EFFECTS OF MATURITY STAGES AND ETHREL ON THE RIPENING AND QUALITY OF TOMATO

B.M. SAIDUR RAHMAN

DEPARTMENT OF HORTICULTURE AND POSTHARVEST TECHNOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

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By

B.M. SAIDUR RAHMAN
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Approved by:

Dr. Satya Ranjan Saha
Supervisor

Dr. Nazrul Islam
Co-supervisor

Dr. Nazrul Islam
Chairman of the Department

কৃষি গবেষণা

বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউট

Bangladesh Agricultural Research Institute

Joydebpur, Gazipur-1701
Bangladesh

Fax : 880-2-9353395
Tel. 880-2-9332340
PABX: 9252091
E.mail: baridg@bttb.net.bd
barires@bttb.net.bd

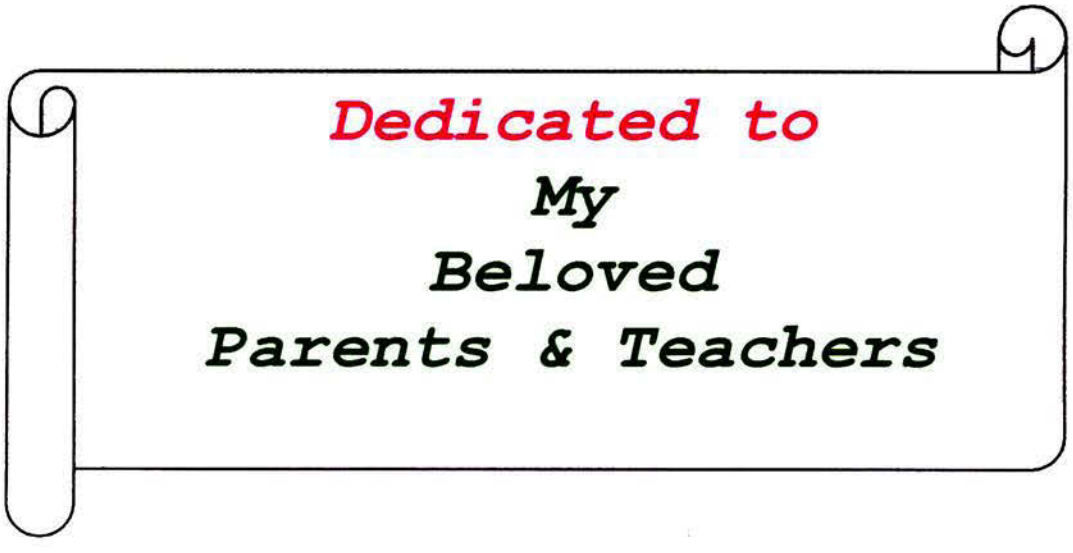
CERTIFICATE

This is to certify that the thesis entitled, "*EFFECTS OF MATURITY STAGES AND ETHREL ON THE RIPENING AND QUALITY OF TOMATO*" submitted to the Faculty of Agriculture, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S)* in *HORTICULTURE* embodies the result of a price of bona fide research work carried out by *B.M. SAIDUR RAHMAN* Registration No. *01513* under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:
Place: **Gazipur, Bangladesh**

(Dr. Satya Ranjan Saha)
Supervisor


Dedicated to
My
Beloved
Parents & Teachers

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ABSTRACT

An experiment was conducted at the laboratories of the Plant Physiology section of the Horticulture Research Centre (HRC) and Post Harvest Laboratories under the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during the period from January to March 2005 to study the effects of different stages of maturity and different concentration of ethrel treatments on changes in ripening and quality of tomato fruits during the postharvest storage. Fruits of three maturity stages viz. mature green, breaker and half-ripe were treated under three ethrel concentrations viz. control, 500 ppm ethrel and 1000 ppm ethrel.

Different maturity stages, ethrel treatments and their combinations showed the highly significant variation on ripening and quality of tomato. The half ripe tomato treated with 1000 ppm ethrel gave quick colour development (3.00 days) and the highest vitamin-C (12.46 mg/100g tomato pulp), titrable acidity (0.456%) reducing sugar (4.50%), non-reducing sugar (1.70%), total sugar (5.07%) and TSS (5.50%) at final day of observation and the mature green tomato treated with 1000 ppm ethrel showed maximum days of shelf life (37.00 days) and showed the highest pH (4.71) at the 500 ppm ethrel treatment. On the other hand, the mature green tomato under control treatment showed the highest weight loss (14.92%) at the final day of observation. The mature green tomato under control conditions showed the delay colour development or ripening (15.00 days) and the lowest vitamin-C (3.68 mg/100g tomato pulp), reducing sugar (3.85%) and TSS (4.49%) at the final day of observation. Half ripe tomato treated with 1000 ppm ethrel showed the lowest weight loss (14.00%), pH (4.26) and non-reducing sugar at the final day observation and green mature tomato treated with 500 ppm ethrel showed the lowest titrable acidity (0.443%) and total sugar (4.73%) and half ripe tomato with control treatment showed the lowest shelf life (20.00 days).

From the investigation, it may be concluded that for early ripening half-ripe tomato treated with 1000 ppm ethrel is the best and to extend the shelf life, mature green tomato treated with 1000 ppm ethrel is the best. On the other hand, weight loss and other physio-chemical characteristics were found to be the highest when half-ripe tomatos were treated with 1000 ppm ethrel.

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ABBREVIATIONS AND ACRONYMS

SAU	Sher-e-Bangla Agricultural University
BARI	Bangladesh Agriculture Research Institute
HRC	Horticulture Research Centre
BBS	Bangladesh Bureau of Statistics
°C	Degree Celsius
TSS	Total Soluble Solid
RH	Relative Humidity
IPGRI	International Plant Genetic Resources Institute
FAO	Food and Agriculture Organization
DS	Days of Storage
DMRT	Dancun`s Multiple Range Test
g	Gram
NS	Non significant
N	Normality
ppm	Parts per million
ml	Mililitre
ha	hectare

CHAPTER 1
INTRODUCTION

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most universally known, widely consumable nutritious and widely grown vegetable in the world. It is native to the Peruvian and Mexican region (Rick and Butler, 1956) and was introduced in this sub-continent during the British period.

The crop is one of the most popular and important vegetables in Bangladesh with a considerable total production of 119935 metric tons produced in an area of 17925.10 ha. (BBS, 2005). The best growing areas of tomato in Bangladesh are Chittagong, Comilla and Rajshahi (Sharfuddin and Siddique, 1985). Quality of produce encompasses sensory attributes, nutritive values, chemical constituents, mechanical properties, functional properties and defects. Its food value is greatly dependent on its chemical composition, such as dry matter, titrable acidity, total sugar, total soluble solid and ascorbic acid which facilitates development of postharvest quality, intrinsic quality such as flavour and taste, transportability and processing. Study in United States indicated that flavor and taste of tomato are related to free sugars, organic acids and sugar acid ratio (Kader *et. al.* 1978).

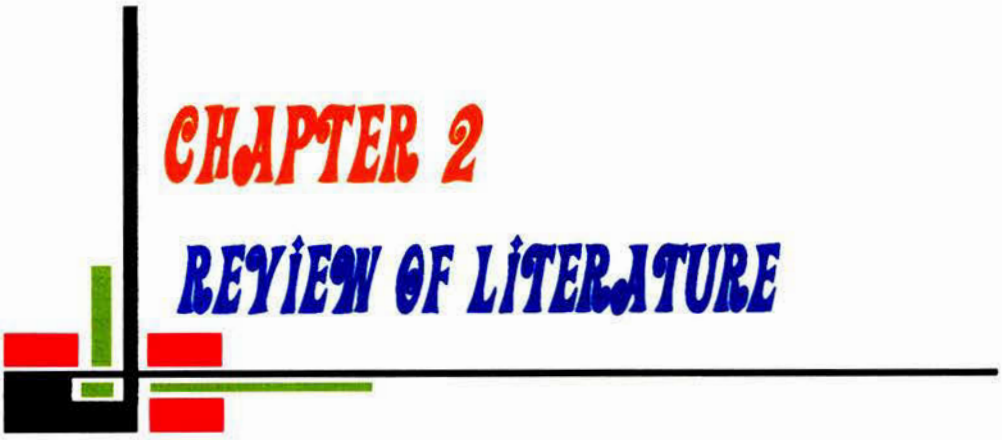
Tomato is grown in Bangladesh mainly during winter season. Tomato growers are often confronted with plenty of the problems. Bumper harvest over a narrow period of time caused a glut in the market with the resultant poor returns. One of the methods of achieving this is to grow suitable early and late varieties, the other being to delay or hasten the process of fruit development and its ripening.

