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RESEARCH ARTICLE

EFFECT OF VARIOUS CHEMICAL TREATMENTS ON SHELF-LIFE AND QUALITY OF APPLE (*MALUS DOMESTICA* BORKH.) DURING STORAGE

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ABSTRACT

Chemical dip treatments viz; Calcium Chloride @ 0.25%; 0.5 % and Neemexcel @ 500 and 1000 ppm along with control (dipped in plain water) coupled with two different storage conditions i.e. Zero Energy Cool Chamber (ZECC) and Ambient storage were evaluated for postharvest rotting and quality of fruits for the extension of shelf-life and fruit quality of apple cv. Red Delicious, for 120 days. Results reveals that on farm storage of apples was highly successful by ZECC as fruits treated with 0.25% $CaCl_2$ and 1000 ppm Neemexcel showed 6.21 times lesser weight loss, with minimum rotting, changes in physico- chemical traits up to acceptable as compared to their counterparts in ambient storage, with a benefit of Rs. 2.33, and lowest PLW (6.80%) and maximum flesh firmness (5.01 kg/cm^2) in fruits with least rotting incidences. Therefore, this technology holds promise for the resource poor farmers in India.

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INTRODUCTION

Apple (*Malus domestica* Borkh.) occupies a place of pride amongst temperate fruit crops of India. In India, apple is grown largely because it is liked very much by the consumers and fetches very good price in the market. It matures by mid-August or early September in mid-hill conditions of India, which often results in the glut of fruits in the market (Chadha and Awasthi 2005; Wijewardane and Guleria 2009). As the demand of good quality fruits increased, the growers are forced to produce good quality fruits with minimum quality losses during transportation and storage in order to fetch remunerative prices for their produce (Sharma, 2010). There are many techniques which are used to extend the storage life, but refrigeration coupled with Controlled Atmosphere Storage (CAS) are most preferred ones. However, these facilities are very expensive and are mostly available in plains, the producers have to bring the fruits to plains for storage, which results not only high postharvest losses but also lands in higher costs (Sharma and Singh, 2010). Further, extension of shelf life of apple fruits can be achieved to some extent by using waxes, chemical treatments, i.e. GA, Calcium Chloride, fungicides, storage in perforated polythenes films accomplished in ZECC can be done.

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On farm storage plays a vital role in maintaining quality soon after harvest for longer periods (Kumar and Nath, 1993 and Issar *et al.,* 2010). Therefore, on-field storage of fruits in Zero Energy Cool Chamber (ZECC) was found to be highly successful in the retention of fruit quality characteristics so that the growers can withhold the transportation of their produce to the markets during glut period for sometime and as soon as the prices shoot up, they can take out the stored produce from ZECC and make handsome returns during the lean periods by sale of their produce (Sharma and Nautiyal, 2007). Application of Calcium Chloride can retain fruit firmness, slow down senescence, ethylene biosynthesis, reduce disease incidences and thereby prolong shelf-life of fruits. In case of apples and pear, calcium application is a feasible operation in packing houses. Calcium Chloride dip treatment and gamma irradiation on storage affects the quality and shelf-life extension of Red delicious apples, treatment is effective in reducing weight loss and firmness and extend the shelf-life of apples by around 20–25 days at 17±2°C, RH 75% following 90 days of refrigeration (Gupta *et al.,* 2011). Chemical treatments like 1-methylcyclopropene (1-MCP) were used to extend the shelf life of 'Patharnakh' pear fruits (Mahajan and Dhatt, 2004 and Mahajan *et al.,* 2010). Mahajan *et al.,* 2006. reported that quality of pear cv. 'Patharnakh' after waxing was better, could be kept for 72 hours at ambient temperature and 144 hours in refrigerator after 60 days of cold storage. Apple fruits can be successfully stored under zero energy cool chamber conditions (temperature 3.10 to 19.80 ºC) for a period of about 100 days after treating with 10 % wax and with 2.5 % $CaCl_2$ and Bavistin (200 ppm) along with storage under ZECC conditions after packing in perforated polythene bags, with minimum rotting, lower mean physiological loss in weight (2.28 %), changes in physico-chemical and sensory quality (Madan and Ullasa, 1993; Faust and Shear, 1972; Ishaq *et al.,* 2009 and Issra *et al.,* 2010). Commercially, good grade waxes were found effective in order to improve glossiness and quality of fruits. Wax coated fruits showed a very low and gradual increase in weight loss with advancement of storage life and finally recorded 1.90 per cent weight loss at the end of 60 days of storage (Mahajan and Chopra, 1995 and Singh *et al.,* 2010).

