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Influence of post-harvest application of ethrel and paper wrapping on physical parameter and ripening of papaya (*Carica papaya* L.) Cv. Madhu Bindu

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Abstract
Papaya (*Carica papaya* L.) is an important and a very popular fruit crop of the tropical and subtropical areas in the world. The experiment was conducted to study the "influence of post-harvest application of ethrel and paper wrapping on papaya (*Carica papaya* L.) cv. Madhu Bindu" during kharif, 2017 at Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand(Gujarat). The experiment was framed in completely Randomized Design with factorial concept replicated thrice with ten treatment combination. The treatment were comprised of five different concentration of ethrel (0 mg/l, 500 mg/l, 750 mg/l, 1000 mg/l and 1250 mg/l) along with paper wrapping (with paper wrapping and without paper wrapping). Fruit dipped in ethrel @ 1250 mg/l shows early ripening. Significantly minimum PLW (%) and spoilage (%) while, maximum firmness and shelf life were observed with no-ethrel treatment (0 mg/l). In case of paper wrapping significantly maximum firmness, minimum PLW and early ripening was observed with paper wrapping while, significantly minimum spoilage and long shelf life was observed in non-wrapped fruit.

Keywords: Post-harvest treatment, ethrel, physical parameter, papaya, dipping, ripening

Introduction
Papaya (*Carica papaya* L.) belonging to the family caricaceae, is one of the most important fruits cultivated throughout the tropical and subtropical regions of the world. Presently, papaya cultivation is spread over tropical and sub-tropical part of the world covering 32^0 N and 32^0 S on the globe. Top twenty papaya cultivating countries are distributed in Asia (India, Bangladesh, Thailand, Indonesia, Philippines, Malaysia and China), Africa (Nigeria, Ethiopia, Congo, Kenya, Ivory Coast and Mozambique), Latin and Central America (Brazil, Mexico, Venezuela, Colombia and Cuba). Some developed countries like USA (Hawaii), Australia, South Africa and Taiwan also cultivate papaya. India is supposed to be the largest producer of papaya in the world. Papaya occupies 1.8% of total fruit crop area and 6.3% of total fruit production in India. It occupies a cultivated area of 133.4 (000 ha) with an annual production of 5699.00 (000 MT) and productivity of 42.3 (MT/ha). Papaya is an abundant source of carotene (2020 I.U./100g), precursor of vitamin A. Papaya fruits are used for the treatment of piles, dyspepsia of spleen and liver, digestive disorders, diphtheria and skin blemishes.
Ethrel is an ethylene-releasing chemical, which can be used to improve fruit color development and stimulates ripening process of the fruit. Fruit ripening is a genetically programmed stage of development overlapping with senescence (Watada *et al*., 1984) [25]. Aqueous solution of ethrel is stable below pH 3.5. Above pH 3.5, the hydrolysis of ethrel begins with the release of free ethylene along with chloride and phosphate ions. On dipping the mature fruits in ethrel, it enters into the fruit cells, releases ethylene and hastens the ripening process. 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 these in view, the present experiment is undertaken to see the "Influence of post-harvest application of ethrel and paper wrapping on physical parameter and ripening of papaya (*Carica papaya* L.) cv. Madhu Bindu" fruit kept at ambient temperatures.

Materials and methods

The present investigation entitled "Influence of post-harvest application of ethrel and paper wrapping on papaya (*Carica papaya* L.) cv. Madhu Bindu" was carried out at Laboratory of the Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during the year 2017. The fruits of papaya cv. Madhu Bindu 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. The experiment was laid out in Completely Randomized Design (CRD) with five treatments and three replications.

The fruits were washed with clean water and dipped for five minutes in the following concentrations of Ethrel solution. i.e. control (E_0), 500 ppm (E_1), 750ppm (E_2), 1000 ppm (E_3) and 1250 ppm (E_4). After each treatment, the fruits were air dried at ambient temperature for 30 minutes in an attempt to reduce possible chemical injury. The control fruits were dipped for five minutes in the distilled water without using the ethrel solution. Half fruits of all ethrel treatments are wrapped with paper (P_1) and remaining fruits are left without covering wrapper (P_0). The number of fruits treated under each treatment was ten, out of which four fruits were examined for their chemical composition in three replications at the interval of 2 days, 4 days, 6 days and 8 days after storage. The data collected for different observations were subjected to statistical analysis by adopting 'Analysis of variance' techniques as described by Steel and Torrie (1980) [23].

Results and Discussion

The results obtained from the present investigation are summarized below:

Fruit firmness (kg/cm^2)

The data revealed that during the entire storage period ethrel exerted their significant effects on fruit firmness. Maximum firmness was noted in E_0 (no ethrel) treatment at 2rd, 4th, 6th and 8th day of storage period (6.27, 5.83, 5.38 and 3.72 kg/ cm^2, respectively). While, minimum firmness at 2rd, 4th, 6th and 8th day of storage period (5.38, 4.56, 3.73 and 1.83 kg/cm^2, respectively) was recorded in ethrel 1250 mg/l (E_4). The reduction in firmness with exogenous application of ethrel may be due to the increased activity of various enzymes involved in fruit softening as well as enhanced ripening (Nair and Singh, 2003) [24]. Similar results were obtained by Brinston *et al*. (1988) [1], Dhillon and Mahajan (2011) [4] in pear, Saeed *et al.* (2006) [16] in banana, Hai *et al.* (2009) [7] in "Tron" and "Hoi" mangoes, Nour and Goukh (2010) [13] in white and pink-fleshed guava fruits and Siddiqui and Dhua (2009) [17] in mango cv. Himsagar fruits.