The process of ripening depends on the maturity or the optimum development of the fruit. Immature fruits do not ripen properly or not at all. Another important aspect is that the storage life of the fruit depends upon the process of ripening. Russo (1968) reported that ethaphon hasten tomato ripening. Ethylene is a colorless gas with a sweet odor. Sargent, (2000) reported that the ripening of tomato gradually increases with the increase of ethylene concentration from 100-150 ppm when CO_2 levels are controlled.

Murray and Hartz (2001) reported that the application of ethylene in the form of ethaphone in tomato hasten uniform ripening keeping the quality of fruit unaffected when proper concentration is used. They further mentioned that a solution of 1000 – 1500 ppm influences significantly on tomato ripening. However, higher rates caused additional maturity advances, but resulted the unacceptable crop phytotoxicity when air temperature exceeded 35°C for extended period. Furthermore, there were variable cultivars responses to similar ethaphone rates.

There had a significant variation in respect of days to ripening due to combined effect of maturity stages and ethrel concentration. Immature tomato was ripened through the application of ethrel, which is thought to reduce the quality of the produce. Meanwhile, the concentration of the growth regulator i.e. ethrel is also should be such a level that might not affect the quality (Murray and Hartz,2001). But such types of information are lacking in our country and that's why the present experiment was undertaken with the following objectives:

- To find out the suitable maturity stage and ethral concentration for ripening of tomato.
- To determine physio-chemical changes in tomato with different maturity stages and different concentrations of ethrel application.
- To determine the shelf life of tomato fruit due to the different maturity stages and different concentration of ethrel.



CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Tomato is one of the most popular and widely grown vegetables of the world. It is a rich source of minerals and vitamins since the consumers purchase fruits on the basis of quality. It is essential to understand the physio-chemical changes that determine the quality of fruits after application of different concentration of ethrel at different maturity stages of fruit. The quality of tomato fruit is largely dependent on the stage of maturity of fruits and various ripening conditions as well as ethrel application, which are principally applied to increase the storability of tomato fruits. Changes in physico-chemical characteristics during storage as well as ripening must be determining the fitness of tomato fruit for fresh consumption and marketing. The scientific literature does include a very few studies on physico-chemical changes in tomato fruits but they are neither adequate nor conclusive. However, available literature and their findings on tomato and some other fleshy fruits that are related to the present study have been presented in the following section.

2.1. Changes in Physical characteristics of tomato fruit

2.1.1. Color development of fruit:

Color is an extremely important tomato quality characteristic. For the consumer color is an important indicator of the eating quality. The color of red tomatoes is determined primarily by their lycopene content. β-carotene is the other principal carotenoid of red tomatoes and can be important factor in tomato color under certain environmental conditions.

Murray and Hartz (2001) reported that the application of ethylene in the form of ethaphone in tomato hasten uniform ripening keeping the quality of fruit unaffected when proper concentration is used. They further mentioned that a solution of 1000 – 1500 ppm influences significantly on tomato ripening. However, higher rates caused additional maturity advances, but resulted the unacceptable crop phytotoxicity when air temperature exceeded 35°C for extended period. Furthermore, there were variable cultivars responses to similar ethaphone rates.

Konsler (1973) reported that darker green color developed during fruit development and persistent until the onset of ripening. He also showed that darker green contains more fruit chlorophyll than the wild type and ripe fruits were darker red both externally and internally.

In USA, Wann *et.al.* (1985) showed that ripe fruits of darker green contain up to 100% more lycopene than normal types. The mean β-carotene content was about 50% higher than that of high pigment contain mutant and 250% higher than of normal genotypes.

Tomes (1963) conducted an experiment in USA and found that carotenoid biosynthesis is very sensitive to temperature. He also stated that the development of lycopene of is inhibited at temperatures greater than 30°C and

fruits ripened under sub optimum temperatures may have more orange color than desired because of the change in the ratio between β-carotene and lycopene.

Cabibel and Perry (1980) suggested that lycopene and β-carotene content could be used as an indicator to determine the stage of maturity of tomato. In India, Bose *et. al.* (1967) found that β-carotene and lycopene concentration increased as the fruit developed from mature green to ripening stages.

Inaba and Crandall (1986) carried out an experiment at Florida and reported that the hand harvested mature green tomatoes cv. Sunny in plastic bags were immersed in ice water (0°C) for 60 minutes before being stored at room temperature delayed color development by 4-5 days and immersed in ice water with CaC_2 (-2°C) for 120 minutes before stored at room temperature extended shelf life by 2-3 weeks.

In USA, Reymundo *et.al* (1976) reported that in the process of ripening of tomato chlorophyll is degraded and yellow orange carotenoid and red lycopene were synthesized. They also stated that the biosynthesis of these pigments is light and temperature dependent.

Balla *et. al.* (1994) carried out an experiment in Slovenia and reported that visual color did not change during over ripening but the texture softened. They

also stated that chlorophyll content decreased and β-carotene and lycopene contents increased. There had a strong correlation between the co-efficient of elasticity and visual color score during ripening.

In Syndney Postharvest Laboratory, Jobling (2000) showed that the concentration of ethylene required for the ripening of different products varies. The concentration applied is within the range of 1 and 100 ppm. The time and temperature of treatment also influences the rate of ripening with fruit being ripened at temperatures 15 to 21°C and relative humidity of 85 to 90%.

In Japan, Dong *et. al.* (1996) reported that respiration and ethylene evolution increased at the green fruit stage and decline at the physiological maturity stage. They said that up to green fruit stage, the fruit contained mainly chlorophyll. This chlorophyll decreased gradually until physiological maturity. The fruit gradually turned red as lycopene content increased.

In a trial at Osaka in Japan, Hamauzu *et. al.* (1995) reported that the color of mature tomato fruits changed from green to red during storage at 20°C. But changes to a mixed color or a speckled pattern of red, orange and yellow at 30°C and turned yellow at 35°C. The epidermis is more sensitive and lycopene was significantly inhibited in surface tissue. High temperature prevented the accumulation of phytoone more than that of lycopene. The content of β-carotene increased in the epidermis and the flesh (more so in the epidermic)

during storage at 30°C, but decreased with extended storage (after about 15 days).

Masarirambi *et. al.* (1995) carried out an experiment at University of Florida, USA, with mature green fruit of tomato cv. Agriset 761 were exposed to ethylene (100 ppm) at 20, 25, 30, 35 or 40°C and 95% RH for 24, 48 or 72 hours and then transferred to air at 20°C for ripening. It was observed that tomatoes exposed to ethylene at high temperatures for 24 hours showed a little difference in color development compared to those exposed to ethylene at lower temperatures increasing the duration of ethylene at lower temperatures. Increasing the duration of ethylene high temperature treatment to 48 or 72 hours at 35 or 40°C inhibited subsequent red color development at 20°C, while prior to exposure to 30°C stimulated color development.

2.1.2. Weight loss of tomato:

Syamal (1981) performed an experiment in India, with pink fruits of tomato cvs. (Roma, Marglobe, Sioux, Best of All, Red Plum, Pusa Ruby, Ponderosa and H.S.102) stored in ventilated polythene bags at 20°C and 65% RH for up to 12 days. He observed that the greatest and least weight losses after 12 days storage occurred in Marglobe and Pusa Ruby @ 15.8 and 14.07% respectively.

In Turkey, Kaynas and Surmeli (1995) observed that weight loss was more severe in fruits at an early stage of maturity and increased as storage

temperature increased. They also stated that while green mature and breaker stages tomato were stored at 4 and 8°C then total weight loss over 35 days ranged from 3 to 8%, depending on cultivars, maturity and temperature.

Yoltas *et. al.* (1994) obtained that a 1.2% semperfresh (a fatty acid sucrose ester mixture) significantly reduced the weight loss in tomato fruit (cv. Galit-135) during storage at 21°C temperature in Turkey.

In India, Mallik *et. al.* (1996) reported that fruits of tomato (cv. Roma-VF) showed the lowest physiological weight loss of 7.7-9.7% after 6 days storage under ambient conditions.

Agnihotri and Ram (1970) observed that a 6% wax emulsion significantly reduced the weight loss in tomato fruit during storage at room temperatures in India.