MATERIALS AND METHODS

The present investigation was conducted in the Department of Horticulture, G. B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, District Tehri-Garhwal, Uttarakhand, state, India, during October, 2010 to February, 2011. Apple fruits of cv. Red Delicious, harvested at optimum maturity, from local orchards in Harsil area of district Uttarkashi, Uttarakhand, India were procured and brought to the laboratory of Department of Horticulture, Hill Campus, Ranichauri, in the month of October 2010. Fruits after thorough sorting and grading, were washed and hydro- cooled at 0-2^0 C for about 2 hrs, followed by drying under shade. The dried fruits were then used for conducting further experiments.

The experiment was carried out under two different storage conditions viz., ambient temperature (9.80 to 28.93^0C) and ZECC (3.19 to 20.08 ^{0}C). One lot of fruits, nearly 6 kg fruits under each treatment (T_2, T_3 ,T_4 and T_5 i.e. Calcium Chloride @ 0.25%; 0.5 % and Neemexcel @ 500 and 1000 ppm along with control T_1 dipped in plain water) were kept for determination of physico-chemical parameters and another lot of about 1 kg fruits was kept for recording PLW. Both lots of fruits were stored under two storage conditions i.e. ambient and ZECC and evaluated periodically (initial, 30, 60, 90 and 120 days) for various physical and chemical quality attributes.

Standard methods were used for recording observations on various physical and chemical (Ranganna, 1997, Sharma and Nautiyal 2009). Total soluble solids were recorded at room temperature using Erma hand refractrometer and were corrected using Standard Reference Tables and expressed in terms of ^{0}Brix at 20 ^{0}C. Acidity was determined by titrimetric method. Total and reducing sugars were estimated using Lane and Eynon's (1923) volumetric method. Starch content of apple fruits was estimated by Anthrone Reagent method as detailed by Sadasivam and Manickam (2004). Pressure/ fruit firmness was determined with the help of Effigy penetrometer (Model FT 327) and expressed in Kg/cm^2. Number of fruits showing sign of decay or rotting was counted separately in each treatment at each storage interval. The cumulative number of rotten fruits was calculated at the end of storage period and expressed as %. Physiological loss in weight (PLW) was worked out as cumulative loss in weight of fruits under various treatments based on the initial fruit weight (before storage).

RESULTS AND DISCUSSION

PLW: Among the five treatments mean physiological loss in weight varied from 6.80 to 15.65 per cent in various treatments, with highest in Control fruits and least in $CaCl_2$ (0.25 %) treated fruits (T_2). It was also observed that there was an increase in PLW from nil to 21.83 per cent (Table 4.14), might be attributed due to the rapid loss of moisture through evapo-transpiration and respiration. However, on the basis of storage conditions, the mean loss in weight was found to be higher in ambient conditions (12.60 %) than ZECC (7.62 %), which might be attributed due to higher relative humidity maintained continuously in ZECC, consequently reducing the rate of moisture exchange between the fruits and the environment. Therefore, ZECC storage coupled with chemical dip treatment of $CaCl_2$ (0.25 %) were found effective in retaining minimum changes in physiological loss in weight of apple fruits during storage.

Rotting: Minimum per cent (nil to 6 %) of rotting was recorded in $CaCl_2$ 0.25% and 0.50% treatments along with storage in ZECC for 120 days of storage and maximum rotting was observed in control(ambient storage conditions) i.e. 22%. The fruits kept in ZECC show rotting lesser than 12 per cent rotting incidence. Among various treatments, fruits treated with $CaCl_2$ (0.25%) and Neemexel (500 ppm and 1000 ppm) showed minimum signs of rotting during storage.

