



Effect of ethrel on ripening and shelf-life of wood apple (*Limonia acidissima* L.) fruits

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Abstract: The fruits were treated with different concentrations of solution i.e. control (water), 1000 ppm ethrel, 2000 ppm ethrel and 3000 ppm ethrel and all the treated fruits were kept at ambient temperature. In this study 3000 ppm ethrel was found to be most effective for uniform ripening and maximum TSS, ascorbic acid, reducing sugars, total sugars and moisture content while, minimum PLW, decay loss and acidity content were recorded in fruits treated with 1000 ppm ethrel during entire period of ripening and shelf-life study. During ripening and shelf-life study PLW, TSS, ascorbic acid and decay loss was continuously increased while reducing and total sugars contents were first increased then decreased whereas total phenols and moisture contents were continuously decreased with increased storage period.

Keywords: Ethrel, Ripening, Shelf-life study, Storage

Introduction

Wood apple (*Limonia acidissima* L.) is one of the minor, underutilized and indigenous fruit plants. It is one of the very hardy fruit crops found all over the plains of Southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh and Madhya Pradesh. It is rare phenomena to find a well planted wood apple orchard subsequently no authentic data are available regarding the area and production of this fruit. The fruit tree can be grown even on saline, marginal lands, waste and neglected lands normally unsuitable for cultivation of other crops or fruit trees. The tree also flourishes well in dry areas and is not affected by any serious pests or diseases due to its resistant nature to both biotic and abiotic stresses.

It is highly regarded as religious, cultural, nutritional and medicinal valued fruit crop. The fruits are consumed as good source of juice during its harvesting season due to their low cost and thirst quenching ability. Fruits have high medicinal value and used in India as a liver and cardiac tonic while unripe fruits are used as an astringent means of treating diarrhea and dysentery in folk medicines. It is effective treatment for hiccough, sore throat and diseases of the gums. Geda and Bokadia (1980) reported antimicrobial activity of essential oil extracted from wood apple fruits and noticed its effectiveness against 12 human pathogenic bacteria. Its medicinal values are described in ancient Sanskrit literature like *Charak samhita* and *Sushruta samhita*. The nutritional and chemical properties of fresh wood apple fruits showed that it contains 6.3 g protein, 15.6 g total carbohydrates, 72 per cent moisture, 4.16 per cent titrable acidity, 2.6 mg/100g vitamin-C, 235 mg/100g total phenol and 1412.55µg/g total antioxidant capacity (Poongodi Vijayakumar

et al., 2013). Thus, large variability in physico-chemical characteristics of wood apple fruits provides an opportunity to select desirable types for commercial exploitation and plantation in waste and neglected lands. The information reveals to post-harvest application of ethrel on ripening and shelf-life study is very limited of the wood apple fruit. In present studies post-harvest application of ethrel advanced the uniform ripening and shelf-life of wood apple fruits. Ethylene is a fruit ripening hormone, however, its mechanism of action on ripening of fruits is not clearly understood. Lyons and Pratt (1964) explained that ethylene induces changes in permeability of mitochondrial membrane, thus, facilitate in the increased movement of ATP and thereby initiating several reactions including increased rate of respiration which leads to ripening of fruits. The ethrel is a well-known source of ethylene used for fruit ripening. The post-harvest losses of fruits due to mismanagement and other unfavorable factors i.e. physiological, biological and environmental. The wood apple fruits are hardy in nature and its ripening and organoleptic quality can be enhanced by application of ethrel.

Therefore, this is essential to overcome the remedies associated with the produce by proper handling and care after harvesting of fruits. Keeping these in view, the study was carried out to minimize the post-harvest losses, reduces the astringency taste and increases the organoleptic quality, shelf-life and maintenance the marketability of the wood apple fruits.

Materials and Methods

The present investigation was carried out at P. G. Laboratory of Department of Horticulture of university during the year 2012-2013. The mature fruits were procured from Ratapur

village of Milkipur tehsil and district Faizabad, fruits were selected thereafter dipped for five minutes in different concentrations of ethrel solution. The control was dipped in to distilled water because ethrel solution was prepared in water. All the treated fruits were kept in room at ambient temperature for ripening and shelf-life studied. The observations were recorded on PLW, moisture, TSS, acidity, ascorbic acid, reducing, non-reducing and total sugars, total phenols and decay loss at 4th day intervals. The data were analyzed using completely randomized design of analysis of variance (Panse and Sukhatme, 1985) and results were interpreted at significance level of 5%.

