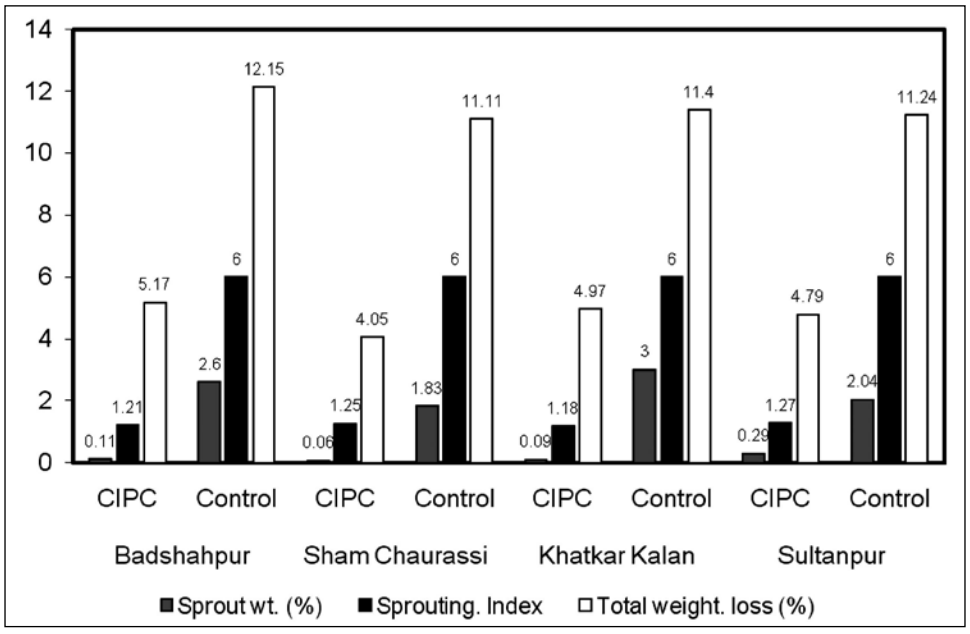

Fig. 1. Sprout weight (%), sprouting index and total weight loss in potatoes after 90 days of storage in improved heaps at four different locations in Punjab. [CD at 5%: Sprout weight: L = 0.29, T = 0.21, L × T = 0.42; Sprouting index: L = NS, T = 0.08, L × T = NS; Total weight loss: L = 0.68, T = 0.49, L × T = NS, where L = Location; T = Treatment; L × T = Location × Treatment; NS = Not significant].

was at par in the two cultivars and the two storage conditions. CIPC-treated tubers appeared firm whereas the control tubers with multiple sprouts had slightly shriveled appearance. There was no need to desprout the treated potatoes before sending to the market or the processing industry. CIPC spray is often applied to potatoes, which have already received one or two CIPC aerosol treatments, to ensure that the tubers remain sprout free during transit and fresh market utilization (Kleinkopf *et al.*, 4), but in this case even single spray application of CIPC remained effective up to 90 days of storage at higher temperatures.

CIPC treatment had no effect on pathological losses in tubers and the proportion of rotted tubers in heaps was negligible (0.11-0.42%) (data not included). There was no incidence of black heart generally reported under high temperature storage (Burton *et al.*, 1). Total weight loss in treated tubers was significantly reduced (4.74%) compared to control potatoes (11.47%) (Fig. 1). Tuber weight loss during storage is an important quality parameter for the potato industry. It results from processes like evaporation, respiration and sprouting. Evaporative loss is the major contributing factor, depending largely on the degree of suberization of the tubers, which reduces moisture loss during storage. Losses in this investigation were lower even in control potatoes as compared to traditional storage methods (15-40%) because the tuber skin was properly set by haulm cutting the crop 3 weeks prior to harvest and proper wound healing was also achieved by keeping harvested tubers in heaps covered with rice straw for 15 days prior to storage. However, evaporation is increased by sprout growth because the epidermis of sprouts is about 100 times more permeable to water than the tuber skin (Burton *et al.*, 1). Higher sprout weight was probably the main cause for higher tuber weight loss during storage in untreated tubers.

CIPC treated tubers with 4.79% weight loss, did not suffer sufficient moisture loss to affect tissue turgor and consequently the potatoes could be sold for prices comparable to tubers from refrigerated cold stores. The farmers could market 6.5% more weight of CIPC treated potatoes (Kufri Pukhraj) and fetch 21.6% higher price than the control (untreated) tubers, besides saving on desprouting labour cost (approx. Rs. 300 /tonne). CIPC treated potatoes after storage fetched Rs. 5,900 /tonne market price at par with the cold stored potatoes (Rs. 5,850 /tonne) and returned a 55.3% higher market price than the price at harvest (Rs. 3,800 /tonne). Untreated potatoes though fetched comparatively lower market price (Rs. 4,850 /tonne), but the price was 27.6% higher than that at the time of harvest. On-farm storage is less expensive compared to refrigerated storage (Rs. 350-400 /tonne v/s Rs. 1,600-1,800 /tonne) (Mehta *et al*., 8), thus, by incurring lower expenditure on storage, farmers could get higher net profit using this storage technology.

