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EFFECT OF ETHEPHON AND PACKAGING PRACTICES ON RIPENING OF MANGO cv. MALDAH

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ABSTRACT

The present research was conducted on two factor Completely Randomized Design (CRD) with eight treatments and three replications. A set of experiments were carried out to evaluate the effect of postharvest ethephon treatment and packaging on ripening of mango cv. Maldah. The treatments consisted of ripening agent i.e., ethephon and control treatment under different packaging condition i.e., fiber with hole, fiber without hole, plastic with hole and plastic without hole. The result revealed that different packaging condition and ripening agents influenced the ripening behavior of mango. The highest TSS (15.26), sugar-acid ratio (23.66) and juice content (126.05) were recorded with fiber (without hole) and the lowest TSS (12.60), sugar-acid ratio (9.01) and juice content (116.05) with plastic (without hole). The highest TA (1.44) was recorded with plastic (without hole) and the lowest (0.66) with fiber (without hole). Similarly, the highest BT (2.83) was recorded with fiber (with hole) and the lowest (1.66) with plastic (without hole). Firmness, sweetness, TSS and juice content were the highest with the interaction effect of fiber bag (without hole) and ethephon treatment. In conclusion, mango fruits with ethephon treatment packed in fiber bag (without hole) enhances quality and ripening of mango whereas under controlled condition and without hole plastic packaging mangoes had low quality performance in terms of physio-chemical properties.

Keywords: Ripening agent, Ethephon, Packaging, Fiber, Plastic.

INTRODUCTION

Mangifera is a genus of flowering plants in the family, Anacardiaceae which is mainly known as Common Mango (*Mangifera indica*). The cultivation of mango has been originated from South East Asia (Mehta, 2017). Mango is one of the most popular tropical fruits grown commercially in 87 nations of the globe (*Tharanathan* et al., 2006). The total area under mango cultivation in Nepal is about 48,204 ha, (MoALD, 2017) mostly in the terai, low-hills, mid-hills and mountains regions. It is

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commonly cultivated for commercial fruit production. A climacteric fruit, the mango ripens quickly after harvest (between 3 and 9 days) (Mitra and Baldwin, 1997). Fruit ripening is a physiological process which is primarily controlled by a gaseous plant hormone called ethylene. The chemical commonly used to ripen fruits commercially is ethephon (2-chloroethyl phosphonic acid) which penetrates into fruit and decomposes to ethylene (Alexander and Grierson, 2002). Growing and marketing of fresh produce are complicated by postharvest losses in quantity and quality between harvest and consumption leading to unprofitability. Post-harvest loss could be rightly stated as the qualitative and quantitative loss of horticultural produce at any moment along the post-harvest chain which includes the change in the edibility and wholesomeness i.e., quality of the produce finally preventing its consumption (Adeoye, 2009; Buyukbay et al., 2010). In Nepal, different studies have shown the postharvest losses of fruits and vegetables are 20-50% (Gautam and Bhattarai, 2012). Improper harvesting practices and improper post-harvest practices result in loss due to the spoilage of produce before reaching the market along with the loss in quality of the produce such as deterioration in appearance, taste and nutritional value. Therefore, it is necessary to extend consumption period of fruits, maintain regular supply to market and assured safe transportation means for long distance.

Although mango is known to be remarkably tolerant of wide range of climatic conditions, the mango should always be grown within specific and well-defined ranges of temperature and rainfall for its profitable cultivation. A rainfall of about 125 cm falling mostly during the monsoon is considered very suitable, favorable temperature for mango is 24-37°C during growing season along with high humidity.

Though post-harvest losses of Mango in Nepal have been reported, no studies have been reported about significance of packaging conditions and chemical treatment to maintain the post-harvest quality of mango. In this study, the experiment was designed to assess the effects of different packaging practices and ethephon treatment on post-harvest of mango and its fruit quality to enhance the ripening process effectively.