Jana and Chattapadhyay (1989) observed that minimum weight loss occurred in tomato fruits treated with NAA, especially at 5 ppm and ripening was delayed best by GA at 200 ppm or 2,4-D at 100 and 200 ppm at room temperature storage up to 15 days.

Tauqur *et. al.* (1989) conducted an experiment in India, with Mango fruits (cvs. Des and Duschvi) treated with CaC_2 (2g/kg fruit). Both treated and control

fruits were wrapped in paper and held in wooden perforated boxes for up to 12 days. After storage they observed that CaC_2 treatment accelerated ripening and resulted in higher percentage of weight loss during storage.

2.1.3. Shelf life of tomato:

Shelf life is the most important aspect in loss reduction biotechnology of fruits and vegetables. There is a natural tendency for the perishable fruits and vegetables to degrade to the simpler inorganic compounds (CO_2, H_2O, NH_3) from which they were synthesized is the first place through spontaneous biochemical reactions which occur with decrease in free energy and increase in the randomness (entropy) of the system, consequently reduce the shelf life as well as other qualities of fruits and vegetables. The conservation of shelf life of fruits has been one of the prime concerns of mankind throughout the recorded history (Salunkhe and Desai, 1984).

Subburamu *et. al.* (1990) conducted as experiment in India, with tomato fruits of the cultivars (PKM-1, Marutham, Pusa Ruby and Palyuri), harvested at 4 maturity stages viz. (i) Mature green (ii) Breaker (iii) Half ripe and (iv) Red ripe were held under ambient conditions for longer shelf life. They observed that the shelf life was longer (11-12.5 days) in fruits picked at the mature green satge, their quality after storage was poor and tomatoes picked at the breaker stage were of better quality and held an acceptable shelf life (8.3-10.5 days).

Cultivar PKM-1 had the best keeping quality with the other cultivars being similar to one another.

In India, Anju-Kumari *et .al.* (1993) reported that the shelf life for all tomato cultivars (Roma-VF, Pusa, Sioux and Solan Gola) were longest with harvesting at the mature green stage (10.9-13.5 days) but resulted in the lowest ascorbic acid content after storage and in patchy color develop on ripening.

At Mohonpur in India, Mallik *et. al.* (1996) reported that tomato cultivars (Roma, Pusa Ruby, Sioux and Solangola) at an ambient condition. Earlier harvesting, being 10.9-13.5 days for mature green fruits and 3.5- 5.1 days for red ripe fruits increased shelf life. Fruits of Roma showed the lowest physiological weight loss (7.7-9% after 6 days) and longest shelf life (13.5 days when harvested at the mature green stage). They also said that fruits harvested at the breaker of half ripe stage exhibited good shelf life and keeping quality.

In another experiment at Yalova in Turkey, Kaynas and Surmeli (1995) recorded that tomato fruits (cvs. ES-58, 11-2278, Tobol and Riogrande) exhibited a shelf life of 40 days at 12°C when fruits stored at were green mature and breaker stages and pink fruits can be held for 25-30 days at 8°C. They also stated that tomatoes at the light red and red stages can be held for 10-15 days at 8°C and for 10 days at 12°C.

Park *et. al.* (1994) conducted an experiment with tomatoes at 2 maturity stages viz breaker and pink were coated with corn-zein film, control (non-coated) and coated tomatoes were stored at 21°C. They found that corn-zein film delayed color change and loss of firmness and weight reduced in storage. They also stated that coating fruits with corn-zein film extended the shelf life by 6 days.

At Hariana in India, Sandooja *et. al.* (1987) studied the effect of Ethrel/CaC_2, Kinettin, GA_3 and $KmnO_4$ on tomato fruit quality during storage and reported that treatment of fruits with $KmnO_4$ at 1000 ppm immediately after green mature stage resulted in prolonged storage life and decreased weight loss and decay during storage.

Hossain *et. al.* (1996) carried out an experiment at the Bangladesh Agricultural Research Institute, Gazipur and recorded that the tomato fruits of the lines TMO-850 and TMO-854 exhibited a shelf life of 14-17 days when stored at ordinary storage condition.

Dennis *et. al.* (1979) stated that it was possible to store green mature fruits cultivars (Sonato and Soatine) for up to 6 to 10 weeks at control atmosphere storage (3% O_2, 5% CO_2 and 92% N_2) at 13°C and 93-95% RH.

At room temperature the tomato fruits could be stored up to 12 days only with less than 10% weight loss compared to 20 days at 10°C and 28 days at 5°C and

the respiration rate was higher in ethaphon treated fruits than in those ripened on the plants (Gupta *et. al.*, 1988).

2.2. Changes in chemical characteristics of tomato fruit

2.2.1. Ascorbic acid content of tomato pulp

Tomatoes are a rich source of ascorbic acid, which varied from 15 to 65 mg/100g juice of fruits in different varieties. It has been found 62.7 mg/100g in the juice of *L. peruvianum* and 46.5 mg/100g in juice of *L. pimpinellifolium.* There is a marked variation approximately 11.2 to 21.6 mg/100g of fruit weight (Reynard and Kanapause, 1942).

In Forida, Matthews *et. al.* (1973) analyzed a total of 41 varieties and breeding lines of tomato and found ascorbic acid content range 10.7 mg/100 g tropi-red to 20.9 mg/100g in red Rook.

Borooah and Mohan (1975) studied in an experiment in India, with 11 varieties and found that Sioux having the largest fruit size had less ascorbic acid content and Chicku Grande, the smallest fruit had the highest ascorbic acid content of 20-30 mg/100g.

Dalal *et. al.* (1965) studied the changes in ascorbic acid content of tomato fruits of different maturity stages at Florida. They harvested tomato fruits at large green, breaker, pink, red ripe stages. The tomato fruits were chemically

analyzed and it was observed that the ascorbic acid content increased in large green to red stage from 14.5 to 23.0 mg/100g but at red ripe stage vitamin-C decreased which was 22.0 mg/100g of fruit.

Dod and Kale (1977) studied the performance and quality characters of 12 tomato varieties in ascorbic acid content in India. Chameli had loss ascorbic acid (14.20 mg%) as where, the HS-101 has the highest ascorbic acid (25.00 g%).

Mallik *et. al.* (1996) conducted an experiment with tomato cultivars (Roma, Pusa-Ruby, Siolex and Solongola) to study the changes in ascorbic acid content. The tomato fruits were harvested at mature green, breaker, half ripe and red ripe stages. They observed that ascorbic acid content was the lowest in mature green fruits at harvest and after storage, during which it decreased.

Islam *et. al.* (1996) conducted an experiment at Kagawa in Japan, with vine ripened tomato (cv. TM0126) and fruits were stored at 15, 25, 20°C and 80-90% RH. They observed that at all temperatures ascorbic acid concentration decreased linearly. They also reported that ascorbic acid concentration was higher when fruits were stored at 15°C.

2.2.2 pH of tomato juice

In India, Saimbhi *et. al.* (1987) reported a wide range of variation of pH content from 3.6 to 4.6 in different tomato varieties. Cultivars with high pH were not suitable for processing. The pH should be less than 4.00.

Saimbhi *et. al.* (1995) reported in a study of forty seven hybrids of tomato for various physico-chemical characters. The pH in tomato hybrid varied from 3.7 to 4.9. But Cerne *et. al.* (1994) observed no significant difference in fruit pH. Lopez-lago *et. al* (1997) found the pH range of tomato 3.5-4.3 from Costarica Ivory Coast.

Singleton and Gortner (1965) found that the pH of the fruit pulp of developing pineapple (cv. Smotth Cayenne) showed almost a straight-line fall from the early readings.

In an experiment in Brazil, Botrel *et. al* (1993) observed that ripe pineapple fruits held at 5°C had a higher pH than that held at 25°C, while Abdullah *et. al.* (1986) notieced that pH values in pineapple fruits (cv. Sarawak) stored at 5, 10, 15or 20°C for 1, 2 or 3 weeks followed by 1 week holding periods at ambient temperature (28°C) were unrelated to the different storage conditions.

2.2.3. Titrable acidity content of tomato pulp

Dalal *et. al.* (1965) reported that tomato fruits contained 0.31% acidity (as citric acid) at ambient condition. Saimbhi *et. al.* (1995) observed in 47 hybrids of tomato that total acid content in the fresh tomato fruit varied from 0.23 to 0.20%. Significant differences in total acidity was observed by Awasthi *et. al.* (1992) which varied from 0.77- 1.06%.

