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**STUDIES ON THE EFFECT OF ETHREL AND DIFFERENT WRAPPING MATERIALS
ON POST - HARVEST CHANGES OF PAPAYA FRUITS (*CARICA PAPAYA L*)****Priyanka Singh*, Sanjay Kumar and Sutanu Maji**Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, (A Central University),
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Received on: 30th August, 2014Accepted on: 8th December, 2014**ABSTRACT**

The present experiment entitled, “Studies on the effect of Ethrel and Different Wrapping Materials on post-harvest changes of papaya fruits (*Carica papaya L.*)” was carried out to investigate the effect of ethrel and different wrapping materials on percentage loss of weight, acidity, reducing sugar and total carotenoids of papaya fruits. Ethrel has been found very effective growth regulator in ripening and improving fruit quality in many climacteric as well as non-climacteric fruits. The objective of this work was to evaluate the effects of various concentrations of Ethrel (500 ppm, 750 ppm, 1000 ppm and 1500 ppm) on shelf life of papaya fruits alone and in combination with various wrapping materials like paddy straw, tissue paper, newspaper and shrink film when stored under ambient conditions. The treated fruits were observed for biochemical aspects such as loss of weight (%), acidity (%), reducing sugar (%) and total carotenoids (mg/100g). The observations were recorded at 3, 6 and 9 days after storage and the experiment was laid down using Completely Randomized Design. From the experiment it was clear that the overall performance of the above characteristics was found the best when the fruits were treated with 1500 ppm ethrel followed by 1000 ppm ethrel in combination with paddy straw.

Keywords: Papaya, ethrel, wrapping material, ripening and shelf life.**INTRODUCTION**

Papaya (*Carica papaya L.*) is one of the major fruit crops cultivated in tropical and subtropical zones of the world. India is the largest producer (4196 thousand tonnes) contributing about 37% of the papaya produced in the world with a cultivated area of about 106 thousand hectare and the productivity of 39.6 metric tonnes per hectare Anonymous (2010). In general, papaya fruits have a short shelf life of 5 to 6 days at room temperature of 25 °C-28 °C and up to 3 weeks at lower temperatures of 10 °C-12 °C. When stored at 15 °C and 20 °C, the papaya fruits can be stored for 9 to 10 days. Like other tropical fruits, papaya fruits are sensitive to low temperatures below 10 °C and may develop symptoms of chilling injury such as pitting of the skin, hard lumps around the vascular bundles, scald, water soaking of the flesh, abnormal ripening with uneven colouration and greater susceptibility to diseases. Use of plant growth regulators has been found very useful for achieving the short term objective of improving fruit quality. Ethrel has been found very effective growth regulator in ripening and improving fruit quality in many climacteric fruits. Different wrapping materials are being used by fruit growers to prolong the storage life. Skin evaporation (transpiration) and to some extent respiration cause a loss of water from fruit and this loss in weight can be effectively cut down by the use of various packaging

materials like polythene, tissue paper, newspaper, paddy straw and shrink film.

Keeping in view of the above facts, the present experiment, “Studies on the effect of Ethrel and Different Wrapping Materials on Post Harvest Changes in Papaya (*Carica papaya L.*)” has been taken up together with the information on percentage of ripening, loss in weight acidity, reducing sugar and total carotenoids through treatments with different concentration of ethrel, use of various wrapping materials and combination of ethrel with wrapping materials.

MATERIALS AND METHODS

The present investigation entitled “Studies on the effect of Ethrel and Different Wrapping Materials on Post Harvest Changes in Papaya (*Carica papaya L.*)” was carried out at Laboratory of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University (A Central University) Lucknow, during the year 2010 and 2011. The fruits of papaya cv. Pusa Delicious which were physiologically mature and have attained the full size, light green with tinge of yellow at apical end were used for the study. The fruits were selected on the basis of uniformity, maturity, size and shape. Ethrel solutions of various concentrations were prepared in laboratory. The fruits were dipped in various concentrations of ethrel for five minutes. After the

treatment the water was drained off completely. Then drained fruits were dried with the muslin cloth and wrapped in various packaging materials i.e. using no wrapper, newspaper, paddy straw and shrink film. The treated fruits were stored at ambient conditions.

The numbers of fruits treated under each treatment were twelve, out of which nine fruits were analyzed in three replications at the interval of 3 days, 6 days and 9 days after storage for their chemical composition. The remaining three fruits were tested for physical characters for the same intervals. The treatments were as following: T₀P₀-Water only+ Unwrapped, T₀P₁-Water only+ Tissue paper, T₀P₂-Water only+ News paper, T₀P₃-Water only+ Paddy straw, T₀P₄-Water only+ Shrink Film, T₁P₀-Ethrel 500 ppm+ Unwrapped, T₁P₁-Ethrel 500 ppm + Tissue paper, T₁P₂-Ethrel 500 ppm + News paper, T₁P₃-Ethrel 500 ppm + Paddy straw, T₁P₄-Ethrel 500 ppm + Shrink Film, T₂P₀-Ethrel 750 ppm + Unwrapped, T₂P₁-Ethrel 750 ppm + Tissue paper, T₂P₂-Ethrel 750 ppm + News paper, T₂P₃-Ethrel 750 ppm + Paddy straw, T₂P₄-Ethrel 750 ppm + Shrink Film, T₃P₀-Ethrel 1000 ppm + Unwrapped, T₃P₁-Ethrel 1000 ppm + Tissue paper, T₃P₂-Ethrel 1000 ppm + News paper, T₃P₃-Ethrel 1000 ppm + Paddy straw, T₃P₄-Ethrel 1000 ppm + Shrink Film, T₄P₀-Ethrel 1500 ppm + Unwrapped, T₄P₁-Ethrel 1500 ppm + Tissue paper, T₄P₂-Ethrel 1500 ppm + News paper, T₄P₃-Ethrel 1500 ppm + Paddy straw, T₄P₄-Ethrel 1500 ppm + Shrink Film.

