



# Influence of Ethephon Treatments on Quality Changes in Dashehari Mango (*Mangifera indica L.*) during Ripening

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### Abstract

Mango fruits require ripening treatment after harvest to hasten ripening and develop ideal eating quality. Present investigations were carried out to elucidate the potential of ethephon as postharvest dip treatment for enhancement of ripening and quality characteristics of 'Dashehari' mango fruits. Freshly harvested fruits were immersed in aqueous solutions of ethephon at 0, 200, 400, 600 or 800  $\mu\text{LL}^{-1}$  and then placed at ambient temperature for ripening studies. Evaluation of physico-chemical parameters was made at 0 (before treatment), 48, 72, 96, 120 and 144 hrs of ripening. Pulp colour was expressed as  $L^*$ ,  $a^*$ ,  $b^*$ ,  $h^\circ$  and  $C^*$  values. Results indicated that fruit firmness declined linearly to the dose of ethephon applied and fruit texture became edible after 72 hrs in ethephon 600 or 800  $\mu\text{LL}^{-1}$  treatments. Total soluble solids increased with ripening of fruits and maximum values were recorded at the end of ripening period. There was consistent decrease in juice acid content of fruits with ethephon applications. Highest dose of ethephon (800  $\mu\text{LL}^{-1}$ ) induced ripening in fruits after 72 hrs of treatment but showed detrimental effect on sensory quality afterwards. However, fruits given 600  $\mu\text{LL}^{-1}$  ethephon dip ripened after 72 hrs after treatments and these fruit maintained excellent quality attributes up to 144 hrs. Ethephon applications exhibited enhancement in colour attributes of fruit pulp in terms of improved redness or yellowness and chroma. The results indicated that dipping mango fruits in 600  $\mu\text{LL}^{-1}$  ethephon developed the superior ripening quality at ambient temperature.

### Keywords

Mango; Ethephon; Ripening quality; Pulp Colour

### Introduction

Mango fruit is known for its high nutritional value, excellent taste, flavor and is recognized as "The king of fruits" [1]. Dashehari is leading commercial cultivar of mango grown in north-western India, due to its high yield potential and superb taste. Depending upon the stage of maturity, fruit can be processed in to juice, pulp, chutneys, pickles and dehydrated mango slices etc. However, 'Dashehari' mangoes is primarily consumed as fresh fruit but due to heterogeneous ripening a wide variation in the eating quality is observed. Mango fruit is harvested at mature, fully green, firm stage before the onset of ripening changes. At this stage fruits are hard in texture, low in TSS, high in acidity with poor taste or flavor and needs ripening treatment to be fit for fresh consumption.

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In common practice fruits are subjected to artificial ripening by the calcium carbide due to low cost and easy availability in the market [2], that decomposes to acetylene and results in poor quality. However, its use is not permitted globally due to risk of explosion and carryover of toxic substances like arsenic and phosphorus to consumers [3]. Hence, there is need to find alternative of calcium carbide to enhance the ripening in mango. Ethylene plays a very important role in regulation of fruit ripening [4]. Ethylene released by the breakdown of Ethrel<sup>®</sup> is the cause of softening of fruit and accelerate the onset of ripening of fruits [5]. An earlier report suggests that ethrel/ethephon (2-chloroethylphosphonic acid) can be used to ripen different varieties of mango fruit *cv.* Amarpali [6], 'Langra' [7] and Ataulfo [8]. So there is a need to identify suitable treatment to induce uniform ripening in 'Dashehari' mango that ensures optimum quality for fresh fruit consumption. Therefore, the present studies were aimed to study effect of ethephon treatments on quality changes of mango fruits during ripening at ambient conditions.