Saimbhi *et. al.* (1987) and Bajaj *et. al.* (1990) reported a wide range of variation in acid content of different tomato cultivars. The variation in total acidity ranged from 0.30 to 0.56%. Cerne *et. al.* (1994) reported that small to medium sized fruits had the higher acid contents and the large fruits with low acidity. Lopez-lago *et. al.* (1997) found that total acidity in fresh tomato fruits of Costarica and Ivory Cost was 0.682%.

Increase of tomato titrable acidity is associated with pH and citrate is largely responsible for it. Stevens and Long (1971) also stated that citrate is correlated with titrable acidity but not with malate.

The changes in organic acid content during growth and development of tomato fruit was studied by Boe *et. al.* (1967) at Florida. They stated that the acid content was found to be lower in immature fruits and it was the highest at the stages when color appeared with a rapid decrease as the fruit ripened at ambient condition. They also reported that citric acid was the major constituent

of total acid. Malic acid occurred in small concentration and decreased as the fruit ripened. In addition tomato citric and malic acid, Hobson and Davies (1971) also reported other organic acids such as formic and acetic acids in fresh tomato fruits.

In USA, Sands (1995) and Winsor *et. al.* (1962) reported that maximum acidity is found at the pink stage of tomato fruits with subsequent fall. The total organic acid, especially malic acid and citric acid has been influenced by the stage of maturity and increase in quantity with maturity of tomato as reported by Dalal *et. al.* (1965). On the other hand, Davies (1966) reported that malic acid decreased continuously by advancing ripening and onwards to soft stage, the citric acid decreased as malic acid increased. Sinaga (1986) observed that titrable acidity increased during maturation of tomato (cv. Moneymaker) from the green mature to the red ripe stages.

Studying the quality of five tomato varieties at four developmental stages, Siddiqui *et. al.* (1986) reported that the highest acidity 1.04 g/100ml in vars. MTH-1 and SG-I2 at the yellow and red stage respectively whereas it was low at the green stage.

2.2.4 Sugar content of tomato pulp

Kallo (1985) reported that tomato fruit juice contained 2.50-4.50% sugars. Taranov and Krustakalne (1974) observed sugar content varied from 3.9-4.4% in the tomato variety Yurmales, cultivated under plastic.

Sinaga (1986) working on the effect of maturity stages on quality of tomato (cv. Moneymaker) observed that sugar content increased during maturation from the green mature to the red ripe stages.

The changes in chemical composition during growth and development of tomato fruits were studied by Boe *et. al.* (1967). According to them, the total soluble solids and reducing sugar increased throughout the development of fruit. During maturation and ripening of tomato fruits, there are changes in total sugar, individual sugar and total soluble solids. Winsor *et. al.* (1962) also stated that the total sugar and the total solids increase from mature green stage to red ripe stage.

The turning stage of tomato fruit has the highest sugar content. In USA, Rosa(1926) reported that maximum sugar is found four days after picking of the pink stage fruits. In the advance stage, there may be a decrease in the sugar content. Yamaguchi *et. al.* (1960) observed that reducing sugar is high in a red ripe tomato fruit.

Davies and Kempton (1975) reported that during the initial stage of development of tomato glucose is much higher but at the start of ripening glucose and fructose are in about equal proportions.

Suthar and Bhatnagar (1999) carried out an experiment in India and found that among different cultivers (Pusa Ruby, Junagadh Ruby, Mahabalishwer, Anand, Anguralata, SL 152, and NDT 120), Angurlata had the highest total soluble sugar, reducing sugar during storage for 4-6 days at room temperature or at 4°C. The nutrients are better preserved in fruits stored in the refrigerator. The results also indicted that tomato fruits can be stored for 6 days without much loss in nutrient content.

Dalal *et. al.* (1965) carried out an experiment Florida, to study the chemical composition of tomato fruits. They harvested the tomato fruits at large green, breaker, pink, red and red ripe stage and chemically analyzed them for reducing sugar. They found that reducing sugar (%) was about 2.4% in large green, 2.90% in breaker, 3.10% in pink, 3.45% in red and 3.65% in red ripe stage of fresh weight.

Vine-ripened tomato (c. TM 0126) fruits were stored at 15, 25 or 30°C and 80-90% RH. At all temperatures, fruit soluble sugar concentrations increased with storage duration. Fruits stored at 25 or 35°C had high respiration and no marked respiratory climacteric and slow ripening. Fruits stored at 15°C had

higher total soluble solids and soluble sugars but showed less red color formation (Islam *et. al.*, 1996).

In Korea, Kim *et. al.* (1996) reported that the respiration rate increased at higher storage temperatures but decreased with storage period. Ethylene production was suppressed at 0, 5, 10, 30 or 35°C but was high for fruits stored at 20°C due to mould infection. They also stated that total sugar content of fruits decreased with storage. Sucrose content of fruits increased but glucose and fructose decreased when fruits were stored at lower temperatures.

2.2.5. TSS (Total Soluble Solid) content of tomato pulp

During maturation and ripening of fruit there are changes in total soluble solid. The total soluble solid increase from mature green stage to red ripe stage (Winsor *et. al.*, 1962). Kalloo (1985) obtained 4.00-7.00% TSS in tomato juice, while Singh (1980) recorded 4.80-8.80% TSS in tomato juice. Lopez-Lago *et. al.* (1997) found that the physico-chemical properties of fruit from Costarica and Ivory Coast respectively were 12.8 to 13.00 TSS in tomato juice.

Tomato cultivars ES-58, H-2274, Tobol and Riogrande were harvested at the green mature and breaker stages and then stored 4 and 0°C. It was found that fruit soluble solids increased somewhat during storage (Kaynes and Surmeli, 1995).

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. Experimental site: The present investigation was carried out in the laboratories of the Plant Physiology Section of the Horticulture Research Center (HRC) under the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazpur during the period from 18 January to 10 March, 2005. The Plant Physiology Laboratory room of the Horticulture Research Center of BARI was used to keep tomato for ripening conditions. Postharvest laboratory was used for chemical analysis of tomato at different stages.

3.2. Physical condition of the storage room: The temperature and relative humidity of the storage room were recorded daily with a digital temperature humidity meter. The average temperature of the storage room was 20.75°C and relative humidity 70.84%. Detailed of the diurnal temperature and humidity of storage room has been furnished in appendix I.

3.3. Materials used in the experiment: The materials used for the study were freshly harvested tomatos of the variety BARI tomato-9. The tomato fruits were collected from the HRC field. Tomato fruits of three distinct maturity stages were harvested in the morning hours, immediately transferred to the physiology laboratory of HRC with careful handling and placed in storage room under different conditions of ripening and treatment different concentration of ethrel within a few hours in per treatment of the experiment.

3.4 Treatments and Experimental Design : The experiment comprised of two factors as follows;

Factor A : Stages of maturity of tomato fruits

Factor B: Different ethrel solution

The levels of factor A were:

i) Green matured tomato (M_1)

ii) Breaker stage of tomato (M_2)

iii) Half ripened tomato (M_3).

The levels of factor B were:

i) E_0- Control

ii) E_1- 500 ppm ethrel

iii) E_2- 1000 ppm ethrel

Thus, there were (3x3) treatment combinations. The combinations were as follows:

M_1E_0: green matured tomato + Control

M_1E_1: Green matured tomato + 500 ppm ehtrel

M_1E_2: Green matured tomato + 1000 ppm ehtrel

M_2E_0: Breaker stage of tomato + Control

M_2E_1: Breaker stage of tomato + 500 ppm ehtrel

M_2E_2: Breaker stage of tomato + 1000 ppm ehtrel

M_3E_0: Half ripened tomato + Control

M_3E_1: Half ripened tomato + 500 ppm ehtrel

M_3E_2: Half ripened tomato + 1000 ppm ehtrel

The two-factor experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. Sixteen of uniform sized tomato fruits were kept in each replication.

3.5 Details of the experimental factors:

3.5.1 Maturity stage: The tomatoes used in the experiment were harvested at three distinct maturity stages. The first category of fruits was in mature green stage. The fruits in this type at harvest were in light green color having no distinct ribs on the surface. The fruits on visual observation seemed to start developing color within few days. The second type was in breaker-stage tomato when the distal end of the fruit just turns yellowish ring. The third category fruit was in half ripened stage when fruits were found in some lashes of red color developed on the pale white in majority percentage there was still light green color visible on the surface.