The fruits sampled were assessed for percentage of ripening, weight loss, titratable acidity, reducing sugar and total carotenoids. Percentage of ripening (%) was calculated as per the formula, Ripening (%) = The number of ripe fruit(s)/total number of fruit(s) x 100 and expressed as a percentage. Weight loss (%) was determined by weighing the fruit in each treatment at different intervals of storage and was expressed as percentage deviation in weight on the basis of initial weight. Titratable acidity and reducing sugar -were determined following the method described by Ranganna (2007). Total Carotenoids were measured by taking 5 grams of the sample, grounded with acetone and anhydrous sodium sulphate in a pestle and mortar (Ranganna, 2007). The data were tabulated and statistically analysed using Factorial C.R.D. Comparison of treatment means were made with the help of Critical Differences (C.D.). The analysis of variance of the experimental design was carried out for each character separately as suggested by Chandel, (1984). Duncan Multiple Range Test (DMRT) was used to group the treatment means on the basis of C.D. The values were marked with English alphabets. The alphabet 'a' denoted the maximum value and subsequent lower values in decreasing order were marked alphabetically. The values marked with same alphabet(s) indicated that they were statistically *at par* i.e. statistically indifferent.

RESULT AND DISCUSSION

EFFECT OF ETHREL AND WRAPPING MATERIALS ON RIPENING OF PAPAYA FRUITS

From the results of the present study as presented in the Tables 1,2 and 3 it was clear that at 3 DAS, under

unwrapped conditions the maximum percentage of ripening was found in the fruits treated with ethrel @ 1500 ppm while the minimum was observed at control (i.e. without ethrel). Among the interactions the maximum percentage of ripening was observed at ethrel application @ 1500 ppm in combination with paddy straw, newspaper and tissue paper. At 6 DAS, all the fruits got ripened except shrink film wrapped fruits. Ethrel application was found to be effective alone and in combinations with wrapping materials for the promotion of ripening process.

According to Holl (1977) ethylene probably brings about the climacteric since in many fruits the rise in respiration in directly preceded by an elevation in the ethylene concentration. The respiratory climacteric can be induced by ethylene treatment without a simultaneous change in tissue permeability. It had also been reported that ethylene altered the proportion of individual transfer RNA. This effect of ethylene may influence the translation of m RNA and thus initiate ripening. Nour and Goukh (2010) observed the effect of ethrel (250,500 and 1000 ppm) on fruit ripening of white and pink fleshed guava fruits. They observed that depending upon the concentration ripening was 2-6 days faster in fruits dipped in aqueous solutions of ethrel compared with untreated fruits.

Among the interactions, a combination of ethrel and paddy straw has given the maximum percentage of ripening followed by the interaction of ethrel with newspaper and tissue paper. Randhawa *et al.* (1982) in pear and Sandho *et al.* (1982) in Flordrasun peaches found more percentage of ripening in paddy straw wrapped fruits than paper wrapped fruits. Shrink film wrapped fruits (alone and in combination) did not get ripened even at 9 DAS. Similar result was obtained by Singh and Rao (2005) in shrink film wrapped papaya fruits.

EFFECT OF ETHREL AND WRAPPING MATERIALS ON WEIGHT LOSS

Data presented in the Table 4,5 and 6 clearly indicated that weight loss of papaya fruits was increased significantly in all the treatments of ethrel alone and in combination at all the levels of storage (i.e. 3 DAS, 6 DAS and 9 DAS). Under unwrapped conditions the maximum weight loss was observed in the ethrel application @ 1500 ppm and the minimum weight loss was recorded at control. Dhillon and Mahajan (2011) reported the similar result in ethrel treated fruits of pear cv. Patharnakh. They observed that physiological loss in weight increased with the increase of concentration of ethrel.

Among the interactions the maximum weight loss was observed in ethrel application @ 1500 ppm in combination with paddy straw. The shrink film wrapped fruits showed the best result with the minimum weight loss at every combination of various ethrel concentrations. Similar result was also obtained by Singh and Rao (2005) in shrink film wrapped papaya fruits.

