Original research paper

Evaluation of the Effect of Ethephon on Ripening Time, Shelf Life, Physico-chemical Properties and Nutritive Value of Tomato (*Lycopersicon esculentum*)

ABSTRACT

Aims: The aim of this study is to determine the effects of ethephon on ripening time, shelf life, physico-chemical properties (total soluble solid and titratable acidity) and nutritive value (moisture, protein, carbohydrate, ash, fat, crude fiber, vitamin C, β-carotene, sodium, potassium, calcium and magnesium content) of tomato.
Study design: Selected tomatoes were divided into two experimental groups namely control (non-treated) and ripened by ethephon. In cases of non-treated, tomatoes were kept in bamboo basket and covered with straw. Two to four samples were taken from each group for experiment. Each experiment was replicated for three times.
Place and Duration of Study: The study was conducted in the laboratory of the Department of Applied Food Science and Nutrition, Department of Food Processing and Engineering, Department of Applied Chemistry and Chemical Technology of Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh. It was conducted for a period of six months from 1st January, 2018 to 30th June, 2018.
Methodology: TSS (Total Soluble Solid) was determined by using hand refractometer, proximate composition by standard AOAC method, vitamin C and β-carotene by UV-spectrophotometric method, sodium and potassium by flame photometric method, titratable acidity, calcium and magnesium by titremetric method. To compare differences in control and treated group, significant difference was considered at the level of $P<0.05$.
Results: Ethephon treated tomatoes ripen quickly with attractive surface color and had shorter shelf life than non-treated tomatoes (control). Physico-chemical properties including total soluble solid and titratable acidity increased significantly ($P<0.05$) in treated group (4.66±0.57°B; 0.32±0.01% respectively) than control (3.33±0.57°B; 0.28±0.01% respectively). Moisture content also significantly ($P<0.05$) increased in ethephon treated tomato (94.15±0.27g/100g) than non-treated (85.54±0.23g/100g). But significantly lower amount of carbohydrate, ash, crude fiber were observed in artificially ripened tomato by ethephon (2.5±0.45g/100g; 0.51±0.02g/100g; 0.82±0.03g/100g respectively) than naturally ripened (3.7±0.26g/100g; 0.59±0.01g/100g; 0.90±0.01g/100g respectively). Apparently protein and fat content were found insignificantly less amount in artificially ripened tomato by ethephon. The significant lowest concentration of vitamin C and β-carotene were observed in ethephon ripened tomato (16.65±0.01mg/100g; 413.33±1.15µg/100g respectively). Mineral contents of ethephon treated tomato (Na 3.65±0.47mg/100g; K 199±1.00mg/100g; Ca 4.75±0.07mg/100g; Mg 8.57±0.19mg/100g) found significantly ($P<0.05$) fewer amounts than control tomato (Na 3.96±0.01mg/100g; K 213.67±0.57 mg/100g; Ca 5.57±0.15mg/100g; Mg 9.96±0.04mg/100g).
Conclusion: Application of ethephon on tomato hastens ripening time and physico-

chemical properties but reduces shelf life and nutritive value of tomato.

Keywords: Ethephon; tomato; nutritional quality; ripening time; shelf life.

1. INTRODUCTION

Fruits and vegetables are generally rich sources of vitamins, minerals and phytochemicals, dietary fibers, carotenoids and polyphenols [1-3]. Tomato (*Lycopersicon esculentum*) is the most important vegetable of the world including tropical, sub-tropical and temperate regions [4]. It is also widely used by food industries as a raw material for the production of different products such as puree or ketchup. Tomato is also the most common vegetable in the Mediterranean diet, a diet known for its health, especially as regards the development of chronic degenerative diseases [5]. Worldwide tomato ranks third in area and production after potato and sweet potato but ranks first among processed vegetables [4]. Tomato is one of the most important and popular vegetables in Bangladesh with a considerable total production of 3,88,725 metric tons produced in an area of 68,366 acres [6].

Tomato is a rich source of vitamin A and C and is known as "poor man's orange". Among fruits and vegetables, tomatoes occupy the 16th place as a source of vitamin A and the 13th as a source of vitamin C. Lycopene, which gives the red color to ripe tomatoes, has anti-tumor properties. It also serves as an antioxidant because the β-carotene present in tomato helps to prevent and neutralize free radical and ascorbic acid acts as an effective eliminator of superoxide, hydrogen peroxide, singlet oxygen and other free radicals [4].