MATERIALS AND METHODS

The experiment was conducted at Horticulture Laboratory of the Institute of Agriculture and Animal Science (IAAS), Campus of Live Sciences, Dang district of Nepal during monsoon season of year 2017 (July 10 to July 18). Dang district is located between 27.9904º North latitude and 82.3018º East longitude with an altitude of 725m from the mean sea level and sub-tropical climate. The district covers 2,955 km^2. This location falls in Inner-Terai region of Mid-Western Development Region of Nepal. The site was characterized with rainy season during the experiment. The temperature of laboratory was recorded using Alcohol thermometer and humidity was recorded using hygrometer.

The fruits used were collected from mango orchard of Campus of Live Sciences. Unripe mango with uniform peel colour, size and free from mechanical damage, bruises, sun burns and fungal/insect attack were selected. The fruits were washed with flowing tap water and air dried in laboratory. The experiment was conducted in Completely Randomized Design (CRD) with three replications. Two treatments i.e., with chemical (ethephon in liquid form) and without chemical (control) with two packaging conditions i.e., fiber bag packaging and plastic bag packaging were selected. Four mangoes were kept in each treatment bag. The bags were with or without hole. The holes were made with punching machine (20 holes in each package, size: 13cmx10cm) and placed randomly in laboratory. The fruits were then dipped first in the ethephon 1400 ppm solution as a common treatment for 2 minutes and placed in the laboratory at ambient storage condition. Later the fruits were labeled and packed in the various packaging materials (4 numbers in each bag) and kept according to lot in the laboratory.

Mangoes were evaluated for Titrable Acidity (TA), Total Soluble Solids (TSS), Sugar-acid ratio, Sugar analysis (Benedict's test) and Juice Content. Each data was recorded at 3 days interval up to 8 days.

Titrable acidity

Titrable acidity was determined by the method described by (Ranganna, 1986).

Mango juice was extracted from the sample fruits and blended using juice blender. Then the titrable acidity (TA) was determined. Mango juice (10 ml) was diluted with 20 ml distilled water and then five drops of phenolphthalein was added as an indicator. It was titrated with 0.1N NaOH until the indicator changed pink and then titrate volume of NaOH was recorded. The TA, expressed as citric acid (with equivalent weight of 64.04) using the following formula.

$$\% \text{ Acid} = \frac{(\text{ml NaOH}) \times (\text{N of the base in mol/liter}) \times (\text{Eq. wt. of acid})}{(\text{Sample volume in ml}) \times 10}$$

Where N= Normality

Total soluble solids

Total soluble solids (TSS) of mango juice were measured by a portable hand Refractometer with a range of 0 to 30° Brix and resolutions of 0.2. The brix reading was used to determine TSS by placing 1 to 2 drops of clear juice on the prism of the Refractometer. Between samples reading, the prism of the Refractometer was washed with distilled water and dried with a tissue paper. The brix value of mango was within the range of 10°-14°.

Sugar/Acid Ratio

It was determined by the method described by (Ranganna, 1986).

The °Brix value of the fruit concerned was obtained before calculation of the sugar/acid ratio. The calculations for determining the sugar/acid ratios of all produce are the same, but as some products contain different acids the appropriate multiplication factor must be applied to each calculation. Some products may contain more than one type of acid, it is the primary acid that is tested. For citric acid: 0.0064 (Citrus fruit), which was used to calculate sugar/acid ratio. Following formula was used in calculation:

$$\text{Percentage acid} = \frac{\text{Titre} \times \text{acid factor}}{10 \text{ (ml juice)}} \times 100$$

$$\text{Sugar acid ratio} = \frac{°\text{Brix value}}{\text{Percentage acid}}$$

Benedict's test

Benedict's test was estimated by the procedures described by (Lane and Eynon, 1923).