Table 1. Effect of ethrel and wrapping materials on percentage of ripening of papaya fruits cv. Pusa Delicious after 3 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	22.22	33.34	27.78	44.43	44.44	44.44	55.56	55.56	55.56	66.67	66.67	66.67	0.00	0.00	0.00
Ethrel @500 ppm	44.44	44.44	44.44	44.43	44.44	44.44	55.56	55.56	55.56	66.67	66.67	66.67	0.00	0.00	0.00
Ethrel @750ppm	44.44	44.44	44.44	44.44	44.44	44.44	44.44	55.56	50.00	66.67	66.67	66.67	0.00	0.00	0.00
Ethrel @1000 ppm	66.67	66.67	66.68	66.67	66.67	66.670	66.67	66.67	66.67	66.67	100.00	66.67	0.00	0.00	0.00
Ethrel @1500ppm	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
Mean	55.55	57.78	56.67	55.56	60.00	60.00	55.56	66.67	65.56	55.56	73.34	73.34	0.00	0.00	0.00
S.E.m±	For Ethrel= 7.988			For Wrapping material 7.9879			For Ethrel x wrapping material = 17.861								
C.D.(P=0.05)	For Ethrel= 2.811			For Wrapping material = 2.811			For Ethrel x wrapping material = 6.287								

Table 2: Effect of ethrel and wrapping materials on percentage of ripening of papaya fruits cv. Pusa Delicious after 6 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
Ethrel @500 ppm	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
Ethrel @750ppm	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
Ethrel @1000 ppm	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00
Ethrel @1500ppm	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00
Mean	80	80	80	80	80	80	80	80	80	80	80	80	0.00	0.00	0.00

NA- Not Available for study

Table 3: Effect of ethrel and wrapping materials on percentage of ripening of papaya fruits cv. Pusa Delicious after 9 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00

Ethrel @500 ppm	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00
Ethrel @750ppm	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00
Ethrel @1000 ppm	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00
Ethrel @1500ppm	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00
Mean	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.00	0.00	0.00

NA- Not Available for study

Table 4: Effect of ethrel and wrapping materials on physiological weight loss (%) of papaya fruits cv. Pusa Delicious after 3 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	9.19	9.10	9.14e	6.77	7.41	7.09c	7.01	7.78	7.40d	7.38	8.29	7.84c	0.14	0.11	0.12d
Ethrel @500 ppm	10.18	10.56	10.37d	7.28	7.78	7.53bc	7.80	8.41	8.11c	8.66	8.84	8.75bc	0.24	0.21	0.22c
Ethrel @750ppm	11.62	12.27	11.95c	7.98	7.87	7.93b	8.62	8.86	8.74c	11.32	9.40	10.36ab	0.24	0.26	0.25bc
Ethrel @1000 ppm	12.33	13.40	12.86b	9.70	8.71	9.21a	9.94	8.93	9.44b	10.83	9.93	10.38ab	0.29	0.29	0.29b
Ethrel @1500ppm	14.65	14.19	14.42a	9.95	9.27	9.61a	10.85	11.01	10.93a	11.81	11.92	11.86a	0.46	0.34	0.40a
Mean	11.59	11.90	11.75	8.34	8.21	8.27	8.85	9.00	8.92	10.00	9.68	9.84	0.28	0.24	0.26
C.V.	3.245	1.313	3.636	5.928	3.438	6.116	7.998	0.907	6.405	20.650	0.883	14.491	10.905	18.939	18.526
S.E.m±	0.217	0.090	0.174	0.285	0.163	0.207	0.408	0.047	0.233	1.193	0.049	0.582	0.017	0.026	0.019
C.D.(P=0.05)	0.684	0.284	0.508	0.899	0.513	0.602	1.287	0.148	0.679	N.S.	0.155	1.695	0.055	0.083	0.057
S.E.m±	For Ethrel= 0.1366			For Wrapping material = 0.1366			For Ethrel x wrapping material = 0.3055								
C.D.(P=0.05)	For Ethrel=0.3824			For Wrapping material = 0.3824			For Ethrel x wrapping material = 0.8551								

Table 5: Effect of ethrel and wrapping materials on physiological weight loss (%) of papaya fruits cv. Pusa Delicious after 6 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	10.93	11.95	11.44e	9.33	9.12	9.23d	9.68	9.91	9.79e	9.68	10.13	9.91d	0.63	0.54	0.58d
Ethrel @500 ppm	13.42	12.35	12.89d	10.56	10.95	10.76c	10.62	11.25	10.93d	11.54	11.87	11.71c	0.71	0.64	0.67cd
Ethrel @750ppm	14.37	13.23	13.8c	11.55	10.55	11.05c	11.73	11.63	11.68c	12.16	12.05	12.11c	0.75	0.73	0.74bc
Ethrel @1000 ppm	15.21	15.45	15.33b	12.96	11.97	12.46b	13.02	13.31	13.16b	13.47	15.03	14.25b	0.83	0.81	0.82b

Ethrel @1500ppm	20.25	19.01	19.63a	14.95	14.96	14.95a	15.44	15.34	15.39a	16.04	16.90	16.47a	0.98	1.09	1.03a
Mean	14.84	14.40	14.62	11.87	11.51	11.69	12.10	12.29	12.19	12.58	13.20	12.89	0.78	0.76	0.77
C.V.	2.411	1.736	4.229	8.058	12.257	9.729	3.917	3.378	3.593	4.717	1.476	4.696	14.508	14.527	13.960
S.E.m±	0.207	0.144	0.252	0.552	0.814	0.464	0.274	0.240	0.179	0.343	0.112	0.247	0.065	0.064	0.044
C.D.(P=0.05)	0.651	0.455	0.735	1.740	2.566	1.352	0.862	0.755	0.521	1.080	0.354	0.720	0.206	0.201	0.128
S.E.m±	For Ethrel= 0.1223			For Wrapping material = 0.1223			For Ethrel x wrapping material = 0.2736								
C.D.(P=0.05)	For Ethrel= 0.3424			For Wrapping material = 0.3424			For Ethrel x wrapping material = 0.7657								