The color and quality of ripe tomatoes are important considerations for the consumer and for the commercial producer. During the period of growth and development, there are many chemical and physical changes in the tomato that have an impact on the quality of the fruit and on the ripening behavior after harvest. The ripening of the tomato is characterized by the loss of chlorophyll and the rapid accumulation of carotenoids, especially lycopene, since chloroplasts become chromoplasts [7].

Ripening is a natural process that brings a series of biochemical changes that are responsible color changes, changes in respiration rate, changes in the rate of ethylene production, changes in tissue permeability, softening, changes in the composition of carbohydrates, changes in organic acids, changes in proteins, production of volatile compounds in the skin etc [8]. For the prevention of postharvest losses, calcium carbide (CaC_2), ethylene (C_2H_2), ethephon ($C_2H_6ClO_3P$) and other non-recommended pesticides are used for the ripening of immature fruits quickly with a nice color. Today some growers and traders in Bangladesh, use some chemicals like Ripen, Gold-Plus, Profit etc. for the ripening of various fruits such as tomato, papaya and banana directly in the fields and in the processing areas [9]. Scientific literature indicates that ethrel or ethephon (2-chloroethylphosphonic acid) is a potential chemical that can be used to ripen fruit [10]. In application, this chemical penetrates into the fruit and decomposes into ethylene.

Bangladesh faces the typical problem of using artificial ripening agents like ethephon. Dishonest traders are using ripening agent in fruits to accelerate the ripening of climacteric fruits such as mango, banana, papaya, jackfruit etc. Ethephon is known as ripening agent frequently used in quick ripening of fruits. Ethephon ripened fruits have more acceptable colour than naturally ripened fruits. Ethephon treated samples had highest extent of moisture content as compared with the control samples [11]. Ethephon treatment causes a significant increase in fruits weight due to the excess moisture formation [12].

Generally farmers apply artificial ripening agent namely ethephon in tomato due to provide a fresh look and nice uniform color that attract the consumer. The another reason of using such ripening agents is to reduce post harvest losses and losses during transportation because of lacking of proper preservation technique of transportation from producer to consumer. During transportation, if ripened tomatoes are carried, these becomes bruised and losses the acceptable characteristics. But if mature green tomatoes are used for transportation these doesn't bruised. So farmers prefers to transport green tomatoes for supplying different parts of the country and then applying ethephon two to four days ago before selling. Becase ethephon accelerates the ripening of green tomatoes. So artificial ripening process is accelerated.

For commercial agriculture, accelerated ripening of fruit is recommended worldwide for uniform ripening, flavor and quality. In the developed country, ethylene gas is used to accelerate the ripening of climacteric fruits. This is healthy and does not pose a threat to human health. Furthermore, in Bangladesh, ethephon, are sprayed on tomato by farmers whose doesn't not have proper knowledge to apply proper amount of ethephon at proper stage. Hence nutritional quality deteriorates. Though tomatoes are the source of micronutrient but ethephon which is used as ripening agent in tomatoes have effects on the nutritional quality of fruits. Considering the forgoing problem, the present section describes the effects of ethephon on the changes of ripening time, shelf life, physico-chemical properties and nutritional composition (carbohydrate, protein, fat, fiber, ash, crude fiber content and vitamin, mineral) in tomato. It is necessary to put forward recommendations to the policy makers to develop strategic national plan to maintain the fruits quality in the supply chain.

2. MATERIAL AND METHODS

2.1 Collection of Sample

Fresh tomatoes were collected directly from production field of Khulshi and Oxygen area of Chittagong into clean polythene bags and transported to the laboratory for analysis.

2.2 Pre-treatment of Samples

The skin (body) of tomatoes were washed gently with distilled water and then cleaned properly with cotton cloth to remove dust, adhered particles and agricultural chemicals. Then tomatoes were stored in a cool and dry place.

2.3 Treatment by Ethephon

For ethephon solution, selected tomatoes were dipped into 1000 ppm aqueous solution for 10 minutes. Then tomatoes were air dried before packing in cardboard/cartoon. Selected tomatoes were stored at room temperature [13].