TSS: The minimum changes in TSS of apple fruits were recorded in Neemexel treatment (1000 ppm) i.e. 13.35 ºBrix and maximum in control. TSS content increased from13.47 to 14.08 ºBrix with the progress in storage period, which might be due to hydrolysis of starch and pectin substances and accumulation of sugars (Table 4.17). Overall lesser changes in TSS of fruits were observed in ZECC Storage than that of their counterparts stored in ambient conditions were due to reduced rate of respiration and ripening in former than their respective counterparts, therefore causing lesser conversion of starch into sugars in these treatments.

Titratable Acidity: During120 days of storage, titratable acidity of fruits followed a declining trend from 0.45 to 0.18 per cent. The minimum mean titratable acidity was recorded in Neemexcel (1000 ppm) treated fruits i.e. :0.27 which was statistically at par with the $CaCl_2$ (0.50 %) treated fruits i.e. :0.29 while, it was maximum in control fruits. Further, the changes in acidity content of fruits stored in ZECC were minimum among all treatment combinations in comparison to ambient storage.

Total Sugars: Although highest mean values of total sugars were obtained in Neemexel (1000 ppm) treatment i.e. 12.53%. But there was a steady increase in total sugars of apple fruits during 120 days of storage, irrespective of treatment combinations. Overall, there was about 38.55 per cent increase in total sugars during 120 days storage of apple fruits. However, the changes in total sugars contents were lesser in the fruits $CaCl_2$ (0.25%) and stored under ZECC conditions as compared to their counterparts.

Sensory Evaluation: The overall acceptability of apple fruits based on skin colour, flavour, crispness and shrinkage, by and large, followed by a decline towards the end of storage period, indicating optimum eating quality of fruits upto 60 days only. Further, the mean scores for all the chemical treatments were on the acceptable side for all the sensory attributes under study. It was also observed that the fruits Neemexel (1000 ppm) and stored under ZECC conditions retained better sensory quality as compared to their counterparts under ambient storage.

Table 1. Effect of chemical methods on physiological loss in weight (%) of apple fruits during storage under different storage conditions

Storage Conditions (S)	Packaging Treatments (T)	Storage Intervals (I)						Mean (T)
		Initial	30	60	90	120	Mean (I)	
Ambient (18.0to27.93ºC) RH (83.8to 93%)	Control	0.00	6.80	13.08	24.50	38.38	16.55	15.65
	$CaCl_2$ 0.25%	0.00	6.47	11.77	17.11	21.07	11.28	6.80
	$CaCl_2$ 0.50%	0.00	7.35	13.49	14.92	22.91	11.74	9.79
	Neemexel 500ppm	0.00	6.07	11.97	17.20	22.37	11.52	8.39
	Neemexel 1000ppm	0.00	5.78	11.34	15.83	26.52	11.89	9.90
	Mean	0.00	6.50	12.33	17.91	26.25	12.60	
ZECC (3.19 to 20.08 ºC) RH (83.8 to 93%)	Control	0.00	3.07	9.09	25.06	36.48	14.74	
	$CaCl_2$ 0.25%	0.00	0.90	1.18	3.66	5.86	2.32	
	$CaCl_2$ 0.50%	0.00	3.81	9.12	11.05	15.27	7.85	
	Neemexel 500ppm	0.00	2.18	2.85	7.22	14.07	5.27	
	Neemexel 1000ppm	0.00	3.33	8.46	12.38	15.39	7.91	
	Mean	0.00	2.66	6.14	11.87	17.42	7.62	
Grand mean (I)		0.00	4.58	9.24	14.89	21.83		

$CD_{0.05}$		$CD_{0.05}$	
Treatments (T)	0.15	TxS	0.21
Storage Conditions (S)	0.10	TxI	0.33
Storage Intervals (I)	0.15	SxI	0.21
		TxSxI	0.48