Table 6: Effect of ethrel and wrapping materials on physiological weight loss (%) of papaya fruits cv. Pusa Delicious after 9 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	15.16	11.19	13.17d	10.55	10.99	10.77e	11.06	11.93	11.50e	11.16	13.34	12.25e	1.18	1.24	1.21c
Ethrel @500 ppm	16.59	16.00	16.29c	11.44	12.49	11.97d	12.13	13.49	12.81d	13.60	14.51	14.06d	1.26	1.30	1.28c
Ethrel @750ppm	17.40	16.99	17.19bc	14.05	13.99	14.02c	14.15	14.27	14.21c	15.48	14.86	15.17c	1.24	1.36	1.30c
Ethrel @1000 ppm	18.20	18.99	18.59b	15.41	16.04	15.72b	16.34	16.82	16.58b	17.45	17.99	17.72b	1.61	1.51	1.56b
Ethrel @1500ppm	24.05	21.91	22.98a	16.62	17.02	16.82a	17.77	17.97	17.87a	19.03	19.06	19.04a	1.83	1.78	1.81a
Mean	18.28	17.01	17.65	13.61	14.11	13.86	14.29	14.90	14.59	15.34	15.95	15.65	1.42	1.44	1.43
C.V.	0.862	6.135	7.460	6.880	0.563	4.919	5.842	2.324	4.845	6.648	1.085	5.733	11.335	3.797	8.115
S.E.m±	0.091	0.603	0.537	0.541	0.046	0.278	0.482	0.200	0.289	0.589	0.100	0.366	0.093	0.031	0.047
C.D.(P=0.05)	0.287	1.899	1.565	1.704	0.145	0.811	1.519	0.630	0.841	1.856	0.315	1.067	0.293	0.099	0.138
S.E.m±	For Ethrel = 0.1531			For Wrapping material = 0.1531			For Ethrel x wrapping material = 0.3423								
C.D.(P=0.05)	For Ethrel= 0.4285			For Wrapping material = 0.4285			For Ethrel x wrapping material = 0.9582								

Table 7: Effect of ethrel and wrapping materials on titratable acidity (%) of papaya fruits cv. Pusa Delicious after 3 Days of treatment.

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	0.384	0.448	0.416a	0.305	0.369	0.337a	0.295	0.361	0.328a	0.254	0.315	0.285a	0.494	0.555	0.524a
Ethrel @ 500 ppm	0.269	0.333	0.301b	0.201	0.265	0.233b	0.198	0.262	0.230b	0.187	0.252	0.219b	0.456	0.519	0.488b
Ethrel @ 750ppm	0.237	0.301	0.269b	0.170	0.233	0.202b	0.163	0.226	0.194c	0.148	0.213	0.180c	0.434	0.497	0.465c
Ethrel @1000 ppm	0.198	0.256	0.227c	0.120	0.124	0.122d	0.105	0.113	0.109d	0.089	0.104	0.096d	0.391	0.454	0.423d
Ethrel @1500ppm	0.078	0.081	0.079d	0.077	0.102	0.090c	0.069	0.072	0.070e	0.064	0.066	0.065d	0.388	0.062	0.225e
Mean	0.233	0.284	0.258	0.175	0.219	0.197	0.166	0.207	0.186	0.148	0.190	0.169	0.433	0.417	0.425
C.V.	4.902	4.256	12.527	0.875	2.714	14.245	0.582	0.684	14.653	0.550	2.687	16.266	0.764	1.212	20.150
S.E.m±	0.007	0.007	0.013	0.001	0.003	0.011	0.001	0.001	0.011	0.000	0.003	0.011	0.002	0.003	0.035

C.D.(P=0.05)	0.021	0.022	0.038	0.003	0.011	0.033	0.002	0.003	0.032	0.001	0.009	0.033	0.006	0.009	0.102
S.E.m±	For Ethrel = 0.0084			For Wrapping material = 0.0084				For Ethrel x wrapping material = 0.0189							
C.D.(P=0.05)	For Ethrel= 0.0236			For Wrapping material =0.0236				For Ethrel x wrapping material = 0.0528							

Table 8: Effect of ethrel and wrapping materials on titratable acidity (%) of papaya fruits cv. Pusa Delicious after 6 Days of treatment.