### Materials and Methods

Physiological mature 'Dashehari' mango fruit uniform in size, free from any external defects were harvested from College Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana, India (33°54'N, 75°47'E, 247 amsl) during the year 2014. Fruits were harvested in morning hours with the help of fruit clippers, desapped and immediately shifted to Post Harvest Laboratory of the Department. Selected fruits were immersed in aqueous solutions of ethephon (Ethrel<sup>®</sup>, Sisco Research Laboratories Pvt., Ltd. India) at 0 (control), 200, 400, 600 and 800  $\mu\text{LL}^{-1}$  for five minutes and dried naturally at room temperature. After treatments, fruits were packed in corrugated fibre board boxes and kept at ambient conditions (33  $\pm$  2°C, 40-60% RH). Physico-chemical analysis and colour changes of fruit were determined at harvest and 48, 72, 96, 120 and 144 hours after treatments application. Fruit firmness was recorded by using stand mounted penetrometer (model FT-327, USA) fitted with 8 mm spherical tip. A small portion of fruit peel was removed and firmness was noted from both sides of fruit and expressed in lbf. Soluble solids content (SSC) were determined by digital refractometer (ATAGO, PAL<sup>-1</sup>, model 3810, Japan) by placing one to two drops of juice on prism of the refractometer. Sensory quality of fruits was rated by in house panel of 10 judges on the basis of appearance, flavor, texture and overall acceptability using nine point hedonic scale described by Amerine et al. [9]. Titratable acidity was determined by method given by George and Murphy [10] and expressed as per cent maleic acid. Pulp colour of fruits was recorded as  $L^*$ ,  $a^*$  and  $b^*$  coordinates from opposite positions of each fruit in CIE units using Color Flex spectrophotometer (HunterLab Color Flex, Hunter Associates Inc., Reston, VA, USA) [11]. The values of  $L^*$ ,  $a^*$ ,  $b^*$  were recorded while the hue angle ( $h^\circ$ ) =  $\tan^{-1}(b^*/a^*)$  and Chroma ( $C^*$ ) =  $[a^{*2} + b^{*2}]^{1/2}$  were calculated.  $\beta$ -carotene of fruit pulp was extracted using acetone and petroleum ether by the method described by Ranganna [12]. The colour intensity of  $\beta$ -carotene eluent was measured at 452 nm using petroleum ether as blank.

### Statistical analysis

The experiment was laid out in Completely Randomized Block Design (Factorial) with four replications for each treatment. Ten

fruits per replication were used for the study. Data were analyzed for Analysis of Variance (Proc GLM) using statistical package SAS 9.3 (The SAS system for Windows, Version 9.3, SAS Institute, Cary, NC). Values of different parameters were expressed as the mean  $\pm$  standard error using Tukey's HSD test ( $p < 0.05$ ).

## Results and Discussion

### Effect on fruit firmness

A change in firmness of mango fruit is considered important and reliable indices for determining the extent of ripening. Fruits were hard at harvest and there was gradual loss of firmness with progress of ripening period (Figure 1a). After 144 hrs of treatments, fruit firmness could not be detected with penetrometer used in experiment due to too much softening of flesh. In mango the fruit softening with ripening is because of activity of endo- polygalacturonase [13] and glucanases [14]. A linear reduction in fruit firmness was noted in ethephon treated fruits as compared to control after 48 to 96 hrs of ripening and thereafter no significant changes were observed in fruit firmness among various treatments. Fruit softening was at steeper rate in higher doses of ethephon (600 and 800  $\mu\text{L}^{-1}$ ) and fruits attained optimum ripe stage after 72 hrs while control fruit attained similar softening after 120 hrs of

ripening period. These findings are in close conformity with the earlier results reported by Singh and Janes [15] Gill [7].