3.5.2 Preparation of ethrel solution:

'Ripen-15' was the trade name of ethrel source which is marketed by National Agri Care Pvt. Ltd. Ripen-15 had the ethrel concentration of 39%. So, to prepare 500 ppm ethrel solution; 1.3 ml of Ripen 15 was added to 1 litre of distilled water. As such for the preparation of 1000 ppm etrel concentrations, 2.6 ml of Ripen 15 were added to 1 litre of distilled water respectively. After preparing the solution then the different stages of tomato were deep in different concentration of ethrel solution for 15 minutes.

3.6 Collection of data: To assess the effect of stages of maturity and ripening process on the physio-chemical changes of tomato fruits during storage, the data on different physical and chemical parameters were collected at 3 days interval during the storage period. The shelf life, color development, weight loss or gain (%), % marketable fruits were studied during the entire storage period. All the chemical characteristics were studied only up to 12^{th} day of storage fruits while weight loss was recorded until 15 days and colour development and shelf life of tomato were recorded until 40 day of storage.

3.7 Parameters studied:

3.7.1 Changes in physical characteristics of tomato fruit:

i) Color development of fruit and ripening of fruits

ii) Weight loss (%)

iii) Shelf life of tomato

3.7.2 Changes in chemical characteristics of tomato fruit

i) Ascorbic acid content of tomato pulp.

ii) pH of tomato juice.

iii) Total titrable acidity content of tomato pulp.

iv) Reducing sugar content of tomato pulp.

v) Non-reducing sugar content of tomato pulp.

vi) Total sugar content of tomato pulp.

vii) TSS content of tomato pulp.

3.8 Method of studying different parameters.

3.8.1 Color development and ripening of fruit:

The peel color of fruit was recorded by matching with a standard color chart (IPGRI, 1992). Development of various spots on the peel of fruits and softening and rotting of fruits were also recorded.

3.8.2 Weight loss (%): The weight loss of tomato fruit sample was calculated by using the following formula:

$$\% \text{ Total weight loss of fruit} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

The weight losses of the sample were recorded periodically during the storage period.

3.8.3 Shelf life of tomato: The shelf life was calculated by counting the days required to attain the last stage of ripening, but up to the stage when fruits remained still acceptable for marketing.

3.8.4 Ascorbic acid content of tomato pulp: Ascorbic acid in tomato pulp was estimated by 2, 6-Dichlorophenol indophenol visual titration method as described by Rangana (1979). The reagents used for the estimation of vitamin-C were as follows:

i) Metaphosphoric acid (6%)

ii) Standard ascorbic acid solution.

iii) 2-6 dichlorophenol indephenol dye.

For estimation of vitamin C, the following steps were followed:

a. ***Standardization of dye solution:*** Five millimeter standard ascorbic acid solution was taken in a conical flask and 5 ml metaphosphoric acid (HPO_3) was added to it and shaken. A microburette was filled with dye solution. Then the mixed solution was titrated with dye using phenolphthalein indicator solution to a pink color end point that persisted at least for 15 seconds. Dye factor was calculated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titrate}}$$

b. ***Preparation of solution:*** Ten gram fresh tomato pulp was taken in a blender machine and homogenized with 6% metaphosphoric acid and then the blender material was filtrated and transferred to a 100 ml volumetric flask and the volume was made up to the mark with 6% metaphosphoric acid.

c. ***Titration:*** Five millimeter of metaphosphoric acid extracted sample was taken in an aliquot and titrated with standard dye solution, using phenolphthalein indicator to a pink colored end point that persisted at least 15 seconds. The filtration was replicated thrice for each fruit. Ascorbic acid content was calculated by using the following formula:

$$\text{Ascorbic acid content (mg/100 g of fruit pulp)} = \frac{T \times D \times V1}{V2 \times W} \times 100$$

Where,

T = Titrate

D = Dye factor

V1 = volume made up

V2 = volume of extract taken for estimation and

W = weight of sample taken for estimation

3.8.5 pH of tomato juice: The pH of the sample was determined by the method described by Rangana (1979). One gram of sample was homogenized in 1 ml of boiled distilled water and 1 ml of de-ionized water of pH 7.0 and the pH of tomato juice was recorded by using an electronic pH meter. The pH meter was standardized with the help of buffer solution.

3.8.6 Total titrable acidity content of tomato pulp: Ten gram pulp was taken in a blender machine and homogenized with distilled water. The blender material was then filtered and transferred to a 100 ml volumetric flask and the volume was made up to the mark with distilled water and titrated with 0.1N NaOH just below the end point using phenolphthalein indicator. The titration was done for three times. Percentage of titrable acidity was calculated using the following formula:

$$\% \text{ Total titrable acidity content of tomato pulp} = \frac{T \times N \times E \times V1}{W \times V2 \times 1000} \times 100$$

Where,

T = Titrate

N = Normality of NaOH

V1 = Volume made up

V2 = Volume of sample taken for estimation

E = Equivalent weight of acid

W = weight of sample.

3.8.7 Sugar content of tomato pulp: Sugar content was estimated by determining the volume of unknown sugar solution of tomato pulp required for complete reduction of standard Fehling's solution. The following procedure was followed in determining sugar content.

a. Standardization of Fehling's solution: Ten ml of both Fehling's solution A and Fehling's solution B was mixed together in a beaker. Ten ml of mixed solution was pipetted into a 250 ml conical flask and 25 ml distilled water was added to it. Standard sugar solution was taken in a burette. The conical flask containing mixed solution was heated on a hot plate. When the solution began to boil, three drops of methylene indicator solution was added to it without removing the flask. Mixed solution was titrated by standard sugar solution. The end point was indicated by decolorization of the indicator. Fehling's factor was calculated by using the following formula:

$$\text{Fehling's Factor (gm of invert sugar)} = \frac{\text{Titrate x } 2.5}{1000}$$

b. Preparation of sample: Twenty gram of fresh tomato fruit pulp was taken in a blender machine and homogenized with distilled water. Then the blender

material was transferred to a 250 ml volumetric flask. The volume was made up to the mark with distilled water. The pulp solution was filtered. Hundred ml of filtrate was taken in a 250 ml volumetric flask. Five ml of 45% neutral lead acetate solution was added to it and then shaken and waited for 10 minutes. 5 ml of 22% potassium oxalate solution was further added to the flask and the volume was made up to the mark with distilled water and filtered.

c.Titration of reducing sugar: Carbohydrates with a free aldehyde or a free keton group and they are in hemiacetal or hemiketal form are referred to as reducing sugar. Ten ml of mixed Fehling's solution was taken in a 250 ml conical flask and 50 ml distilled water was added to it. Purified pulp solution (filtrate) was taken in a burette. Conical flask containing the mixed Fehling's solution was heated on a hot plate. Three to five drops of methylene blue indicator were added to the flask when boiling started and titrated with solution taken in the burette. The end point was indicated by decolorization of indicator. Percentage of reducing sugar was calculated according to the following formula:

$$\% \text{ Reducing sugar content of tomato fruit pulp} = \frac{F \times D \times 100}{T \times W \times 1000}$$

Where,

F = Fehling's factor W = Weight of sample

D = Dilution

T = Titrate

d.Titration of total invert sugar: Fifty ml of purified solution (filtrate) was taken in 250 ml conical flask. Five gm citric acid and 50 ml distilled water were added to it. The conical flask containing sugar solution was boiled and finally cooled. Then the solution was transferred to a 250 ml volumetric flask and neutralized by 0.1 N NaOH using phenolphthalein as indicator. The volume was made up to the mark with distilled water. Then the mixed Fehling's solution was titrated using similar procedure followed as in case of invert reducing sugar mentioned earlier. The percentage of total invert sugar was calculated by using the formula used in case of reducing sugar.

e. Estimation of non-reducing sugar: Carbohydrates with aldehyde or keton group is not free and they are in acetal or ketal form are referred to as non-reducing sugar. Its are estimated by

% Non-reducing sugar = % total invert sugar - % reducing sugar.

f. Estimation of total sugar:

% Total sugar = % reducing sugar + % non-reducing sugar.

3.8.8 TSS content of tomato pulp: The total soluble solid (TSS) content of tomato fruit pulp was determined by using an Abbe refractometer by placing a drop of pulp solution on its prism. The percentage of TSS was obtained from direct reading of the refractometer. Temperature correction was made by using methods described by Rangana (1979).