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	0.175	0.238	0.207a	0.139	0.182	0.160a	0.131	0.171	0.151a	0.115	0.126	0.121a	0.391	0.438	0.415a
Ethrel @ 500 ppm	0.153	0.223	0.188ab	0.137	0.174	0.155ab	0.128	0.169	0.148a	0.111	0.125	0.118a	0.337	0.336	0.337b
Ethrel @ 750ppm	0.126	0.218	0.172ab	0.118	0.153	0.135bc	0.116	0.151	0.133a	0.105	0.119	0.112a	0.334	0.281	0.307c
Ethrel @1000 ppm	0.106	0.186	0.146b	0.102	0.132	0.117c	0.099	0.113	0.106b	0.081	0.110	0.096b	0.325	0.256	0.290d
Ethrel @1500ppm	0.069	0.066	0.067c	0.067	0.066	0.066d	0.064	0.063	0.064c	0.060	0.062	0.061c	0.284	0.218	0.251e
Mean	0.126	0.186	0.156	0.112	0.141	0.127	0.108	0.133	0.120	0.095	0.109	0.102	0.334	0.306	0.320
C.V.	1.143	21.706	29.205	1.216	10.375	16.006	0.960	1.225	13.944	1.616	9.281	10.942	0.309	1.943	9.153
S.E.m±	0.001	0.023	0.019	0.001	0.008	0.008	0.001	0.001	0.007	0.001	0.006	0.005	0.001	0.003	0.012
C.D.(P=0.05)	0.003	0.074	0.054	0.002	0.027	0.024	0.002	0.003	0.020	0.003	0.018	0.013	0.002	0.011	0.035
S.E.m±	For Ethrel = 0.0050			For Wrapping material = 0.0050				For Ethrel x wrapping material = 0.0112							
C.D.(P=0.05)	For Ethrel= 0.0140			For Wrapping material =0.0140				For Ethrel x wrapping material = 0.0313							

Table 9: Effect of ethrel and wrapping materials on titratable acidity (%) of papaya fruits cv. Pusa Delicious after 9 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	0.114	0.112	0.113a	0.106	0.098	0.102a	0.093	0.096	0.095a	0.081	0.087	0.084a	0.213	0.205	0.209a
Ethrel @ 500 ppm	0.090	0.099	0.095b	0.071	0.090	0.080b	0.070	0.090	0.080b	0.066	0.084	0.075b	0.175	0.179	0.177b
Ethrel @ 750ppm	0.078	0.096	0.087bc	0.068	0.083	0.076b	0.066	0.082	0.074bc	0.062	0.073	0.067bc	0.137	0.162	0.149c
Ethrel @1000 ppm	0.066	0.090	0.078c	0.064	0.081	0.073b	0.061	0.077	0.069c	0.055	0.065	0.060c	0.124	0.145	0.135cd
Ethrel @1500ppm	0.060	0.062	0.061d	0.052	0.054	0.053c	0.048	0.048	0.048d	0.040	0.040	0.040d	0.111	0.132	0.122d
Mean	0.081	0.092	0.087	0.072	0.081	0.077	0.068	0.079	0.073	0.061	0.070	0.065	0.152	0.165	0.158

Mean	1.143	1.662	9.076	4.780	1.384	10.225	5.757	2.557	10.819	5.547	5.965	10.234	7.257	5.982	8.651
C.V.	0.001	0.001	0.003	0.002	0.001	0.003	0.002	0.001	0.003	0.002	0.002	0.003	0.006	0.006	0.006
S.E.m±	0.002	0.003	0.009	0.006	0.002	0.009	0.007	0.004	0.009	0.006	0.008	0.008	0.020	0.018	0.016
C.D.(P=0.05)	For Ethrel = 0.0017			For Wrapping material =0.001				For Ethrel x wrapping material = 0.0037							
S.E.m±	For Ethrel= 0.0047			For Wrapping material =0.0047				For Ethrel x wrapping material = 0.0105							

Table 10: Effect of ethrel and wrapping materials on reducing sugar (%) of papaya fruits cv. Pusa Delicious after 3 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	3.66	3.68	3.67d	3.98	4.01	4.00	4.11	4.16	4.14d	4.16	4.56	4.36d	3.22	3.22	3.22d
Ethrel 500 ppm	4.12	4.14	4.13c	4.42	4.48	4.45d	4.49	4.62	4.567c	4.70	4.69	4.69c	3.33	3.29	3.31c
Ethrel 750ppm	4.44	4.54	4.49b	4.91	4.86	4.88c	5.15	5.27	5.21b	5.36	5.42	5.39b	3.48	3.57	3.53b
Ethrel 1000 ppm	4.46	4.63	4.55b	5.16	5.24	5.20b	5.37	5.40	5.39b	5.45	5.50	5.47b	3.55	3.62	3.59ab
Ethrel 1500ppm	6.38	5.70	6.04a	6.75	6.68	6.72a	7.26	7.36	7.31a	7.44	7.65	7.55a	3.57	3.65	3.61a
Mean	4.61	4.54	4.58	5.05	5.05	5.05	5.28	5.36	5.32	5.42	5.56	5.49	3.43	3.47	3.45
C.V.	2.326	2.724	4.388	2.459	1.733	2.026	1.523	0.540	1.405	0.665	4.896	3.774	1.631	0.368	1.453
S.E.m±	0.062	0.071	0.082	0.072	0.051	0.042	0.046	0.017	0.031	0.021	0.157	0.085	0.032	0.007	0.020
C.D.(P=0.05)	0.195	0.225	0.239	0.226	0.159	0.122	0.146	0.053	0.089	0.066	0.495	0.246	0.102	0.023	0.060
S.E.m±	For Ethrel = 0.0261			For Wrapping material =0.0261				For Ethrel x wrapping material =0.0583							
C.D.(P=0.05)	For Ethrel=0.0729			For Wrapping material =0.0729				For Ethrel x wrapping material = 0.1630							