Physico-chemical analysis: Physiological loss in weight of fruit was calculated by subtracting the average weight of fruit on the day of observation from the initial weight of fruit. Moisture content was determined by drying the known amount of samples in an oven at 70 °C to constant weight. The per cent moisture content was calculated against the fresh fruit weight and expressed (Ranganna, 2010). Total soluble solids were determined by hand refractometer (ERMA made) of 0-32% (Ranganna, 2010). The total acidity present in sample was ascertained by titration of samples against NaOH solution. Then known amount of aliquot was taken and titrated against 0.1 N sodium hydroxide standard solution using 2-3 drops phenolphthalein as an indicator (Ranganna, 2010). To determine vitamin-C content sample was prepared in 3 per cent metaphosphoric acid solution and known volume aliquot was titrated against 2, 6 dichlorophenol indophenols dye solution (A. O. A. C., 2012). The Fehling's 'A' and 'B' solutions (Lane and Eynon, 1923) were used to estimate the sugars content and procedure as suggested by (Ranganna, 2010). The total phenols were ascertained by the method of Swine and Hills (1959). The fruits started decaying visually was separated from the lots of treated and control fruits and their weight was recorded on electronic balance.

Results and Discussion

Data furnished on physiological loss in weight due to post-harvest application of ethrel in table-1 revealed that per cent physiological loss in weight was continuous increased with storage period. The minimum PLW was recorded in control fruits while maximum PLW was observed with higher concentration of ethrel (3000 ppm) during entire period of study. Kulkarni *et al.*, (2011) showed that increase in PLW was directly proportional to increase in the ethrel concentration. Physiological loss in weight of wood apple fruits was increased might be due to greater loss of moisture particularly with higher concentration of ethrel as well as increased transpiration and respiration rate as ethrel increases the rate of respiration. Increased PLW with higher concentration might be due to rigorous effect of ethrel on disorganization of cell wall structure which resulted higher respiration rate as reported by Singh and Tiwari (1994). Similar, increase in physiological loss in weight during storage period has also been reported in other climacteric fruits such as banana (Kulkarni *et al.*, 2011) and pear (Dhillon and Mahajan, 2011) as well as in non-climacteric fruits such as kagzi lime (Bisen *et al.*, 2012). These reports are in support of present findings.

Observations with respect to per cent of moisture content presented in Table-1 clearly reflected that total moisture per cent retention was increased with increasing the ethrel concentration. Moisture per cent content was decreased gradually with increased the storage period at ambient temperature. Maximum per cent moisture 69.30 %, 63.40 %, 58.60 % and 55.02 % content was recorded with T₄ on 4th, 8th, 12th and 16th day of observation respectively, and minimum per cent moisture 63.40 %, 52.50 %, 42.10 % and 35.30 % content was noticed in control on 4th, 8th, 12th and 16th day respectively . The decrease in moisture content in wood apple fruit with increased storage period might be due to

Table-1: Post-harvest application effect of ethrel on physiological loss in weight (%), moisture (%), TSS (%) and acidity (%) content of wood apple fruit

Treatments	Physiological loss in weight (%)				moisture (%)				TSS (%)				Acidity (%)			
	Days of ambient storage				Days of ambient storage				Days of ambient storage				Days of ambient storage			
	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th
T ₁ - Control	12.86	19.20	32.10	52.50	63.40	52.50	42.10	35.30	16.40	16.80	17.70	17.85	2.86	2.80	2.69	2.63
T ₂ -1000 ppm	13.24	18.31	22.07	30.23	67.10	59.30	53.65	48.20	17.60	18.10	18.45	18.90	2.75	2.66	2.55	2.52
T ₃ -2000 ppm	15.44	22.80	25.62	33.43	68.20	61.15	55.20	51.68	18.20	18.35	19.10	20.10	2.56	2.53	2.46	2.44
T ₄ -3000 ppm	21.62	27.34	31.10	38.45	69.30	63.40	58.60	55.02	18.65	18.90	19.55	20.40	2.43	2.39	2.30	2.28
SEm ±	0.88	1.34	0.65	0.65	0.70	0.69	0.69	0.67	0.64	0.64	0.64	0.63	0.12	0.12	0.12	0.12
C D at 5%	2.00	3.03	1.46	1.46	1.59	1.57	1.55	1.52	1.45	1.45	1.45	1.43	0.28	0.28	0.27	2.27