3.9 Statistical analysis : The data obtained for physio- chemical characteristics of tomato were statistically analyzed to fined out the significance of the difference among the treatments. The analysis was performed by F-test and the significance of the difference between pairs of treatment means were evaluated by the Duncan's New Multiple Range Test (DMRT), at 1% and 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4
RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter includes the findings of the results and discussion with appropriate interpretation. The results included the effects of different maturity stages of tomato along with varied concentrations of Ethrel on the ripening and quality of tomato. The results have been presented under the following headlines

4.1 Changes in physical characteristics of tomato fruit

4.1.1 Colour development and ripening of fruits

Colour development of tomato occurred during process of ripening of different types of matured fruit have been presented in Fig. 1. It was found that matured green tomato required 9.67 days for complete ripening all the fruits attained red colour. Breaker stage and half-ripe tomato became red at 7 and 5.33 days respectively. The tomatoes treated with 1000 ppm ethrel by ripened more quickly (4.33 days). 500 ppm ethrel treated tomatoes developed colour by 6.67 days after storage and control fruits required 11.00 days (Fig. 2).

There had a highly significant variation due to the combined effect of different stages of maturity and ethrel concentration in respect of colour development or ripening of tomatoes (Appedix II). Mature green, breaker and half ripe tomatoes provided with 1000 ppm ethrel treatment showed the sign of full ripening respectively by 6, 4 and 3 days where 500ppm ethrel treatment and control had 8, 7 and 5 days and 15, 10 and 8 days respectively (Fig. 3). It showed that half ripe tomato treated with 1000 ppm ethrel, gave quick colour development and ripening.

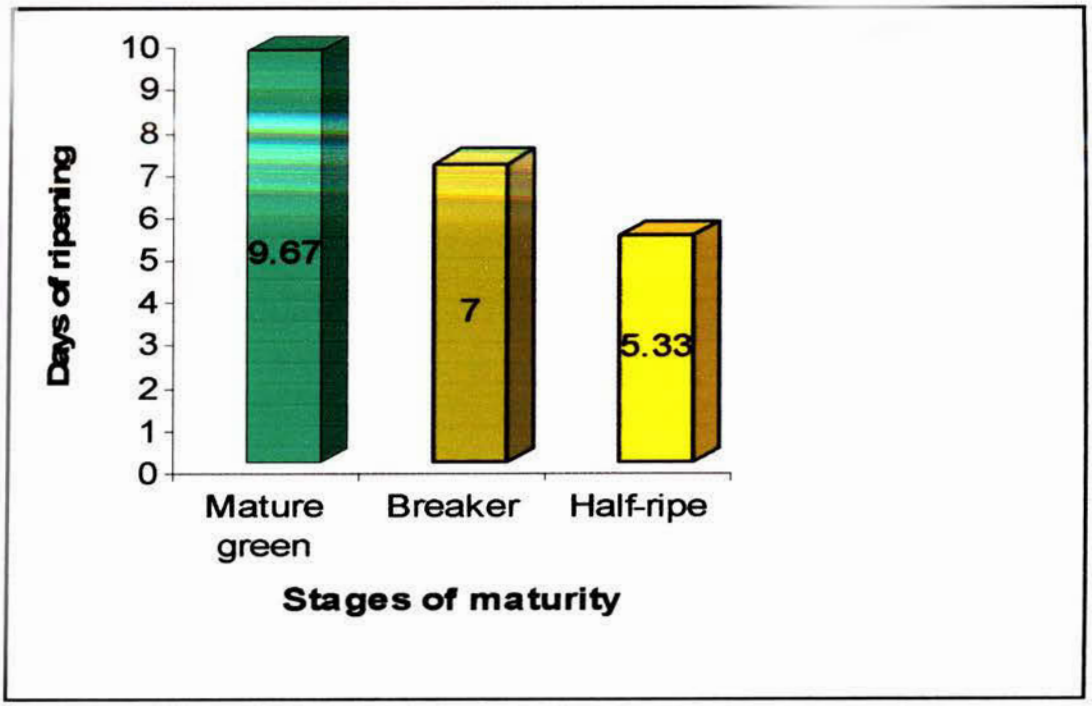


Fig. 1. Colour development of tomato as influenced by different maturity stages

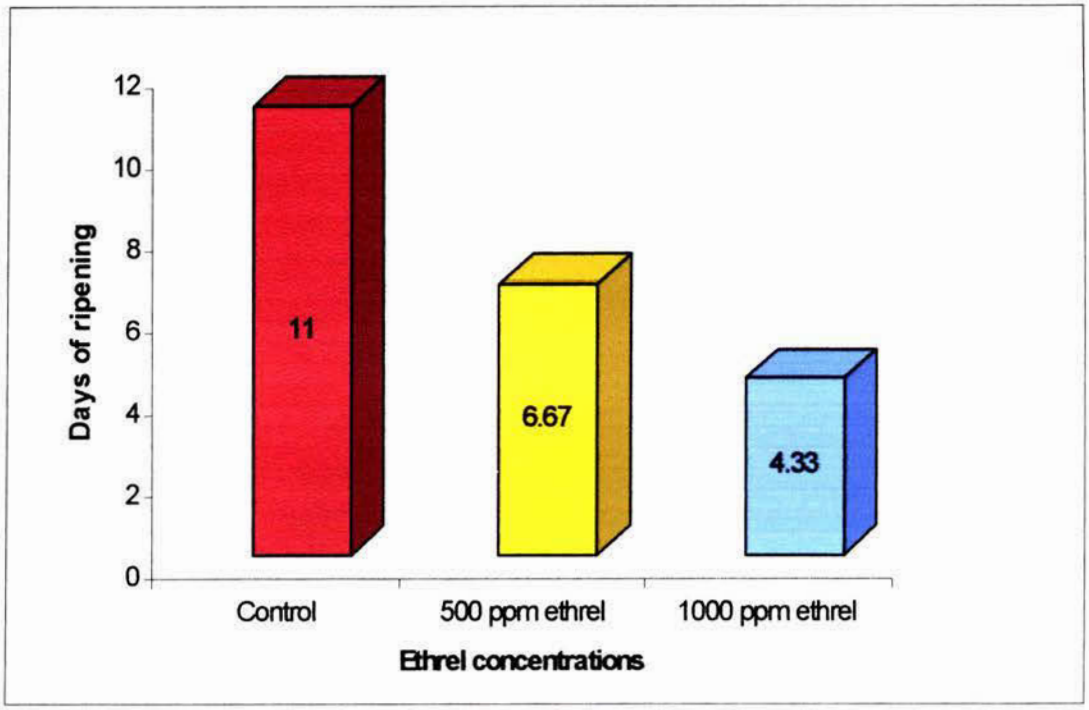


Fig. 2 Colour development of tomato as influenced by different concentrations of ethrel