2.4 Determination of Ripening Time

In order to determine days required for ripening, tomatoes were daily observed for their colour and the time (days) required to reach light red to 60 - 90% fully red ripe stage for tomato [14].

2.5 Determination of Shelf Life

The shelf life was calculated by counting the days required to attain the last stage of ripening but up to the stage when tomato remained still acceptable for marketing [14].

2.6 Determination of Total Soluble Solid (TSS)

The total soluble solid content was recorded with the help of a portable refractometer. The crushed tomato pulp was placed in the prism of the refractometer and the readings were observed through the eyepiece. For a precise measurement, the readings taken were corrected for temperature variations at 20°C and the results were expressed as °Brix (°B) [15].

2.7 Determination of Titratable Acidity

A known weight of the crushed tomato sample was taken in a 100 ml volumetric flask and the volume was made up by the addition of distilled water. After filtration, 10 ml of the filtrate was taken in a separate conical flask and then titrated against 0.1 N sodium hydroxide using phenolphthalein as an indicator. The end point was determined by the appearance of a faint pink colour. Then titratable acidity was calculated [15]. The titratable acidity was determined by using the following formula

$$\text{Titratable acidity\%} = \frac{\text{Eq. wt of acid} \times \text{Normality of NaOH} \times \text{Volume of acid} \times \text{Titre value}}{\text{wt of sample} \times \text{volume of sample} \times 1000} \times 100$$

2.8 Determination of Proximate Composition Analysis

The moisture content, protein, fat, ash, crude fiber of the experimental groups were measured in triplicate using the standard AOAC methods [16].The moisture was measured by oven drying at 105°C to constant weight, crude protein content by the Kjeldahl procedure (6.25 × N), total fat by extraction of ether, Ash by incineration in a muffle furnace at 550°C to constant weight. Crude fiber was measured by digesting the sample. Carbohydrate content were calculated by difference method i.e

%Carbohydrate = 100 - (%Moisture + %Protein + %Fat + %Ash +%Fiber)

2.9 Determination of Vitamin C

Vitamin C were determined by UV visible spectrophotometric method, as described by Rahman et al. [17].

2.10 Determination of β-Carotene

β-carotene were analyzed by UV-spectrophotometric method, as described by Karnjanawipagul et al. [18].

2.11 Determination of Minerals

Sodium (Na) and potassium (K) content were determined by using flame photometer [19]. Sodium and potassium in solution was atomized into an oxy-hydrogen flame that exits atoms of sodium or potassium, causing them to unit radiation to specific wavelength. The amount of radiation emitted is measured on a flame photometer, under standard condition which is proportional to the concentration of sodium or potassium. Calcium (Ca) and magnesium (Mg) content were analyzed by using titrimetric method [19].

2.12 Statistical Analysis

Data collected in this study was analyzed using MS Excel, 2007 and SPSS (Statistical Package for the Social Sciences) version 22.0. *P* value was used to compare differences in the means of the ripening time, shelf life, total soluble solid (TSS), titratable acidity, moisture, protein, fat, carbohydrate, ash, crude fiber, vitamin C, β-carotene and minerals. A significant difference was considered at the level of $P<0.05$.

3. RESULTS AND DISCUSSION

3.1 Effect of Ethephon on Ripening Time and Shelf Life of Tomato

Results of the effect of ethephon on ripening time and shelf life were shown in table 1. Significant differences ($P<0.05$) were observed in ripening time and shelf life of tomato those were ripened artificially with ethephon than those were ripened naturally or control group.

Ethephon was more effective in early ripening as compared to control tomato. In the present study, the untreated normal tomatoes were ripened in 5 days after harvest. But the treated tomatoes were ripened in 2 days after harvest. It clearly indicated that ethephon was more effective in early ripening of tomatoes as compaired to untreated. Hakim et al. [9] found that, ethephon solution was more efficient in hastening tomato ripening and the concentrations of 250, 500, 750 and 1000 ppm ethephon reduced the ripening time in tomato.