Table 11: Effect of ethrel and wrapping materials on reducing sugar (%) of papaya fruits cv. Pusa Delicious after 6 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	5.82	5.86	5.84d	6.03	6.07	6.05d	6.39	6.44	6.42c	6.46	6.53	6.49c	4.18	4.22	4.20e
Ethrel @ 500 ppm	6.22	6.27	6.25c	6.35	6.35	6.35c	6.50	6.52	6.51c	6.61	6.61	6.61c	4.44	4.42	4.43d
Ethrel @ 750ppm	6.52	6.59	6.56b	6.55	6.63	6.59b	6.73	6.84	6.79b	6.82	6.94	6.88b	4.72	4.71	4.72c
Ethrel @ 1000 ppm	6.66	6.75	6.70a	6.80	6.94	6.87a	6.87	7.09	6.98a	7.07	7.07	7.07a	4.94	4.86	4.90b
Ethrel @ 1500ppm	5.75	5.99	5.87d	5.80	6.00	5.90d	5.95	6.12	6.03d	6.06	6.41	6.24d	5.23	5.16	5.19a
Mean	6.20	6.29	6.24	6.31	6.40	6.35	6.49	6.60	6.54	6.60	6.71	6.66	4.70	4.68	4.69
C.V.	1.280	1.361	1.573	2.091	1.912	2.059	2.176	1.338	1.973	2.067	1.418	2.117	1.280	0.592	1.074
S.E.m±	0.046	0.049	0.040	0.076	0.071	0.053	0.082	0.051	0.053	0.079	0.055	0.058	0.035	0.016	0.021

C.D.(P=0.05)	0.144	0.156	0.117	0.240	0.223	0.156	0.257	0.161	0.154	0.248	0.173	0.168	0.109	0.050	0.060
S.E.m±	For Ethrel = 0.0209			For Wrapping material =0.0209			For Ethrel x wrapping material =0.0468								
C.D.(P=0.05)	For Ethrel= 0.0586			For Wrapping material =0.0586			For Ethrel x wrapping material = 0.1311								

Table 12: Effect of ethrel and wrapping materials on reducing sugar (%) of papaya fruits cv. Pusa Delicious after 9 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	3.82	3.81	3.81e	3.92	3.93	3.92e	4.33	4.39	4.36d	4.42	4.46	4.44c	5.21	5.16	5.19c
Ethrel 500 ppm	4.16	4.20	4.18d	4.22	4.25	4.24d	4.39	4.43	4.41d	4.48	4.55	4.52c	5.36	5.27	5.31c
Ethrel 750ppm	4.33	4.40	4.37c	4.41	4.46	4.44c	5.15	5.23	5.19c	5.19	5.34	5.27b	5.48	5.49	5.49b
Ethrel 1000 ppm	5.12	5.19	5.15a	5.70	5.46	5.58a	5.86	5.64	5.75a	6.00	6.09	6.05a	5.93	6.06	5.99a
Ethrel 1500ppm	4.60	4.60	4.60b	5.39	5.36	5.37b	5.43	5.51	5.47b	6.07	5.96	6.02a	6.09	6.19	6.14a
Mean	4.41	4.44	4.42	4.73	4.69	4.71	5.03	5.04	5.04	5.23	5.28	5.26	5.61	5.63	5.62
C.V.	0.573	0.935	0.915	0.978	0.727	1.506	0.846	2.198	1.929	3.754	0.845	2.643	1.027	0.994	1.228
S.E.m±	0.015	0.024	0.017	0.027	0.020	0.029	0.025	0.064	0.040	0.113	0.026	0.057	0.033	0.032	0.028
C.D.(P=0.05)	0.046	0.076	0.048	0.084	0.062	0.084	0.077	0.202	0.116	0.357	0.081	0.165	0.105	0.102	0.082
S.E.m±	For Ethrel = 0.0164			For Wrapping material =0.0164			For Ethrel x wrapping material =0.0366								
C.D.(P=0.05)	For Ethrel= 0.0458			For Wrapping material =0.0458			For Ethrel x wrapping material = 0.1024								

Table 13: Effect of ethrel and wrapping materials on total carotenoids (mg/100g) of papaya fruits cv. Pusa Delicious after 3 Days of treatment.

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	2.44	2.36	2.40d	2.58	2.53	2.55 d	2.66	2.58	2.62d	2.70	2.96	2.83	1.86	1.58	1.72
Ethrel @ 500 ppm	2.66	2.60	2.63c	2.71	2.69	2.70c	2.73	2.71	2.72c	2.86	2.75	2.81	2.02	1.73	1.87
Ethrel @ 750ppm	2.76	2.71	2.73b	2.80	2.72	2.76c	2.89	2.93	2.91b	2.93	3.03	2.98	2.12	1.81	1.96
Ethrel @ 1000 ppm	2.80	2.78	2.790b	2.90	2.89	2.90 b	2.90	2.96	2.93b	3.16	3.09	3.12	2.18	1.89	2.04
Ethrel @ 1500ppm	3.26	3.19	3.22a	3.38	3.33	3.35 a	3.40	3.36	3.38a	3.44	2.89	3.17	2.38	1.93	2.15
Mean	2.78	2.73	2.76	2.87	2.83	2.85	2.92	2.91	2.91	3.02	2.95	2.98	2.11	1.79	1.95
C.V.	4.371	0.703	3.082	3.687	1.433	2.685	3.454	0.784	2.455	4.530	10.995	9.057	26.931	5.960	20.917
S.E.m±	0.070	0.011	0.035	0.061	0.023	0.031	0.058	0.013	0.029	0.079	0.187	0.110	0.328	0.061	0.166
C.D.(P=0.05)	0.221	0.035	0.101	0.193	0.074	0.091	0.183	0.041	0.085	0.249	N.S.	N.S.	N.S.	0.194	N.S.
S.E.m±	For Ethrel = 0.0414			For Wrapping material =0.0414			For Ethrel x wrapping material =0.0926								
C.D.(P=0.05)	For Ethrel=0.1159			For Wrapping material =0.1159			For Ethrel x wrapping material = 0.2591								