Benedict's test is used to test for simple carbohydrates. The Benedict's test identifies reducing sugars (monosa1ccharide's and some disaccharides), which have free ketone or aldehyde functional groups. When Benedict's solution and simple carbohydrates are heated, the solution changes to orange red/ brick red. This reaction is caused by the reducing property of simple carbohydrates. The copper (II) ions in the Benedict's solution are reduced to Copper (I) ions, which causes the color change. The red copper (I) oxide formed is insoluble in water and is precipitated out of solution. This accounts for the precipitate formed. As the concentration of reducing sugar increases, the nearer the final colour is to brick-red and the greater the precipitate formed. Sometimes a brick red solid, copper oxide, precipitates out of the solution and collects at the bottom of the test tube.

For this test, approximately 1 ml of sample was placed into a clean test tube. Then, 2 ml (10 drops) of Benedict's reagent ($CuSO_4$) was placed in the test tube. After that, the solution is then heated in a boiling water bath for 3-5 minutes. Finally, color change in the solution of test tubes or precipitate formation was observed. The six stages were represented as 1 = totally green; 2 = <25 % color change; 3 = 25-50 % color change; 4 = >50 % but <100 % color change; 5 =100 % color change; and 6 = color with many black spots. A color chart was used to support the visual or sensory observation.

Statistical Analysis

The mean values of data of different parameters recorded in the study were analyzed by GEN STAT version 10.3 in the computer software. Data were subjected to analysis of variance (ANOVA) to evaluate the significance of treatment effect. Means of each other within the parameters were compared by Duncan's Multiple Range Test (DMRT) at 1% and 5% level of significance. Microsoft excel (2010) was used for tabulation of the data.

RESULTS AND DISCUSSION

TSS, TA, SUGAR/ACID

Data presented in Table 1 indicates that TSS and TA both were found highly significant in case of packaging condition and were found significant in case of chemical treatment (Table 1). Moreover, TSS was higher on ethephon treatment and lower in case of control. This is due to the fact that ripening agent i.e., ethephon accelerates uniform ripening of the textural properties of mango. Untreated fruits exhibited the highest variation in pulp texture due to uneven ripening. On ripening stage, degradation of cell wall and hydrolysis of starch to sucrose becomes fast on ethephon treatment. Reduced respiration also retards softening on plastic bag and slows down various compositional changes such as TSS, which are associated with ripening. The observed increment in TSS of fruits stored on fiber packaging without hole may indicate higher respiration rate and ripening.

Similarly, TA was higher for plastic bag without hole and lower for fiber bag without hole. Also, TA was higher under control and considerably lower on ethephon treatment. In general, the values of TA were the highest at earlier stage of storage indicating that unripe fruits are more acidic than ripen ones.

Sugar-acid ratio was found highly significant on both the cases of chemical treatment and packaging condition. Sugar acid ratio was higher on fiber packaging and comparatively lower in case of plastic without hole. Not only this, ethephon treated bags attained higher value whereas under natural condition i.e., without any chemical treatments the mean score was obtained. At the beginning of the ripening process the sugar/acid ratio is low, because of low sugar content and high fruit acid content, this makes the fruit taste sour. During the ripening process the fruit acids are degraded, the sugar content increases and the sugar/acid ratio achieves a higher value. Mango flavor and taste are related to the level of soluble solids in the fruit, which are mainly sugars.

Table 1. Effect of ripening agents and packaging condition on total soluble solid (TSS), titrable acidity (TA) and sugar acid ratio of mango

Treatments	TSS	TA	Sugar/ acd
Packaging condition (First factor)			
Plastic (without hole)	12.60	1.44	9.01
Plastic (with hole)	13.65	0.98	13.84
Fiber (without hole)	15.26	0.66	23.66
Fiber (with hole)	14.56	0.69	21.80
P	<0.01	<0.01	<0.01
Ripening agent (Second factor)			
Ethephon	14.78	0.837	20.07
Control	13.26	1.054	14.08
P	<0.01	<0.05	<0.01

Sugar test (Benedict's test) and juice content

The effect of ripening agents and packaging conditions on sugar content was found to be highly significant. The amount of reducing sugar was higher in case of Fiber (with hole) treatment. The increase in reducing sugars in mango during ripening could be due to hydrolysis of starch into reducing sugars.