### Effect on soluble solids

Soluble solids contents of mango increased consistently with advancement of ripening regardless of treatment and all the treatments reached maximum soluble solids content at the end of ripening period (Figure 1b). However, ethephon treated fruits had significantly higher soluble solids content in contrast to control fruits. Soluble solids content has been positively correlated with sweetness and sucrose [16]. Increased soluble solids may be explained by higher respiration rate and conversion of starch to sugars [17]. Improvement in soluble solids occurred at rapid rate from 0 to 48 hrs of ripening in  $\geq 400 \mu\text{L}^{-1}$  ethephon doses and thereafter, a slow increase in SSC was displayed up to 120 hrs after treatments. By the end of 144 hrs of ripening, difference in soluble solids content among various treatments was not significant. Among various ethephon treatments significantly higher Soluble solid content was observed in higher doses (600 and 800  $\mu\text{L}^{-1}$  ethephon) up to 96 hrs of ripening as compared to other treatments. But there was no significant difference between 600  $\mu\text{L}^{-1}$  and 800  $\mu\text{L}^{-1}$  ethephon treatments at all ripening intervals. These findings are in close conformity with the earlier results reported by Zhang [18].

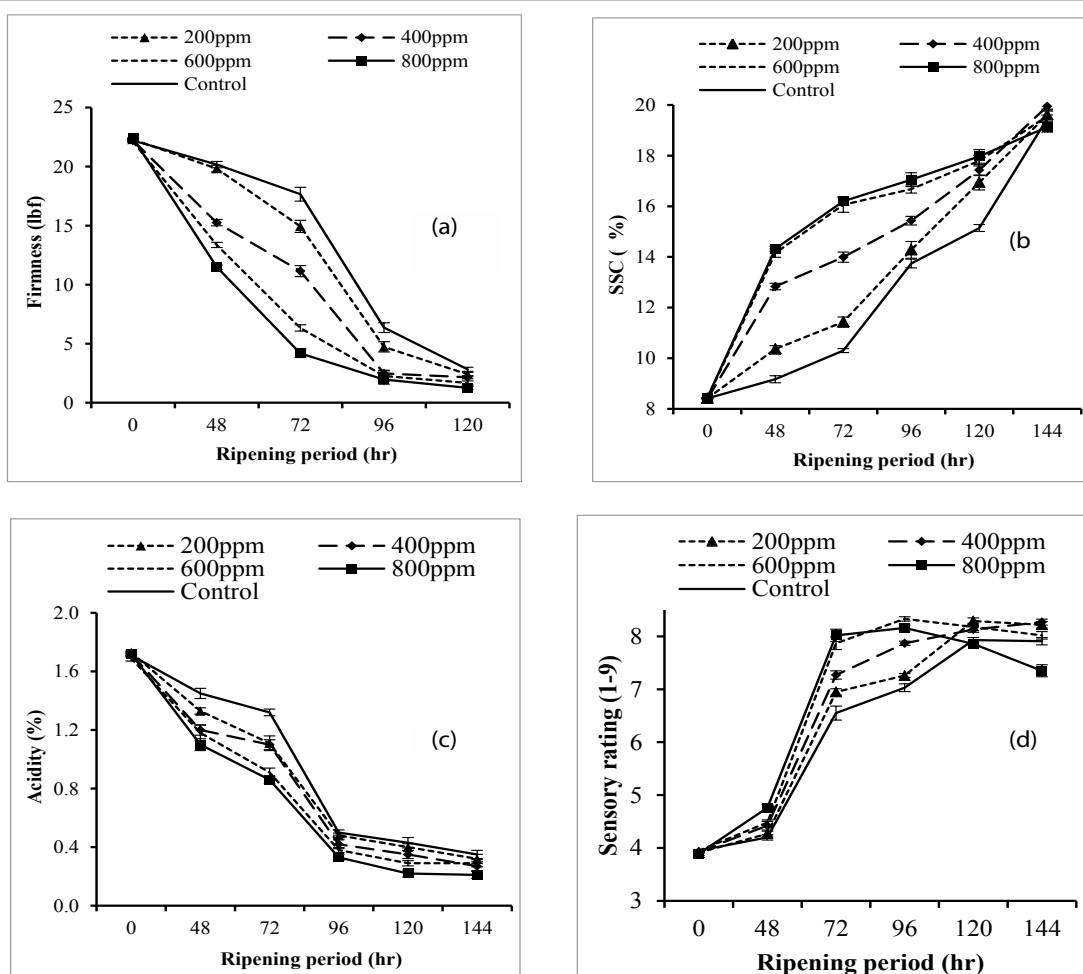
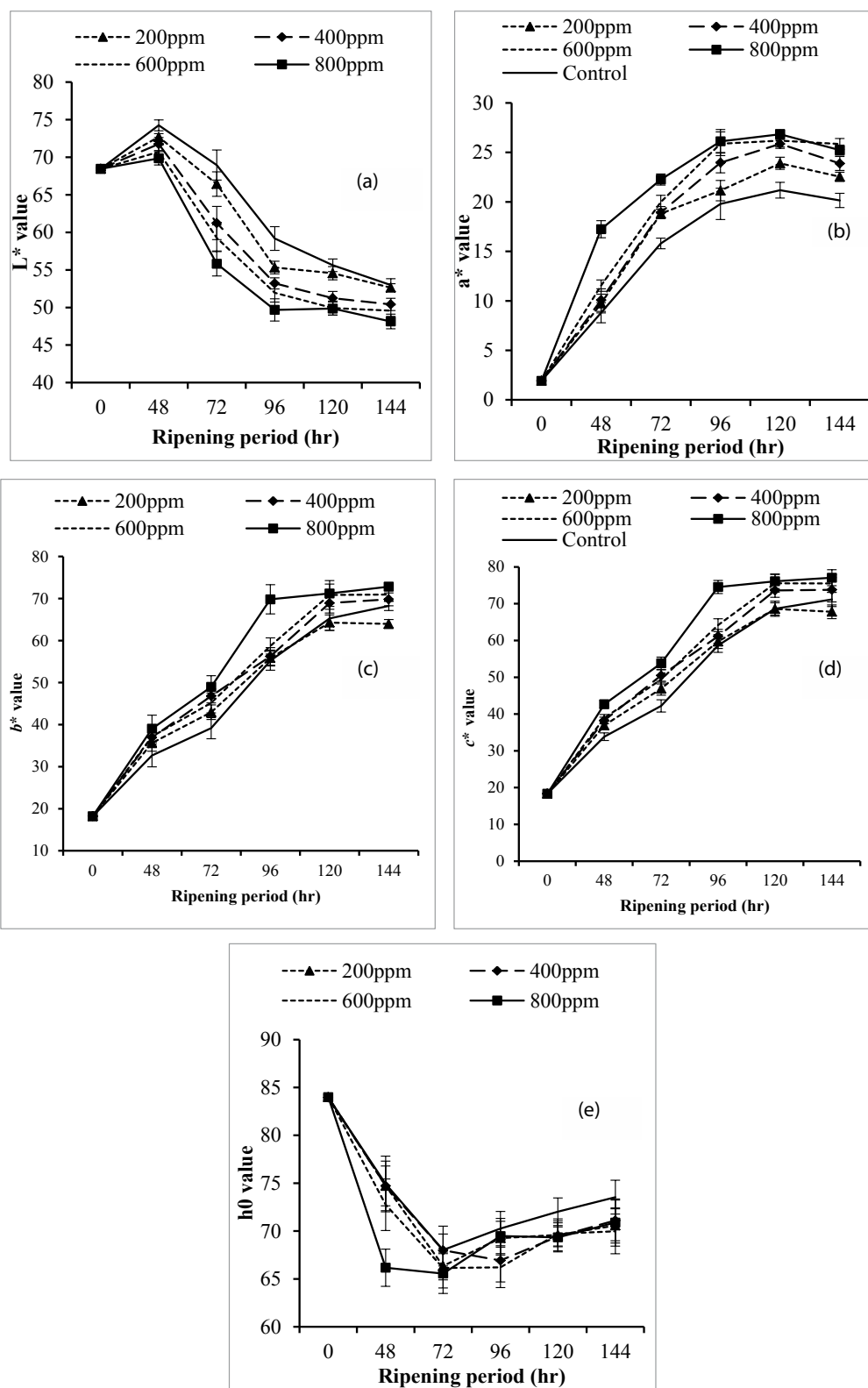