N.S.-Non-significant

Table 14: Effect of ethrel and wrapping materials on total carotenoids (mg/100g) of papaya fruits cv. Pusa Delicious after 6 Days of treatment.

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	2.78	2.84	2.81	3.00	2.89	2.95c	3.01	2.92	2.96c	3.27	2.95	3.11	2.33	2.04	2.18
Ethrel @ 500 ppm	2.89	2.88	2.88	3.02	2.92	2.97c	3.09	3.02	3.06c	3.21	3.08	3.14	2.38	2.09	2.24
Ethrel @ 750ppm	2.99	2.89	2.94	3.11	3.03	3.07bc	3.19	3.05	3.12bc	3.24	3.06	3.15	2.39	2.23	2.31
Ethrel @1000 ppm	3.10	2.93	3.01	3.27	3.12	3.19a	3.46	3.29	3.37a	3.49	3.25	3.37	2.41	2.14	2.28
Ethrel @1500ppm	2.94	2.99	2.97	3.22	3.22	3.22ab	3.27	3.26	3.27ab	3.32	3.32	3.32	2.40	2.20	2.30
Mean	2.94	2.91	2.92	3.12	3.04	3.08	3.20	3.11	3.16	3.30	3.13	3.22	2.38	2.14	2.26
C.V.	0.459	0.195	5.040	5.672	0.834	4.084	5.841	0.902	4.255	10.246	2.324	7.632	19.153	5.803	14.523
S.E.m±	0.119	0.041	0.060	0.102	0.015	0.051	0.108	0.016	0.055	0.195	0.042	0.100	0.263	0.072	0.134
C.D.(P=0.05)	N.S.	N.S.	N.S.	N.S.	0.046	0.150	N.S.	0.051	0.160	N.S.	0.132	N.S.	N.S.	N.S.	N.S.
S.E.m±	For Ethrel = 0.0386			For Wrapping material =0.0386			For Ethrel x wrapping material =0.0864								
C.D.(P=0.05)	For Ethrel=0.1081			For Wrapping material =0.1081			For Ethrel x wrapping material = 0.2417								

N.S.-Non-significant

Table 15: Effect of ethrel and wrapping materials on total carotenoids (mg/100g) of papaya fruits cv. Pusa Delicious after 9 Days of treatment

Treatments	unwrapped			tissue paper			newspaper			paddy straw			shrink film		
	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled	1 st year	2 nd year	Pooled
Control	1.99	2.01	1.20c	2.19	2.23	2.21c	2.19	2.24	2.22b	2.20	2.26	2.23b	3.10	2.89	2.99c
Ethrel @ 500 ppm	2.09	2.23	2.160b	2.17	2.24	2.20c	2.21	2.25	2.23b	2.24	2.27	2.25b	3.18	3.07	3.12bc
Ethrel @ 750ppm	2.20	2.28	2.240b	2.22	2.27	2.258c	2.25	2.28	2.26b	2.27	2.31	2.29b	3.24	3.14	3.19ab
Ethrel @1000 ppm	2.39	2.43	2.41a	2.66	2.69	2.68a	2.72	2.75	2.73a	2.82	2.87	2.85a	3.41	3.17	3.29a
Ethrel @1500ppm	2.56	2.26	2.41a	2.27	2.38	2.32b	2.58	2.58	2.58a	2.90	2.67	2.79a	3.48	3.18	3.33a
Mean	2.25	2.24	2.24	2.30	2.36	2.33	2.39	2.42	2.40	2.48	2.47	2.48	3.28	3.09	3.19
C.V.	1.080	1.896	3.945	2.081	1.010	2.137	9.473	1.170	6.054	7.911	1.363	5.631	3.502	0.611	4.278
S.E.m±	0.014	0.025	0.036	0.028	0.014	0.020	0.131	0.016	0.059	0.113	0.019	0.057	0.066	0.011	0.056
C.D.(P=0.05)	0.044	0.077	0.105	0.087	0.043	0.059	N.S.	0.052	0.173	0.357	0.061	0.166	0.209	0.034	0.162
S.E.m±	For Ethrel =0.0215			For Wrapping material =0.02			For Ethrel x wrapping material = 0.0481								
C.D.(P=0.05)	For Ethrel= 0.0603			For Wrapping material =0.0603			For Ethrel x wrapping material = 0.1347								