Mature green tomato had a higher storability than ethephon treated tomato. According to the present study, ethephon levels had also significant ($P<0.05$) effect on shelf life of tomatoes. The shelf life of control and ethephon treated tomato were recorded 15 days and 5 days respectively. Similar types of study conducted by Hakim et al. [9]; Sang and Kwan [20]. Hakim et al. [9] found that high treatment on fruits required less shelf life while lower dosage required longer shelf life indicating high dosage treatment samples reacted rapidly with fruit samples and quick ripening led to spoilage. Sang and Kwan [20] revealed that ethephon application on fruits induced symptoms of tissue degeneration hence physico-chemical changes also occurred.

Table 1. Comparison of ripening time (days) and shelf life (days) between control and ethephon treated tomato

Sample	Variable (Days)	Control	Ripened by ethephon	*P*-value
Tomato	Ripening time	5.3±0.57	2.3±0.57	0.003*
	Shelf life	14.67±0.57	4.66±0.57	0.000*

**Statistically significant at 5% level*

Results are means ± standard deviation (SD) of triplicate

3.2 Effect of Ethephon on Physico-chemical Parameter of Tomato

In the present study, the total soluble solid and titratable acidity content of ethephon treated tomato was represented at table 2.

Total soluble solid (TSS) content of tomato pulp varied significantly ($P<0.05$) in control and ethephon treated. Ethephon ripened tomato contained the highest quantity of TSS 4.66±0.57°B while it was the lowest 3.33±0.57°B in control or naturally riped tomatoes. This is in consonance with the results of Moniruzzaman et al. [14]; Moneruzzaman et al. [21] and Helyes et al. [22].

Significant ($P<0.05$) changes of titratable acidity was found in ethephon treated sample. Ban et al. [23] showed that ethephon application stimulated the decrease in titratable acidity. In the present study, the ethephon treated tomato pulp gave the higher titratable acidity

(0.32±0.01%) than control (0.28±0.01%). This result corroborates the results of Hakim et al. [9]; Moniruzzaman et al. [14]; Moneruzzaman et al. [21].

Table 2. Comparison on physico-chemical parameter between control and ethephon treated tomato

Sample	Variable	Control	Ripened by ethephon	*P*-value
Tomato	Total soluble solid (°B)	3.33±0.57	4.66±0.57	0.047*
	Titratable acidity (%)	0.28±0.01	0.32±0.01	0.004*

**Statistically significant at 5% level*

Results are means ± standard deviation (SD) of triplicate

3.3 Effect of Ethephon on Proximate Composition of Tomato

The moisture content was increased in tomatoes those were artificially ripened after the treatment by ethephon; other proximate compositions were decreased in ethephone treated tomatoes presented in table 3. The results were significant (P<0.05) for the moisture, carbohydrate, ash and crude fiber in tomato ripened by the ethephon.

Moisture content increased from 85.54±0.23g/100g to 94.15±0.27g/100g respectively in control and ethephon treated tomato. This result is similar with Hakim et al. [9] and Shadan and Gholamhossein [12]. Hakim et al. [9] observed that the ethephon treated samples had highest extent of moisture content as compared with the control samples. Shadan and Gholamhossein [12] revealed that ethephon treatment causes a significant increase in fruits weight that is the result of the excess moisture formation.

The protein content of the control or naturally ripened tomato was 1.24±0.05g/100g. This reduced in ethephon treated ripe tomato 1.17±0.02g/100g. Similar results of protein content was observed by Hakim et al. [9] and Rabaya et al. [24]. Hakim et al. [9] revealed that, the protein among ethephon treated tomato, banana, pineapple was reduced than control group.

Ethephon ripen tomato contained the lowest quantity of fat 0.27±0.02g/100g while it was the 0.31±0.02g/100gm in control or naturally ripened tomatoes. This is similar with Hakim et al. [9]; Rabaya et al. [24]. Hakim et al. [9] observed negligible fat content in ethephon treated and control tomato, banana and pineapple.

The carbohydrate content of the control or naturally ripened tomato was 3.7±0.26g/100g. This reduced in ethephon treated ripe tomato 2.5±0.45g/100gm.

The ash content in tomato pulp varied significantly (P<0.05) in control and ethephon treated. In the present study, the ethephon treated tomato pulp gave the lower ash content (0.51±0.02g/100g) than control (0.59±0.01g/100g). This result corroborates the results of Hakim et al. [9]. Hakim et al. [9] reveled that total mineral content (ash) varies from 0.61 to 0.95% in pineapple, from 0.93 to 0.97% in banana and from 0.55 to 0.61% in tomato.