Figure 1: Changes in fruit firmness (a), SSC (b), juice acidity (c) sensory rating (d) of Dashehari mango fruits influenced by ethephon treatments. Vertical bars represent  $\pm$  S.E. of mean (n = 4 replications). Tukey's HSD ( $P < 0.05$ ) for fruit firmness; T=0.53, Ripening period (RP) = 0.53, T x RP = 1.61, for TSS; T= 0.29, RP= 0.33, T x RP=0.99, for acidity; T=0.05, RP= 0.05, T x RP=0.15, for sensory rating T=0.11, RP= 0.12, T x RP=0.36.



**Figure 2:** Changes in L\*: luminosity (a), a\*: redness (b), b\*: yellowness (c), chroma : C\* (d) h<sup>0</sup> : hue angle (e), of Dusehari mango fruits influenced by ethephon treatments. Vertical bars represent  $\pm$  S.E. of mean (n = 4 replications). Tukey's HSD (P<0.05) for L\*: T=1.74, RP= 1.99, T x RP = 5.92, for a\*: T= 1.21, RP= 1.39, T x RP=4.13, for b\*: T=3.32, RP= 3.80, T x RP=11.30, for C\*: T=2.68, RP= 3.07, T x RP = 9.12, for h<sup>0</sup>: T= 2.97, RP= 3.41, T x RP=10.12.

### Effect on titratable acidity

Changes in titratable acidity in ethephon treated and control mango fruits are summarized in Figure 1c. A consistent and significant decline in acid content was exhibited with ripening period in all treatments including control. Mean acid content of fruits at harvest was 5.8 times higher than at the end of ripening period (144 hrs). This decrease might be due to utilization of organic acids as substrates for respiration [19]. Acidity was higher in control fruits throughout the ripening period. Higher doses of ethephon led to sharp reduction in acid content up to 96 hrs of ripening while in control this decrease was steady till 72 hrs followed by steep drop upto 96 hrs after application of treatments. Afterwards, the differences in titratable acid content were narrowed down and at 144 hrs no statistical variation were seen among various ripening treatments. Similar results were documented by Dhillon and Mahajan [20] in pear fruits, who recorded a decrease in acid content with fruit ripening.

### Effect on sensory quality

The mango fruits were inedible at the time of harvest and eating quality improved with ripening in all treatments. Ethephon treatments contributed to develop better organoleptic quality of fruits in terms of decreased flesh firmness, improved appearance, colour and taste. After 72 hrs of ripening, fruits immersed in ethephon 800  $\mu\text{LL}^{-1}$  developed very much desirable eating quality followed by 600  $\mu\text{LL}^{-1}$  ethephon treatments, while the control fruits after the same time had inferior sensory quality (Figure 1d). However, fruit quality in highest dose of ethephon declined significantly at the end of ripening studies and during this stage 200 to 600  $\mu\text{LL}^{-1}$  ethephon doses resulted in very good edible quality attributes. The development of better fruit quality with ethephon treatments might be due to reduction of fruit firmness, increase in soluble solids content and decrease in acidity. Improvement in eating quality of mango fruits with ethephon application have also been reported earlier in 'Kensington Pride' [15] and 'Amarapalli' mango fruits [6].

