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FULL LENGTH ARTICLE

Effect of maturity stages and postharvest treatments on physical properties of apple during storage

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KEYWORDS

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Abstract The objective of this study was to investigate the effect of harvest dates and postharvest treatments on physical properties of apple cv *Red delicious* during storage. Fruits from three harvest dates (H1, H2 and H3) were subjected to various treatments such as T1 (shade cooling), T2 (Hydrocooling), T3 (Hydrocooling + calcium chloride), T4 (Hydrocooling + wax) and T5 (Hydrocooling + calcium chloride + wax) and were stored under ambient and refrigerated conditions for 100 days. Results showed the significant differences in physical properties including fruit length, fruit diameter, length/diameter (L/D) ratio, fruit weight and firmness in various treatments. Maximum fruit length and fruit diameter were observed at harvest date 2nd (H_2), whereas, L/D ratio and fruit weight were observed at harvest date 3rd (H_3) on the storage at zero day. Among the treatments T_5 showed the % maximum fruit length, fruit diameter, L/D ratio and fruit weight. The firmness was decreased in all treatments and harvest dates during storage. The% maximum fruit firmness was exhibited by early harvested fruit (H_1) at zero (0) day of storage. However, changes were more pronounced under ambient conditions than cold storage.

1. Introduction

The physical characteristics of fruits are important for the design of equipments for harvesting and post-harvesting operations such as transporting, cleaning, sorting, sizing and packaging systems (Tabatabaeefar and Rajabipour, 2005). Among these physical properties, mass, volume and projected area are the most important ones in determining sizing systems (Khodabandehloo, 1999). Therefore, determination and

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consideration of these criteria result in the decrease of product loss.

The harvesting of fruits at appropriate time is an important determinant for shelf life and quality. Fruits harvested at advanced maturity are more prone to mechanical injury, having short storage life and greater susceptibility to pathogens and physiological disorders (Juan et al., 1999). In addition, careless harvesting characterized by immature and over mature fruit, is another serious cause of postharvest losses (Ingle et al., 2000).

Various pre-treatments were given to fruits during postharvest processing to enhance their shelf life. Pre-cooling by removing field heat from freshly harvested fruits reduces microbial activity and respiration rates. Furthermore, the respiratory activity and senescence of fruit as well as ethylene production are temperature dependent. Due to the pre-cooling treatments, metabolic activity and consequently respiration rate and ethylene production of the fruits are reduced considerably. This also decreases the ripening rate, diminishes water loss and decay, thus helps preserving quality and prolongs shelf-life of the fruit (Ferreira et al., 1994).

Calcium is an important component and helps in regulation of metabolism in apple fruit. The adequate concentration of calcium maintains fruit flesh firmness and minimizes the incidence of physiological disorders such as water core, bitter pit and internal breakdown (Bangerth et al., 1972). The increase in calcium generally delays the ripening of the fruit and maintains their quality during prolonged storage. The application of calcium also reduces the incidence of storage decay (Conway, 1982). Waxing is nowadays the common postharvest treatment used to increase the shelf life of fruits. Coating apples prior to storage seems an excellent fit for "Red Delicious" because it imparts high gloss, hides bruises and forms a modified atmosphere condition that tends to preserve firmness and prolongs shelf-life. The inhibition of biochemical processes, which cause the ageing of apples and shortening of their storage, may be achieved with the help of natural and artificially made chemical substances, which are used for post harvest treatment for fruits (Alleyne and Hagenmaier, 2000; Bai et al., 2002; Ganai et al., 2015).

Apple (Malus domestica Borkh.) is one of the most important temperate fruit of the world with more than 80% of the world's supply being produced in Europe. In India commercial cultivation of apple is largely confined to the state of Jammu and Kashmir, Himachal Pradesh and Uttarakhand which together accounts for about 2.5% of world production (Ahsan et al., 2008). Keeping in view the significance of this fruit in the economy of the region, the present investigation was aimed to study the effect of harvesting date, pre-cooling and various postharvest treatments on the physical properties of apple during storage.