In case of paper wrapping Fruits wrapped with paper recorded maximum firmness at 2nd, 4th, 6th and 8th day (5.82, 5.04, 4.54 and 2.81 kg/cm^2, respectively). While fruits without wrapping was shows minimum firmness at 2nd, 4th, 6th and 8th day of storage period (5.73, 4.91, 4.42 and 2.71 kg/cm^2, respectively). Similar result was obtained by Jindal *et al*. (2005) [9] in sapota cv. Cricket Ball.

Table 1: Influence of post-harvest application of ethrel and paper wrapping on fruit firmness and physiological loss in weight of papaya (*Carica papaya* L.) cv. Madhu Bindu

Treatments	Fruit firmness (kg/cm^2)				Physiological loss in weight (%)			
	2 day	4 day	6 day	8 day	2 day	4 day	6 day	8 day
Ethrel (E)								
E_0 : No ethrel	6.27	5.83	5.38	3.72	2.48	4.75	6.75	8.23
E_1 : Ethrel @ 500 mg/l	5.96	5.04	4.95	3.11	2.80	5.26	7.34	8.43
E_2 : Ethrel @750 mg/l	5.71	4.81	4.23	2.93	3.07	5.42	7.43	8.79
E_3 : Ethrel @1000 mg/l	5.54	4.63	4.10	2.22	3.19	5.69	7.65	9.24
E_4 : Ethrel @1250 mg/l	5.38	4.56	3.73	1.83	3.66	6.42	8.24	10.64
S.Em. ±	0.05	0.05	0.06	0.05	0.06	0.15	0.22	0.26
C.D. at 5%	0.14	0.16	0.17	0.16	0.17	0.43	0.66	0.77
Paper wrapping (P)								
P_0 : Without paper wrapping	5.73	4.91	4.42	2.71	3.10	5.65	7.55	9.22
P_1 : With paper wrapping	5.82	5.04	4.54	2.81	2.98	5.37	7.42	8.91
S.Em. ±	0.03	0.03	0.04	0.03	0.04	0.09	0.14	0.17
C.D. at 5%	0.09	0.10	0.11	0.10	0.11	0.27	NS	NS

Table 2: Influence of post-harvest application of ethrel and paper wrapping on spoilage, days taken to ripening and shelf life of papaya (*Carica papaya* L.) cv. Madhu Bindu

Treatments	Spoilage (%)				Days taken to ripening	shelf life (Days)
	2 day	4 day	6 day	8 day		
Ethrel (E)						
E_0 : No ethrel	0.00	13.61	34.91	69.99	5.33	7.50
E_1 : Ethrel @ 500 mg/l	0.00	20.26	44.09	76.94	4.88	6.13
E_2 : Ethrel @750 mg/l	0.00	27.39	50.93	83.64	4.12	6.00
E_3 : Ethrel @1000 mg/l	0.00	33.87	62.95	92.62	3.45	5.17
E_4 : Ethrel @1250 mg/l	0.00	43.34	75.94	-	2.60	4.17
S.Em. ±	0.00	1.31	2.19	3.09	0.07	0.20
C.D. at 5%	-	3.85	6.47	9.26	0.20	0.58
Paper wrapping (P)						
P_0 : Without paper wrapping	0.00	26.01	51.68	77.57	4.19	6.13
P_1 : With paper wrapping	0.00	29.37	55.85	84.03	3.96	5.73

S.Em. ±	0.00	0.83	1.39	2.18	0.04	0.12
C.D. at 5%	-	2.44	4.09	NS	0.13	0.37

Physiological loss in weight (%)

The variation in physiological loss in weight was observed significant due to different treatment. Minimum physiological loss in weight was noted in without ethrel (E_0) treatment during 2nd, 4th, 6th and 8th day storage (2.48, 4.75, 6.75 and 8.23%, respectively) which was at par with E_1 at 6th and 8th day of storage (7.34 and 8.43%, respectively) and E_2 at 8th day (8.79%) of storage period. While, maximum physiological loss in weight was noted in ethrel 1250 mg/l (E_4) treatment during 2nd, 4th, 6th and 8th day storage (3.66, 6.42, 8.24 and 10.64%, respectively). This could be due to the fact that, higher ethylene concentration promoted the physiological processes such as respiration, transpiration which resulted into more physiological loss in weight due to moisture loss. Similar finding ware also recorded by Chauhan *et al.* (2012) [3] in orange, Kulkarni *et al.* (2004) [10] in mango fruits cv. Neelum and also Siddiqui and Dhua (2009) [17] in mango fruits cv. Himsagar. Sachin Patil *et al.* (2009) [15] in mango and Madhavi *et al.* (2005) [11] in sapota.