Juice content of mango fruits was found highly significant in both the condition at significance level. In ethephon treatment juice content had the highest mean score which is higher as compared to control condition. Fiber (without hole) contains juice content in greater amount followed by fiber (with hole) (Table 7). Juice content in ethephon treated mango is more because ethephon hasten the ripening process, degradation of cell wall and hydrolysis of starch to sucrose which is more as compared to the controlled situation (No chemical). In the controlled condition there is slow or natural breakdown of the cell wall along with the low or incomplete conversion of starch into the sucrose as compared to the chemical treated.

Table 2. Effect of ripening agents and packaging condition on Benedict's test and juice content

Treatments	BT	Juice content
Packaging condition (First factor)		
Plastic (without hole)	1.66	116.05
Plastic (with hole)	2.33	117.08
Fiber (without hole)	2.5	126.05
Fiber (with hole)	2.83	122.62
P	<0.01	<0.01
Ripening agent (Second factor)		
Ethephon	2.66	123.66
Control	2.0	117.24
P	<0.01	<0.01

Interaction effects

TSS, TA and juice content

Data in Table 3 indicates that Total Soluble Solid of mango was significantly higher on interaction effect of fiber without hole and chemical treatment followed by fiber with hole and chemical treatment while the lower TSS obtained on plastic without hole and under control. Fiber packaging with or without hole accelerates ripening at faster rate and at uniform pattern which is greatly enhanced by ethephon treatment. Thus, we have evaluated that fiber without hole has overall better performances on most of the parameters in comparison with fiber with hole. This might be due to some external as well as internal suitability. Not only this, the aeration in fiber (without hole) might be quite sufficient for uniform ripening as well textural enhancement of mango in comparison with fiber (with hole). There is higher ethylene gas yielding capacity of mango in fiber bag (without hole) due to which it may or may not need holes for smooth operation of physio-chemical properties. Similarly, plastic decelerated ripening which is considered better to upgrade shelf-life of mango and it helps to increase postharvest longevity.

Titrable Acidity was found to be highly significant on interaction effect. However, TA was higher in plastic bag without hole with control and lower in fiber bag without hole with chemical. It was found that, TA was lesser in mangoes treated with chemical (ethephon) than control (without chemical). It is evident from the data that as the days of storage progressed, acidity decreased progressively at ambient conditions. Organic acids are important for respiratory activity and as flavor constituents.

During maturation and ripening, Mango fruit experience a substantial loss of organic acids (Medlicott and Thompson, 1985). This could be attributed to the conversion of acids into sugars and utilization of organic acids during respiration (Srivastava et al., 2000).

Table 3. Interaction effect of ripening agents and packaging condition on Total Soluble Solid (TSS) and titrable Acidity (TA)

Treatments	TSS	TA	Juice content
Packaging condition (First factor)			
Plastic (without hole) + chemicals	12.96	1.22	116.05
Plastic (with hole) + chemicals	14.26	0.97	118.63
Plastic (without hole) + control	12.23	1.67	113.50
Plastic (with hole) + control	13.03	1.01	115.53
Fiber (without hole) + chemicals	16.56	0.58	129.93
Fiber (with hole) + chemicals	15.33	0.58	127.47
Fiber (without hole) + control	13.96	0.74	122.17
Fiber (with hole) + control	13.8	0.79	117.77
P	0.01	0.01	0.01

CONCLUSION

The result of present findings concluded that among all the treatments attempted, postharvest treatment of ethephon with packaging treatment of fiber (without hole) was found excellent in terms of acceleration of uniform ripening. Plastic packaging with control treatment was found to extend post-harvest longevity as significantly higher fruit firmness during storage was observed in it. Moreover, from the above experiment it can be concluded that fiber packaging along with ethephon treatment had a considerable impact on consistent postharvest ripening of mangoes. These treatments not only maintained the fruits qualities, but also reduced post-harvest losses which may be due to spoilage without adversely affecting the organoleptic qualities viz., flavor, texture, taste and overall quality of mango fruits cv. Maldah.

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