Table-2: Post-harvest application effect of ethrel on Ascorbic acid (mg/100g), reducing sugars (%), non-reducing sugar (%) and total sugars (%) content of wood apple fruit

Treatments	Ascorbic acid (mg/100g)				Reducing sugars (%)				Non-reducing sugar (%)				Total sugars (%)			
	Days of ambient storage				Days of ambient storage				Days of ambient storage				Days of ambient storage			
	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th	4 th	8 th	12 th	16 th
T ₁ - Control	5.38	6.98	7.73	7.77	3.90	4.11	4.22	4.29	11.48	11.40	11.36	11.33	15.38	15.51	15.58	15.62
T ₂ -1000 ppm	6.40	7.15	8.17	8.05	4.31	4.60	4.85	4.80	11.45	11.36	11.30	11.26	15.76	15.96	16.15	16.06
T ₃ -2000 ppm	6.58	7.35	8.45	8.28	4.56	4.92	5.13	5.09	11.40	11.31	11.25	11.20	15.96	16.23	16.38	16.29
T ₄ -3000 ppm	6.87	7.72	8.77	8.52	4.88	5.25	5.46	5.41	11.32	11.26	11.16	11.12	16.20	16.51	16.62	16.53
SEm ±	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.61	0.63	0.63	0.63	0.62	0.62	0.62	0.63	0.62
C D at 5%	1.42	1.42	1.42	1.40	1.41	1.41	1.41	1.38	1.43	1.43	1.42	1.40	1.44	1.44	1.44	1.42

Table-3: Post-harvest application effect of ethrel on total phenol (mg/100g) and decay (%) content of wood apple fruit

Treatments	Total phenol (mg/100g)				Decay (%)		
	Days of ambient storage				Days of ambient storage		
	4 th	8 th	12 th	16 th	8 th	12 th	16 th
T ₁ - Control	110.20	108.15	105.15	99.35	4.32	12.36	29.30
T ₂ -1000 ppm	107.10	104.10	100.10	93.20	2.10	6.73	11.45
T ₃ -2000 ppm	102.40	98.35	93.35	83.40	2.80	9.82	16.84
T ₄ -3000 ppm	95.15	90.15	83.15	71.25	6.46	11.84	22.40
SEm ±	8.48	0.74	0.74	0.72	0.62	0.63	0.63
C D at 5%	19.15	1.68	1.67	1.64	1.40	1.41	1.43

transpiration and evaporation of water from the fruit surface. The moisture retention was higher in treated fruits than control and retention was increased with concentration of ethrel which seems to higher concentration of water soluble substances in the treated fruits which influence the loss of water from the cells due to exosmosis. The results of present study are in close conformity to the findings of Kulkarni *et al.*, (2011) in banana variety Robusta and Singh *et al.*, (2012) in Amrapali mango. Where per cent moisture loss was increased with advancement of storage period.

The data portrayed in table-1 apparently indicated that the applications of ethrel after harvesting of wood apple fruits increased total soluble solids content. The application of ethrel 3000 ppm (T₃) was found most effective for maximum content of TSS among the various concentrations of ethrel. How ethrel increased total soluble solids in pulp is not clearly understood, but Ribereau Gayon (1968) suggested that transformation of organic acids is one of the reasons for decreased acidity during ripening. Therefore, possibility seems that ethrel might have enhanced the conversion of organic acid in to sugars and hydrolysis of polysaccharides in to sugars during ripening and thereby enhanced TSS content of fruits. Post harvest application of ethrel reported to increase total soluble solids in banana (Kulkarni *et al.*, 2011) fruits.

Data pertaining to effect of ethrel on acidity content of wood apple fruits during storage period are presented in table-1 that the total titrable acidity of wood apple fruits was reduced by post-harvest application of ethrel however response of ethrel varied with concentrations. The minimum of titrable acidity content was found in fruits treated with 3000 ppm ethrel. How ethrel causes reduction in titrable acidity is not precisely understood however, Ribereau Gayon (1968) described that transformation of organic acids to sugars is one of the reasons for decrease of acidity during fruit ripening. Therefore, possibility seems that ethrel enhanced the conversion of organic acid to sugar because in present finding decrease in acid content corresponding increase in sugars content in the fruits. Decreased acidity with ripening and storage has also been reported by Singh *et al.*, (2012) and Sunitha *et al.*, (2015) in climacteric fruits of mango. Whereas Kulkarni *et al.*, (2011) reported acidity content in banana fruit was increased with increase the ethrel concentration and storage period; this contradiction need further comparative study for confirmation.