Table 1 Effect of harvest dates, post harvest treatments and storage conditions on fruit length (mm) of apple.

Harvest dates	Treatment	Storage													
		Ambient storage (Days)							Refrigerated storage (Days)						
		0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
H1	T1	72.32	71.82	70.72	67.82	63.82	60.52	67.85	72.32	71.92	71.32	70.72	69.82	68.72	70.80
	T2	72.32	71.92	70.82	67.92	63.92	60.62	67.92	72.32	72.02	71.62	70.92	69.92	68.92	70.95
	T3	72.32	72.02	71.02	68.02	64.12	60.82	68.05	72.32	72.22	71.82	71.12	70.12	69.22	71.14
	T4	72.32	71.92	70.92	67.92	64.02	60.72	67.97	72.32	72.12	71.72	71.02	70.02	69.02	71.04
	T5	72.32	72.02	71.02	68.12	64.32	60.92	68.12	72.32	72.32	71.92	71.22	70.32	69.32	71.24
	Sub mean	72.32	71.94	70.90	67.96	64.06	60.72	67.98	72.32	72.12	71.68	71.00	70.04	69.04	71.03
H2	T1	74.21	72.81	71.51	70.21	67.31	63.21	69.88	74.21	73.51	72.71	72.11	71.11	70.31	72.19
	T2	74.21	72.81	71.51	70.31	67.41	63.41	69.94	74.21	73.51	72.71	72.11	70.31	70.31	72.43
	T3	74.21	72.91	71.71	70.51	67.71	63.71	70.13	74.21	73.71	72.91	72.31	71.71	70.91	72.63
	T4	74.21	72.91	71.61	70.51	67.51	63.51	70.04	74.21	73.61	72.81	72.21	71.41	70.71	72.49
	T5	74.21	74.01	71.81	70.71	67.71	63.71	70.36	74.21	73.71	73.11	72.31	71.91	71.21	72.74
	Sub mean	74.21	73.09	71.63	70.45	67.53	63.51	70.07	74.21	73.61	72.85	72.21	71.29	70.69	72.48
H3	T1	74.12	72.72	71.52	69.22	66.62	62.32	69.20	74.12	73.42	72.52	71.72	70.82	69.72	72.00
	T2	74.12	72.72	71.62	69.42	66.42	62.42	69.45	74.12	73.42	72.52	71.72	70.82	69.82	72.07
	T3	74.12	72.92	71.72	70.02	66.62	62.62	69.67	74.12	73.62	72.72	72.02	71.02	69.92	72.24
	T4	74.12	72.82	71.62	69.12	66.52	62.52	69.45	74.12	73.52	72.62	71.92	70.92	69.92	72.17
	T5	74.12	72.92	71.82	70.12	66.82	62.82	69.77	74.12	73.62	72.72	72.02	71.02	70.12	72.72
	Sub mean	74.12	72.82	71.66	69.58	66.60	62.54	69.55	74.12	73.52	72.62	71.88	70.92	69.90	72.16
	Grand mean	73.55	72.62	71.40	69.33	66.06	62.26	69.20	73.55	73.08	72.38	71.70	70.75	69.88	71.89
		CD ($p \leqslant 0.05$) Harvest (H) = 0.001 Treatment (T) = 0.002 H × T = 0.012 Storage (S) = 0.019 H × S = 0.025 H × S × T = 0.030							CD ($p \leqslant 0.05$) Harvest (H) = 0.006 Treatment (T) = 0.001 H × T = 0.021 Storage (S) = 0.023 H × S = 0.024 H × S × T = 0.029						

T1 = Shade cooling (Control); T2 = Hydro cooling; T3 = Hydro cooling + $CaCl_2$; T4 = Hydro cooling + wax; T5 = Hydro cooling + $CaCl_2$ + wax.

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