Table 1a. Effect of chemical methods on physiological loss in weight (%) of apple fruits irrespective of storage conditions

Treatments (T)	Storage Intervals (I)				
	Initial	30	60	90	120
Control	0.00	4.93	11.08	24.78	37.43
$CaCl_2$ 0.25%	0.00	3.68	6.47	10.38	13.47
$CaCl_2$ 0.50%	0.00	5.59	11.31	12.98	19.09
Neemexel 500ppm	0.00	4.13	7.41	12.21	18.23
Neemexel 1000ppm	0.00	4.55	9.90	14.10	20.96

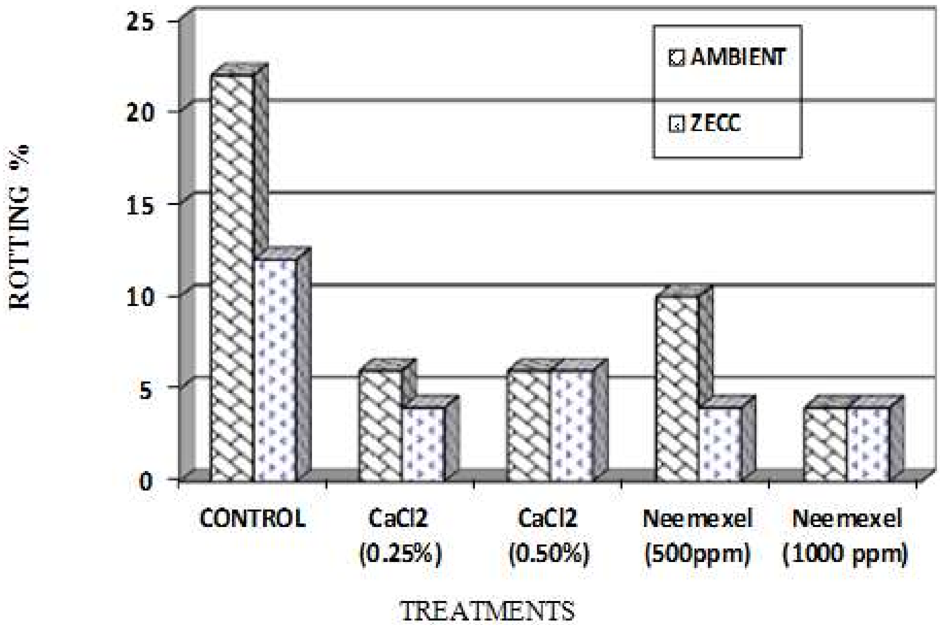

Fig. 1. Effect of carious chemical treatments on rotting (%) of apple fruits during 120 days of Storage under Ambient and ZECC conditions

Table 2. Effect of chemical methods on fruit TSS (ºBrix) of apple fruits during storage under different storage conditions

Storage Conditions (S)	Treatments (T)	Storage Intervals (I)						Mean (T)
		Initial	30	60	90	120	Mean (I)	
Ambient (18.0to27.93ºC) RH (83.8to 93%)	Control	12.30	13.07	14.47	15.73	16.53	14.42	14.08
	$CaCl_2$ (0.25%)	12.30	13.14	14.28	15.37	15.89	14.20	13.96
	$CaCl_2$ (0.50%)	12.30	12.85	13.83	14.68	15.47	13.82	13.67
	Neemexel 500 ppm	12.30	12.70	13.69	14.46	15.80	13.79	13.66
	Neemexel 1000 ppm	12.30	12.73	13.56	14.33	14.93	13.57	13.47
	Mean	12.30	12.90	13.96	14.91	15.72	13.96	
ZECC (3.19 to 20.08 ºC) RH (83.8 to 93%)	Control	12.30	12.87	13.60	14.50	15.46	13.75	
	$CaCl_2$ (0.25%)	12.30	12.91	13.66	14.59	15.20	13.73	
	$CaCl_2$ (0.50%)	12.30	12.55	13.48	14.33	14.83	13.50	
	Neemexel 500 ppm	12.30	12.84	13.55	13.89	15.17	13.55	
	Neemexel 1000 ppm	12.30	12.57	13.23	13.89	14.81	13.36	
	Mean	12.30	12.75	13.50	14.24	15.09	13.58	
Grand mean (I)		12.30	12.82	13.73	14.58	15.41		