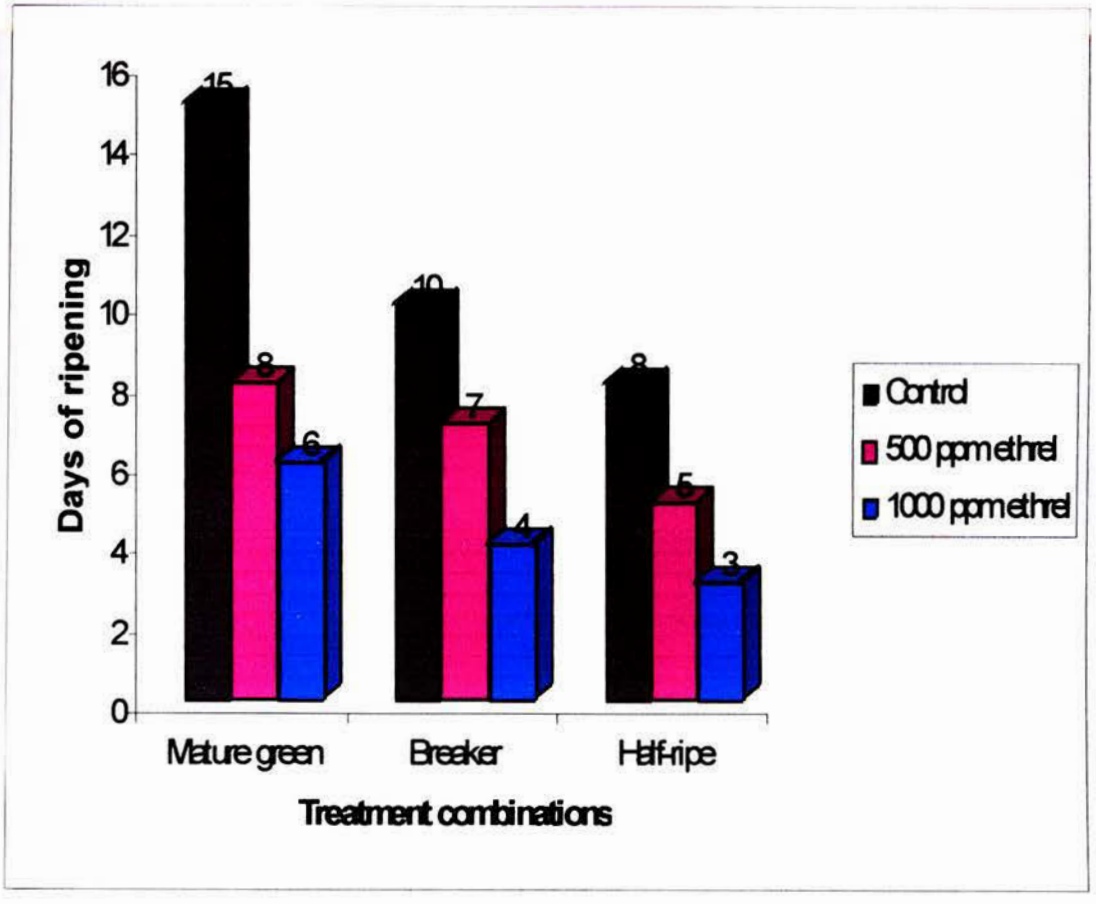


Fig. 3 Colour development of tomato as influenced by combined effects of stages of maturity and ethrel

4.1.2 Weight loss (%)

Stages of maturity of tomatoes, treatment of different concentrations of ethrel and their combined effects were found to have significant influence on total weight loss in percentage (Appendix III).

Total weight loss in mature green tomatoes was always higher during the entire period of storage (Fig. 4). At the 3rd day of storage, it was 5.31% that rose to 14.79 % at 15th day. The total weight loss was the lowest in half-ripe tomatoes, being 4.76% at 3rd day of storage and rose to 14.11% at 15th day (Table 1). The weight loss in mature green tomato was relatively higher probably because of higher rate of dehydration that generally happened in tender tissue.

Ethrel treatment also had significant effect on total weight loss of tomatoes during storage (Table 2). The highest weight loss (14.67%) was recorded in control treatment, while it was the lowest (14.32%) in tomatoes treated with 1000 ppm ethrel at the 15th day of storage. The weight loss of tomatoes under 500 ppm ethrel treatment was 14.34% and it was statistically similar to that of 1000 ppm ethrel treatment at 15th day of storage. Irrespective of ethrel concentration, the weight loss was found to be gradually increased with the advancing storage duration (Fig. 5).

There was highly significant variation among the treatments resulted from the combination of stages of maturity and ethrel treatment in respect of weight loss of tomatoes. The interaction effect between two factors of the experiment was

Table 1. Main effect of maturity stages on the percent weight loss of tomato

Treatment	Weight loss (%)				
	3 DS	6 DS	9 DS	12 DS	15 DS
M_1	5.31a	9.33a	10.63a	12.62a	14.79a
M_2	4.84b	8.18b	10.34b	11.59b	14.43b
M_3	4.76c	7.55c	10.23c	11.19c	14.11c
CV %	1.34	0.46	0.19	1.11	0.51

Table 2. Main effect of ethrel solution on the percent weight loss of tomato

Treatment	Weight loss (%)				
	3 DS	6 DS	9 DS	12 DS	15 DS
E_0	5.03a	8.45a	10.47a	11.90a	14.67a
E_1	4.96b	8.33b	10.44b	11.55b	14.34b
E_2	4.93b	8.28c	10.29c	11.95a	14.32b
CV %	1.34	0.46	0.19	1.11	0.51

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

DS = Days of ripening

Table 3. Combined effect of maturity stages and ethrel on the percent weight loss of tomato

Treatment	Weight loss (%)				
	3 DS	6 DS	9 DS	12 DS	15 DS
M_1E_0	5.45a	9.36a	10.62b	12.75a	14.92a
M_1E_1	5.26b	9.29b	10.73a	12.48b	14.68c
M_1E_2	5.22b	9.33ad	10.55c	12.62ab	14.76bc
M_2E_0	4.76de	8.29c	10.46d	11.73c	14.86ab
M_2E_1	4.89c	8.20d	1036e	11.72c	14.23d
M_2E_2	4.86cd	8.06e	10.20f	11.32d	14.21d
M_3E_0	4.87cd	7.71f	10.34e	11.21d	14.22d
M_3E_1	4.72e	7.49g	10.23f	10.46e	14.10de
M_3E_2	4.70e	7.46g	10.12g	11.91c	14.00e
CV %	1.34	0.46	0.19	1.11	0.51

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

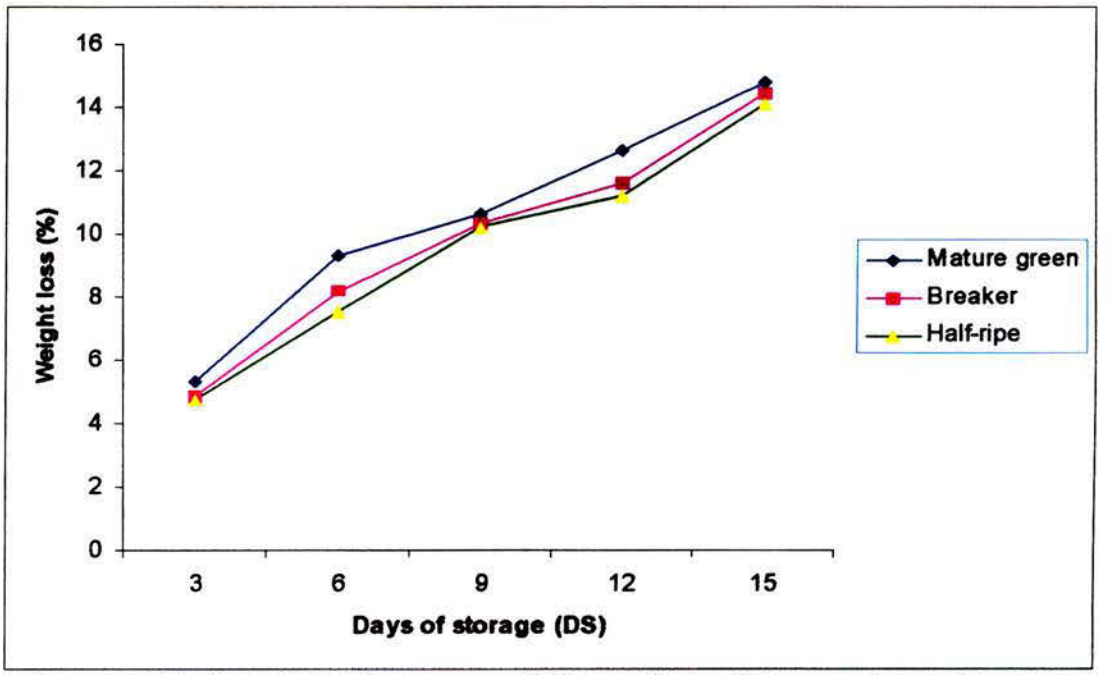


Fig. 4 Weight loss (%) of tomato at different days of storage shown by different stages of matured fruits