In case of paper wrapping The minimum physiological loss in weight was noted in fruits wrapped with paper during 2nd and 4th day storage period (2.98 and 5.37%, respectively) as compared to fruits without wrapping (3.10 and 5.65%, respectively). Similar results were obtained by Somkuwar *et al.* (2005) [21] in grapes, Jindal *et al.* (2005) [9] in sapota, Chandra and Kumar (2012) [2] in guava and Prasad *et al.* (2015) [14] in banana.

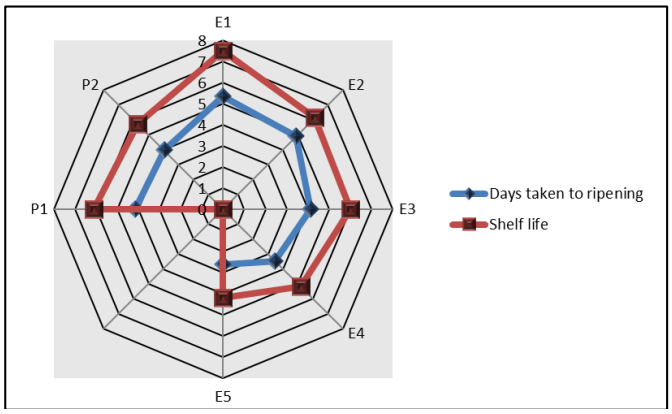

Fig 1: Influence of post-harvest application of ethrel and paper wrapping on days taken to ripening and shelf life of papaya (*Carica papaya* L.) cv. Madhu Bindu

Spoilage (%)

The variation in spoiled fruit was also observed significant and lowest spoilage percentage at 4th, 6th and 8th day of storage period (13.61, 34.91 and 69.99%, respectively) were recorded in without ethrel (E_0) which was at par with E_1 (76.94%) during 8th day of storage period. While, highest spoilage percentage was noted in ethrel 1250 mg/l (E_4) at 4th and 6th day of storage period (43.34 and 75.94%, respectively). This might have occurred due to increased respiration rate, enzyme activities and dissolution of cell wall which ultimately lead to early softening and over-ripening of fruits. This trend of increased spoilage with increased ripeness is similar to that reported by Gupta and Jawandha (2010) [6] for peaches. Similar results were reported in mango fruits by Singh *et al.* (2012c) [20], Sapota fruits by Madhavi *et al.* (2005) [11] and by Srivastava *et al.* (1971) [22].

For paper wrapping maximum spoilage percentage was noted in fruits wrapped with paper during 4th and 6th day storage period (29.37 and 55.85%, respectively) as compared to without wrapped fruit (26.01 and 51.68%, respectively). It might be due to paper wrapping increase the ethylene content in the fruits which increase the ripening process or induce senescence. Similar results were obtained by Jindal *et al.* (2005) [9] and Malik *et al.* (2015) [12] in guava.

Days taken to ripening

Lowest day to start ripening (2.60 days) was recorded in treatment E_4 follow by E_3. While, highest day for attain ripening was required in E_0 treatment. Ethylene probably brings about the climacteric, since in many fruits the rise in respiration is directly preceded by an elevation in the ethylene concentration. This respiratory climacteric can be induced by ethylene treatment without a simultaneous change in tissue permeability. It has also been reported that ethylene alters the proportion of individual transfer RNA species. This effect of ethylene may influence the transfer of m RNA and thus initiate ripening. Similar results were reported by Sing *et al.* (2012a) [18] in papaya and Gama *et al.* (2015) [5] in banana.

In case of paper wrapping, wrapped fruits require less day for ripening (3.96 day) as compare to unwrapped fruits (4.19 day). It might be due to paper wrapping increase the ethylene content in the fruits which increase the ripening process or early ripening. Similar results were obtained by Sing *et al.* (2012b) [19] in papaya.

Shelf life (Days)

The maximum shelf life (7.5 days) was recorded when papaya fruits were treated with no ethrel (E_0) and the minimum (4.17 days) was recorded when papaya treated with ethrel 1250 mg/l (E_4). However it was explained by Holl (1977) [8] that ethylene probably brings about the climacteric, since in many fruits the rise in respiration is directly preceded by an elevation in the ethylene concentration. This respiratory climacteric can be induced by ethylene treatment without a simultaneous change in tissue permeability. It has also been reported that ethylene alters the proportion of individual transfer RNA species. This effect of ethylene may influence the transfer of m RNA and thus initiate ripening also induce senescence. Similar results were reported by Sing *et al.* (2012 a) [18] in papaya and Gama *et al.* (2015) [5] in banana.

The unwrapped fruits shown significantly maximum (6.13 day) as compare to wrapped fruits (5.73 day). It might be due to paper wrapping increase the ethylene content in the fruits which increase the ripening process and also induce senescence. Similar results were obtained by Sing *et al.* (2012 b) [19] in papaya.

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