$CD_{0.05}$		$CD_{0.05}$	
Treatments (T)	0.06	TxS	0.08
Storage Conditions (S)	0.04	TxI	0.12
Storage Intervals (I)	0.06	SxI	0.08
		TxSxI	0.17

Table 2a. Effect of chemical methods on fruit TSS (ºBrix) of apple fruits irrespective of storage conditions

Treatments (T)	Storage Intervals (I)				
	Initial	30	60	90	120
Control	12.30	12.97	14.03	15.12	16.00
$CaCl_2$ 0.25%	12.30	13.02	13.97	14.98	15.54
$CaCl_2$ 0.50%	12.30	12.70	13.65	14.50	15.15
Neemexel 500 ppm	12.30	12.77	13.62	14.17	15.48
Neemexel 1000 ppm	12.30	12.65	13.39	14.11	14.87

Table 3. Effect of chemical methods on titaratable acidity of apple fruits during storage under different storage conditions

Storage Conditions (S)	Treatment (T)	Storage Intervals (I)						Mean (T)
		Initial	30	60	90	120	Mean (I)	
Ambient (18.0to27.93ºC) RH (83.8to 93%)	Control	0.45	0.49	0.44	0.33	0.19	0.38	0.35
	$CaCl_2$ 0.25%	0.45	0.31	0.34	0.24	0.19	0.31	0.30
	$CaCl_2$ 0.50%	0.45	0.48	0.31	0.23	0.20	0.33	0.32
	Neemexel 500ppm	0.45	0.41	0.35	0.24	0.22	0.33	0.32
	Neemexel 1000ppm	0.45	0.35	0.32	0.29	0.24	0.33	0.29
	Mean	0.45	0.41	0.35	0.27	0.21	0.34	
ZECC (3.19 to 20.08 ºC) RH (83.8 to 93%)	Control	0.45	0.39	0.29	0.26	0.19	0.32	
	$CaCl_2$ 0.25%	0.45	0.37	0.27	0.22	0.18	0.30	
	$CaCl_2$ 0.50%	0.45	0.31	0.28	0.27	0.16	0.29	
	Neemexel 500ppm	0.45	0.39	0.33	0.26	0.14	0.32	
	Neemexel 1000ppm	0.45	0.28	0.27	0.22	0.12	0.27	
	Mean	0.45	0.35	0.29	0.25	0.16	0.29	
Grand mean (I)		0.45	0.38	0.32	0.26	0.18		

$CD_{0.05}$		$CD_{0.05}$	
Treatments (T)	0.01	TxS	0.02
Storage Conditions (S)	0.01	TxI	0.02
Storage Intervals (I)	0.01	SxI	0.02
		TxSxI	0.03

Table 3a. Effect of chemical methods on titaratable acidity of apple fruits irrespective of storage conditions

Treatment (T)	Storage Intervals (I)				
	initial	30	60	90	120
Control	0.45	0.44	0.36	0.29	0.19
$CaCl_2$ 0.25%	0.45	0.34	0.31	0.23	0.19
$CaCl_2$ 0.50%	0.45	0.40	0.30	0.25	0.18
Neemexel 500ppm	0.45	0.40	0.34	0.25	0.17
Neemexel 1000ppm	0.45	0.31	0.30	0.26	0.18

Table 4. Effect of chemical treatments on total sugars (%) of apple fruits during storage under different storage conditions