In processing cv. Kufri Chipsona-1, reducing sugar concentrations were higher (149.9-208.9 mg/100 g fresh weight) at all the three locations at 0 day of storage and chip colour was unacceptable (Table 1). Higher reducing sugar content at harvest is the result of prevailing low (<10°C) temperatures during later period of crop growth (Marwaha, 5). The concentration of reducing sugars in potato tuber is an important quality factor in potatoes, affecting the colour of processed products as frying at high temperature results in a typical Maillard's reaction between reducing sugars and free amino acids present in the tuber (Roe *et al.*, 10). Low sugar concentration is a desirable characteristic for potatoes meant for table purposes also to avoid an undesirable sweet flavour. Reducing sugar content in potatoes decreased up to 90 days of storage with more decrease recorded in CIPC treated potatoes (Table 1). High rates of starch resynthesis and respiration during higher temperature storage are responsible for this decrease (Mehta *et al*., 7). Sucrose content in potatoes increased during storage, may be due to the inhibition of invertase activity or synthesis of invertase inhibitor at higher temperature (Uppal and Verma, 11). Though sucrose is not directly involved in Maillard's reaction, there is some evidence of thermal decomposition of sucrose contributing to Maillard's browning (Mehta *et al*., 9).

Chip colour was unacceptable at 0 day of storage at all the three locations. The colour improved significantly during storage and potatoes became suitable for processing (Table 1). CIPC treated and untreated stored potatoes when tested in the industry for quality parameters, were remarked highly acceptable for processing after 45 days of storage (personal comm.). Our laboratory test also showed that CIPC treated potatoes from Shamchaurassi and Badshahpur produced acceptable colour chips after 45 DOS, while potatoes from Khatkar Kalan produced acceptable chips after 75 days (Table 1). The lighter chip colour after storage v/s before storage, attributable to the corresponding decrease in reducing sugars has been reported in our earlier study also (Mehta *et al.*, 7). Chipping quality of untreated (control) potatoes also improved to acceptable level after 45 DOS at Badshahpur and after 75 days of storage at other two locations. Stored potatoes (treated and untreated) were used in the industry for making good

Table 1. Processing quality of potatoes (cv. Kufri Chipsona-1) during storage at three locations in Punjab during March-June.

Location (L)	0 day	Storage days/ Treatment (T)					
		45 day		75 day		90 day	
		CIPC	Control	CIPC	Control	CIPC	Control
Reducing sugar (mg/100 g FW)							
Khatkar Kalan (Nawanshahar)	205.2	92.33	97.71	98.1	116.8	29.8	36.6
Sham Chaurassi (Hoshiarpur)	208.9	151.9	89.6	76.0	65.2	19.2	119.3
Badshahpur (Jalandhar)	149.9	41.8	52.6	25.4	35.6	18.5	25.5
Mean	188.1	95.3	80.0	66.5	72.5	22.5	60.5
CD at 5%		L = 9.5, T = 9.5, L × T = 16.4		L = 7.5, T = 7.5, L × T = 13.1		L = 16.7, T = 16.7, L × T = 29.0	
Sucrose (mg/100 g FW)							
Khatkar Kalan (Nawanshahar)	169.0	146.9	169.7	172.4	238.5	428.8	342.4
Sham Chaurassi (Hoshiarpur)	164.9	162.3	160.4	186.9	270.3	230.6	344.6
Badshahpur (Jalandhar)	170.9	120.5	168.7	170.6	190.5	288.9	304.9
Mean	167.9	143.2	166.3	183.3	265.5	316.1	330.6
CD at 5%		L = NS, T = 10.9, L × T = 18.9		L = NS, T = 31.6, L × T = NS		L = 37.5, T = 37.5, L × T = 64.8	
Chip colour score (On a 1-10 scale of increasing dark colour, score up to 5 was acceptable)							
Khatkar Kalan (Nawanshahar)	6.67	5.67	5.83	1.33	1.83	2.17	4.67
Sham Chaurassi (Hoshiarpur)	6.83	4.17	5.83	1.33	2.33	1.83	4.50
Badshahpur (Jalandhar)	6.33	1.30	3.50	1.17	1.33	1.67	2.33
Mean	6.61	3.72	5.06	1.28	1.83	1.89	3.83
CD at 5%		L = 0.30, T = 0.30, L × T = 0.50		L = 0.21, T = 0.21, L × T = 0.36		L = 0.30, T = 0.30, L × T = 0.50	

quality flakes and French fries up to 90 days of storage (Personal comm.).

In conclusion, the demonstrations validated the research findings. Thus, low-cost heap storage technology can profitably be used by the farmers to increase remunerations from potato cultivation and by the potato industry to maintain the desired quality in processing potatoes for 3-4 months after harvest at lower storage cost. The technology for storage of processing potatoes at elevated temperatures (10-12°C) is new to India and such stores till date are very few in many states. The growth and progress of the potato processing sector is therefore restricted due to lack of round the year availability of potatoes with low reducing sugars and acceptable chip colour. Potatoes stored on-farm in heaps by this low-cost method can meet the needs of the processing industry for short periods (March-June) and potatoes stored at 10-12°C can be used for additional period after June. Also, the potatoes for table purpose in India are generally stored along with seed potatoes in refrigerated stores maintained at 2-4°C, which results in low temperature sweetening. Short term on-farm storage can maintain good flavour of table potatoes and improve the farmers' sale price while incurring low storage cost.

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