The fiber content of the control or naturally ripened tomato was 0.90±0.01g/100g. This reduced in ethephon treated ripe tomato 0.82±0.03g/100g. Similar finding was reported by Rabaya et al. [24] for banana.

Table 3. Comparison on proximate composition between control and ethephon treated tomato

Sample	Variable (g/100g)	Control	Ripened by ethephon	*P*-value
Tomato	Moisture	85.54±0.23	94.15±0.27	0.000*
	Protein	1.24 ±0.05	1.17±0.02	0.361
	Fat	0.31±0.02	0.27± 0.02	0.063
	Carbohydrate	3.7±0.26	2.5±0.45	0.017*
	Ash	0.59±0.01	0.51±0.02	0.005*
	Crude Fiber	0.90±0.01	0.82±0.03	0.012*

**Statistically significant at 5% level*

Results are means ± standard deviation (SD) of triplicate

3.4 Effect of Ethephon on Vitamin C and β-Carotene of Tomato

Vitamin C and β-carotene were decreased significantly (*P*<0.05) in tomato after ripened artificially by ethephon that was represented at table 4. In this research vitamin C content were 20.28±0.01mg/100g and 16.65±0.01mg/100g respectively in naturally ripened and artificially ripened tomato. This is similar with Hakim et al. [9] and Moneruzzaman et al. [21]. Hakim et al. [9] observed that non treated control tomato contained high amount of ascorbic acid (20.2mg/100g tomato) whereas ethephon treated groups contained the ascorbic acid 19.4mg/100g in tomato. Ascorbic acid content of fruits and vegetables decreases even in proper storage treatment due to the prolonged duration [9]

Control or naturally ripend tomato contained 433.00±2.64μg/100gm β-carotene while the ethephon treated tomato contained 413.33±1.15μg/100gm. Similar results also found by Hakim et al. [9].

Table 4. Comparison on vitamin C and β-carotene between control and ethephon treated tomato

Sample	Variable	Control	Ripened by ethephon	*P*-value
Tomato	Vitamin C (mg/100g)	20.28±0.01	16.65±0.01	0.000*
	β-carotene (μg/100gm)	433.00±2.64	413.33±1.15	0.000*

**Statistically significant at 5% level*

Results are means ± standard deviation (SD) of triplicate

3.5 Effect of Ethephon on Mineral Contents of Tomato

Effects of ethephon on mineral contents of tomato were shown on table 5. The analysis of data revealed that application of artificial ripening agent ethephon significantly (*P*<0.05) lower the mineral contents in tomato than naturally ripened. The content of sodium, potassium, calcium and magnesium were significantly reduced in ethephon treated tomato (3.65±0.47mg/100g, 199±1.00mg/100g, 4.75±0.07mg/100g and 8.57±0.19mg/100g respectively) than control (3.96±0.01mg/100g, 213.67±0.57mg/100g, 5.57±0.15mg/100g and 9.96±0.04mg/100g respectively). This result is similar to Hakim et al. [9] and Mahmood et al. [25]. Mahmood et al. [25] reported that artificially ripened fruits contain less mineral contents then naturally ripened.

Table 5. Comparison on mineral contents between control and ethephon treated tomato

Sample	Variable (mg/100g)	Control	Ripened by ethephon	*P*-value
Tomato	Na	3.96±0.01	3.65±0.47	0.000*
	K	213.67±0.57	199±1.00	0.000*
	Ca	5.57±0.15	4.75±0.07	0.001*
	Mg	9.96±0.04	8.57±0.19	0.000*

**Statistically significant at 5% level*

Results are means ± standard deviation (SD) of triplicate

4. CONCLUSION

This study revealed that, selected tomatoes ripened with ethephon provides attractive uniform color, quick ripening time and higher physico-chemical parameter (total soluble solid, titratable acidity) but lower shelf life than control group. Other nutrient compositions were decreased except moisture content. Apart from this, most of the nutrients are significantly found in low in amount (carbohydrate, ash, fiber, vitamin C, β-carotene, sodium, potassium, calcium and magnesium) in ethephon treated tomato. So application of ethephon in tomato should be monitored properly and governments should take proper action against this. Not only governments but also producers and consumers should be aware about considering the aspects of using ethephon in tomato.

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