It is evident from the observations for the ascorbic acid content of wood apple fruits presented in table-2 revealed that

ascorbic acid content in pulp of wood apple fruits were increased in all treatments including control. The ascorbic acid content was increased with increase in both concentration as well as storage period. The maximum (8.52 mg/100g) ascorbic acid content was recorded with 3000 ppm ethrel on 16th day of observation. An increase in ascorbic acid content during ripening and shelf-life study might be due to synthesis of ascorbic acid from sugars (Srinivasan *et al.*, 1973), hence an increased level of sugar with the ethrel application in present findings may be responsible for higher availability of sugar for synthesis of ascorbic acid. Similar results were reported by Sarkar *et al.*, (1996) and Ghos *et al.*, (2003) in litchi and Mahajan (1996) in mango.

Data on changes during post-harvest application of ethrel in wood apple fruits are showed in table-2 revealed that reducing sugars content was lower than non-reducing sugar. In general, after harvest, the sugar content increases in the fruit at the expense of starch. At the commencement of ripening, the majority of sugars are reducing in nature, but the ripe fruits contain more non-reducing sugar than reducing sugars (Venkatesan and Tamilmami, 2014). The reducing sugars content was increased up to 12th day of observation in treated fruits thereafter it was decreased during shelf-life study. The reason for initial increased in reducing sugars was probably the conversion of starch in to sugars and conversion of non-reducing sugar in to reducing sugars afterwards their decrease possibility might be due to utilization of these sugars in the process of respiration and lesser synthesis. Similarly Venkatesan and Tamilmami (2014) in mango fruits reported incremental trend of reducing sugars content with ethrel application.

Data recorded on changes in non-reducing sugar of fruits during storage are presented in table-2 revealed that non-reducing sugar content was decreased with increase ethrel treatments and the maximum non-reducing sugar content was noticed in control followed by with treatment of 1000 ppm of ethrel. The decreasing trend in non-reducing sugar might be due to continuous respiration and less availability of starch to hydrolyze in to sugars. The results supported by findings of Singh *et al.*, (2012) in mango fruits who recorded a reduction in percentage of non-reducing sugar with ripening and storage life of fruits.

Data with respect to per cent changes in total sugars content in wood apple fruits as illustrated in table-2 revealed that total sugars content was increased with increasing the concentration as well as storage period. The total sugars content in wood apple fruits were increasing continuously up to 12th day of observation in all the treatments. Ethrel at 3000 ppm was found most effective in respect to content of total sugars per cent during entire period of study. The increase in total sugars during storage at room temperature might be because of conversion of starch in to sugars and their utilization lesser starch conversion in later period of storage may account for the decrease in sugars. Similar results were reported by Kulkarni, *et al.*, (2011) and Venkatsan and Tamilmami (2014) in mango fruits.

The data as embodied in table-3 clearly reflected that the ethrel treatment of 3000 ppm was most effective for minimizing total phenols content as comparison to other treatments which is desirable for fruits. The decreased in total phenols content of wood apple

fruits during ripening and shelf-life may be due to reduction of tannin content and increase in sugar synthesis. This is in affirmation with the earlier workers of Tarsem *et al.*, (2007) in bael and Apai *et al.*, (2009) in longon fruits. Less phenol was obtained in treated fruits than control because of hastening in ripening of treated fruits.

Data on the cumulative decay loss are furnished in Table-10 showed that there was no decay loss up to 4th day of observation in all the treatments including control. The decay loss was increased with the period of storage at ambient temperature. The minimum (2.10 to 11.45%) decay loss was found with 1000 ppm from 8th day of observation to the end of experiment. The increased in decay loss with advancement of periods might be due to increase the PLW and loss of moisture from the fruits. The analogous results reported by Singh *et al.*, (2012) indicated that no decay loss was observed up to 6th day when mango fruits treated with 1000 ppm ethrel and stored at ambient temperature and thereafter decay loss was started and increased with concentration of ethrel and storage period.

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