Storage Conditions (S)	Treatment (T)	Storage Intervals (I)						Mean (T)
		Initial	30	60	90	120	Mean (I)	
Ambient (18.0to27.93°C) RH (83.8to 93%)	Control	9.80	11.15	12.01	13.42	16.14	12.50	12.50
	$CaCl_2$ 0.25%	9.80	10.75	11.28	13.54	16.85	12.44	12.41
	$CaCl_2$ 0.50%	9.80	10.63	11.64	14.16	16.40	12.53	12.29
	Neemexel 500ppm	9.80	11.19	11.95	13.52	15.89	12.47	12.36
	Neemexel 1000ppm	9.80	11.92	12.34	13.46	15.90	12.68	12.53
	Mean	9.80	11.13	11.84	13.62	16.24	12.53	
ZECC (3.19 to 20.08 °C) RH (83.8 to 93%)	Control	9.80	10.86	12.10	13.84	15.87	12.49	
	$CaCl_2$ 0.25%	9.80	10.34	11.28	14.15	16.27	12.37	
	$CaCl_2$ 0.50%	9.80	10.04	11.11	13.39	15.38	11.94	
	Neemexel 500ppm	9.80	10.12	12.12	13.82	15.37	12.24	
	Neemexel 1000ppm	9.80	10.22	12.56	13.83	15.47	12.38	
	Mean	9.80	10.32	11.83	13.80	15.67	12.28	
Grand mean (I)		9.80	10.72	11.84	13.71	15.95		

$CD_{0.05}$		$CD_{0.05}$	
Treatments (T)	0.19	TxS	0.27
Storage Conditions (S)	0.12	TxI	0.43
Storage Intervals (I)	0.19	SxI	0.27
		TxSxI	0.61

Table 4a. Effect of chemical treatments on total sugars (%) of apple fruits irrespective of storage conditions

Treatment (T)	Storage Intervals (I)				
	Initial	30	60	90	120
Control	9.80	11.01	12.05	13.63	16.00
$CaCl_2$ 0.25%	9.80	10.55	11.28	13.84	16.56
$CaCl_2$ 0.50%	9.80	10.34	11.37	13.77	15.89
Neemexel 500ppm	9.80	10.65	12.03	13.67	15.63
Neemexel 1000ppm	9.80	11.07	12.45	13.64	15.68

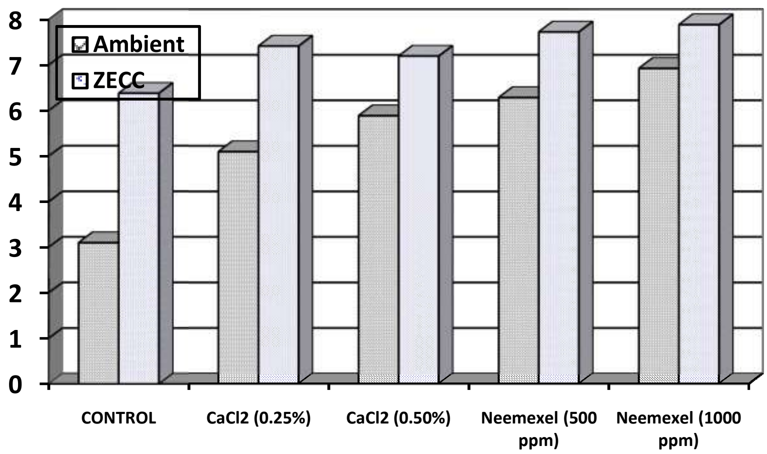

Fig. 2. Effect of various chemical treatment on Sensory quality of apple fruits during 120 days of Storage under Ambient and ZECC conditions

Conclusion

On the basis of these findings of present studies, it may be concluded that on farm storage of apples was highly successful by means of ZECC after treating fruit with 0.25% $CaCl_2$ and 1000 ppm Neemexcel in retaining their physical chemical and sensory quality for 120 days with a benefit of Rs. 2.33. The total expenses on input in the whole experiments was approximately Rs. 3,869.48 on which a gross return of Rs. 9000 were get with a profit of Rs. 5,130.52. Here, the benefit cost ration seems to be 2.33 i.e. with an input of Re.1 in this technique of storing apple fruits, one can get Re. 1.33 in form of return, during lean period, which might be a beneficial for marginal farmers.

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