### Effect on pulp colour

Changes in pulp colour of 'Dashehari' mango fruits with ripening are presented as  $L^*$  (luminosity or lightness),  $a^*$  (redness),  $b^*$  (yellowness),  $C^*$  (chroma value) and  $h^o$  (hue angle) in Figure 2a-e. A decrease in  $L^*$  values of pulp were recorded with ripening of mango fruits. This decrease was significant from 48 to 96 hrs of ripening afterwards slower decline of luminosity was recorded up to 144 hrs of ripening. Ethephon treated fruits recorded higher rate of decrease in  $L^*$  values of pulp as compared to control fruits. The intensity of redness ( $a^*$ ) in pulp colour increased with increase in ethephon dose and with an advancement of the ripening period. Similar change in pulp colour of mango was observed in 'Irwin' mangoes [21]. A significant increase in  $a^*$  values was observed from 0 hrs to 72 hrs of ripening period in ethephon treated as well as control fruits followed by steady increase upto 120hrs of ripening period. However, a slight decline in ' $a^*$ ' values were recorded at the end of ripening period. Similar to ' $a^*$ ' parameter, the ' $b^*$ ' values of pulp colour showed continuous increase in the values with the advancement of ripening period and ethephon dose. Exogenous application of ethephon has been reported to improve fruit colour in mango [22,23]. Significant increase in  $C^*$  values (saturation) of fruit pulp was observed for all ethephon treated and control fruits upto 120 hrs of storage. Maximum  $C^*$  value during entire ripening period was observed in fruits treated with ethephon @800 ppm. The  $h^o$  angle values of fruit pulp showed non-significant

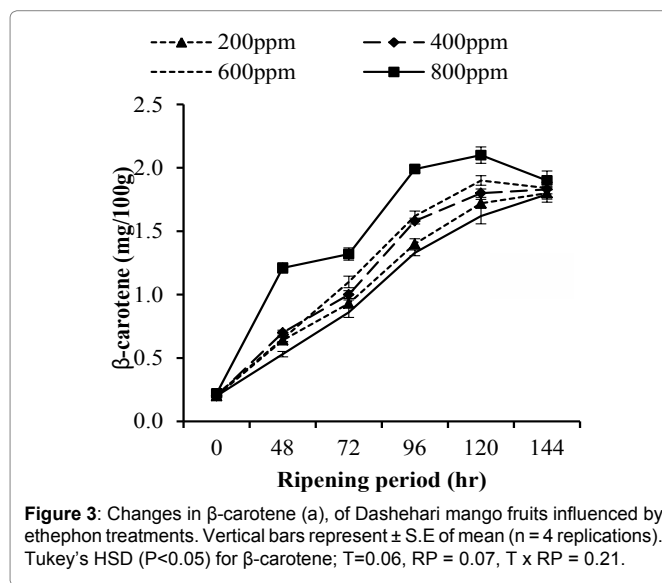


Figure 3: Changes in  $\beta$ -carotene (a), of Dashehari mango fruits influenced by ethephon treatments. Vertical bars represent  $\pm$  S.E of mean (n = 4 replications). Tukey's HSD (P<0.05) for  $\beta$ -carotene; T=0.06, RP = 0.07, T x RP = 0.21.

difference in the treated and control fruits. However, during entire ripening period, maximum  $h^o$  values were observed for control fruits.

### Effect on $\beta$ -Carotene

Various ethephon treatments significantly improved  $\beta$ -carotene of fruit pulp (Figure 3). Increase in carotenoids is associated with an almost complete loss of chlorophyll due to which there is loss of green colour and the development of yellow colouration [24]. A significant increase in  $\beta$ -carotene was recorded in all the treated and control fruits up to 120hrs, except for fruits treated with ethephon @800 ppm, in this treatment increase was observed up to 96hrs of ripening. Maximum  $\beta$ -carotene content was recorded in fruits treated with ethephon @ 800 ppm while the minimum was observed in control fruits during entire ripening period.

It can be concluded that ripening in 'Dashehari' mango fruits can be enhanced with post-harvest dip of ethephon at ambient conditions. However, early ripening with very much desirable quality and longer post ripening life was found in fruits treated with ethephon @ 600  $\mu\text{LL}^{-1}$ .

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