EFFECT OF ETHREL AND WRAPPING MATERIALS ON TITRATABLE ACIDITY OF PAPAYA FRUITS

The result presented in the Table 7,8 and 9 clearly indicated that ethrel alone and in combination with wrapping materials were found significant in reduction of titratable acidity of the fruits under unwrapped conduction, the minimum titratable acidity was recorded in the ethrel application @ 1500 ppm while the maximum was recorded in control at all the levels of storage. Among the interaction the minimum titratable acidity was recorded in the combination of ethrel @ 1500 ppm and paddy straw followed by newspaper and tissue paper at all the levels of storage (i.e. 3, 6 and 9 DAS)

The decrease in fruits pulp acidity was more in various treatment interactions when compared to individual treatments, thereby showing a synergistic or complimentary effect. Gayon (1968) suggested that transformation of organic acid into sugar is one of the reasons for decrease of organic acids during fruits ripening. The ethrel might enhance the conversion of organic acids to sugar since present finding revealed that sugar content is increased and acidity is decreased following ethrel application. In the support of the present finding Mann *et al.*(1994) observed that with the progress of ripening period acid content decreased in ethrel treatment (0-400 ppm) in Patharnakh cultivar of pear fruits. The decrease in acidity was more in paddy straw wrapped fruits compared from paper wrapped at 9 DAS.

Among all the treatment combination shrink film showed the maximum titratable acidity at every combination of various ethrel concentrations at all the levels of storage (i.e. 3 DAS, 6 DAS and 9 DAS), Singh and Rao (2005) observed the similar result in shrink film wrapped papaya fruits.

EFFECT OF ETHREL AND WRAPPING MATERIALS ON REDUCING SUGARS

The present investigation revealed that the reducing sugar (Table 10, 11 and 12) were significantly influenced by the ethrel treatment and its combination with wrapping materials.

At 3 DAS, under unwrapped conditions ethrel @ 1500 ppm showed the highest reducing sugar and the minimum reducing sugar was observed at control i.e. without ethrel. Among the interaction the maximum sugar content was observed in ethrel application @ 1500 ppm with paddy straw followed by newspaper and tissue paper. The minimum sugar content was obtained in the combination of ethrel treatment @0ppm (i.e. without ethrel) with shrink film. At 6 DAS, the maximum reducing sugar was recorded at combination with paddy straw, newspaper and tissue paper followed by ethrel application @ 750 ppm alone and in combination with wrapping materials. At 9 DAS, the sugar content was declined in all the combination of ethrel alone and in combination with various wrapping materials except in the various combination of ethrel and shrink film. However, the maximum reducing sugar content was recorded at ethrel application @ 1000 ppm. Ethrel treatment have been found effective in increasing the

percentage of reducing sugars. These results are in conformity with the finding of Aziz and Tanahy (1975) in banana.

EFFECT OF ETHREL AND WRAPPING MATERIAL ON TOTAL CAROTENOIDS OF PAPAYA FRUITS

The result of the present study indicated that ethrel alone and in combination of different wrapping materials have significant influence on total carotenoids (Table 13, 14 and 15)

At 3 DAS, under unwrapped conditions the maximum total carotenoids were recorded by ethrel application @ 1500 ppm and the minimum was recorded at ethrel application @ 0 ppm (i.e. without ethrel). Among the interactions, the maximum total carotenoids were recorded at ethrel application @ 1500 ppm in combination with paddy straw, newspaper and tissue paper followed by ethrel application @ 1000 ppm and the minimum total carotenoids were recorded in ethrel application @ 0 ppm (i.e. without ethrel) in combination with paddy straw, tissue paper and newspaper.

At 6 DAS, the maximum total carotenoids were recorded in ethrel application @1500 ppm alone and in combination with various wrapping materials like paddy straw, newspaper and tissue paper.

At 9 DAS total carotenoids had declined significantly in all the treatments and their combinations except in the shrink film wrapped fruits where it had increased at all the doses of ethrel. The maximum total carotenoids were recorded in ethrel application @ 1000 ppm alone and in combination with paddy straw, newspaper and tissue paper. Similarly, Kumar and Singh (1993) also observed that maximum β -carotenoids was found in ethrel treated mango fruits. Ethrel might have increased the activity of chlorophyllase enzyme which is responsible for the breakdown of chlorophyll and enhanced β -carotenoids in fruits. Similar result was also reported by Mann and Singh (1994) in pear.

In the case of shrink film a gradual increase was observed in the total carotenoids content at all the levels of storage. However, an increase in the total carotenoids contents was observed with the increase in ethrel concentration. Singh and Rao (2005) also reported the delayed increase in total carotenoids content in papaya fruits.

CONCLUSION

It can be concluded that interaction of wrapping materials and ethrel have significant impact on developing as well as preserving the various physical, chemical and organoleptic attributes of papaya fruits cv. Pusa Delicious necessary for the market value of papaya fruits. The interaction of ethrel @ 1500 ppm with paddy straw was found best for early ripening. Ethrel @ 1000 ppm in interaction with paddy straw was found the most suitable because it retained the fruit quality in terms of sugars, total carotenoids at the end of storage studies. Interestingly, shrink film wrapped fruits in combination with various ethrel concentrations were found best for

prolonging the shelf life of fruits as they did not get ripened even after nine days after storage.

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