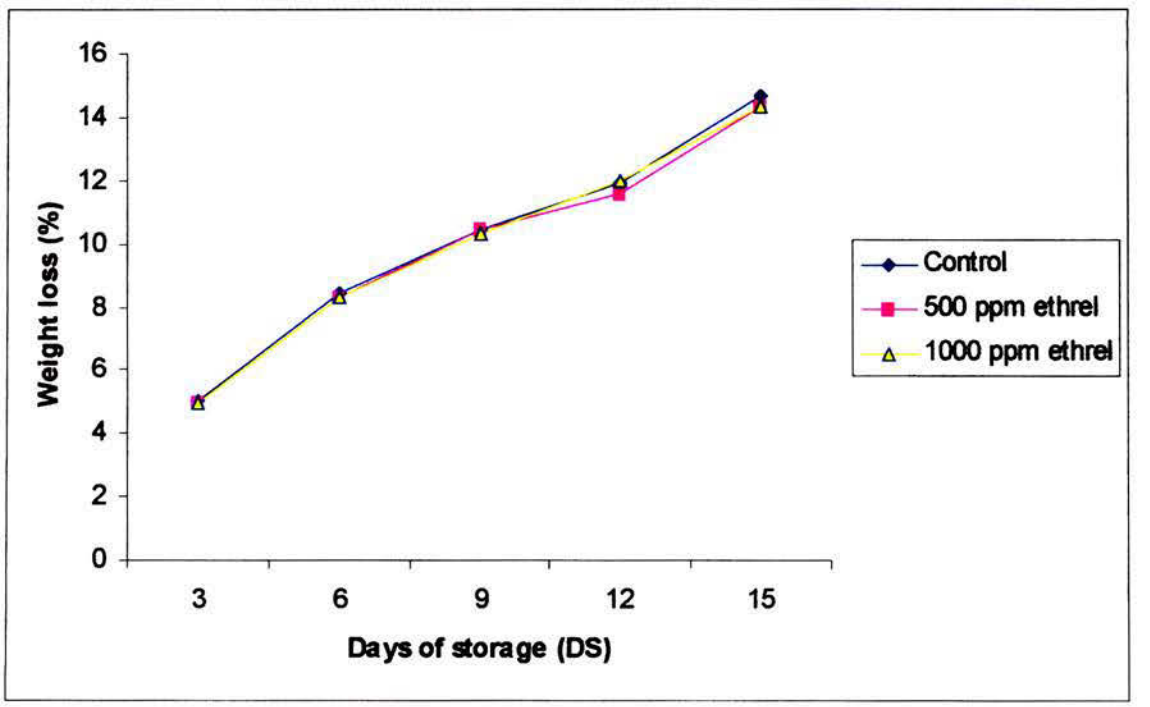


Fig. 5 Weight loss (%) of tomato at different days of storage shown by different concentrations of ethrel

all found to be significant at all days of storage in respect of weight loss tomatoes (Appendix III). The matured green tomatoes under control treatment showed maximum 14.92% weight loss due to their tender tissue followed by 14.86% in breaker stage tomatoes placed with control condition and 14.22% in half ripe tomato and the lowest of 14.00% in half-ripe tomatoes placed same with 1000 ppm ethrel treatment at the 15 days of storage (Table 3).

Syamal (1981) reported the greatest and least weight loss after 12 days of storage occurred in Marglobe and Pusha Rubi @ 15.8 and 14.07% respectively.

4.1.3 Shelf life of tomato

The shelf life of tomato fruits was significantly affected by their stages of maturity. It was recorded that mature green tomato had a higher storability than the breaker followed by half-ripe tomatoes irrespective of their keeping conditions. The maximum shelf life (32.00days) was recorded in mature green tomatoes, followed by breaker stage tomato (29.33 days). The shelf life was minimum (22.67 days) for half ripe tomatoes (Fig. 6).

Ethrel treatment also had significant effect on the shelf-life of tomatoes (Fig. 7). 1000 ppm ethrel treatment was recorded to give the longest life (32.00 day) to tomato fruits in storage, followed by 500 ppm ethrel treatment (28.00 days). The lowest life was (24.00 days) recorded by control treatment.

There was a highly significant variation among the treatments resulted from the combination of stages of maturity and ethrel treatments in respect of shelf life of tomatoes (Appendix IV). The highest shelf life (37.00 days) was observed in

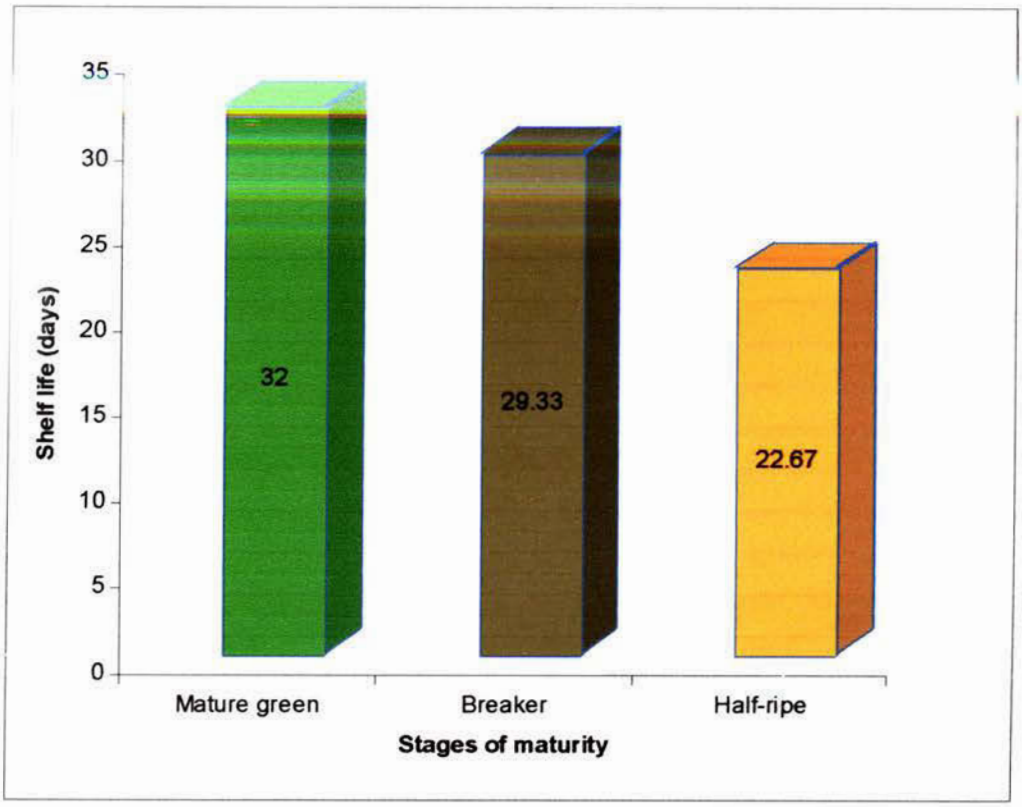


Fig. 6 Shelf life of tomato influenced by different stages of maturity

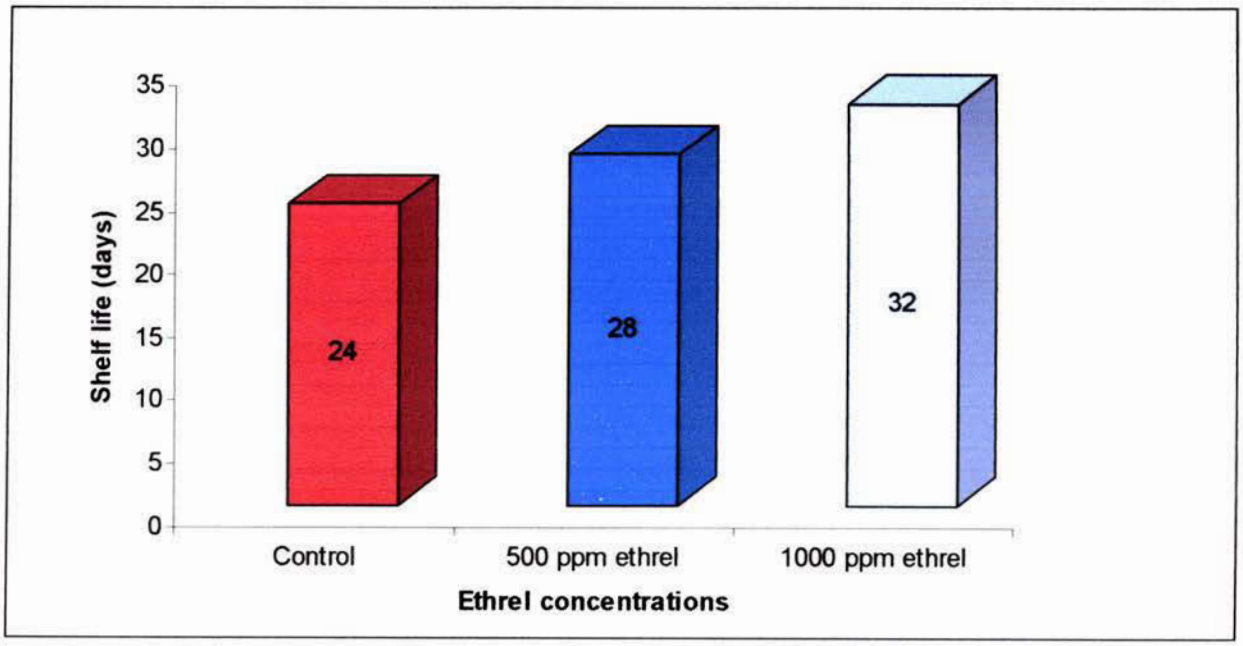


Fig. 7 Shelf life of tomato fruits as influenced by different concentrations of ethrel solution

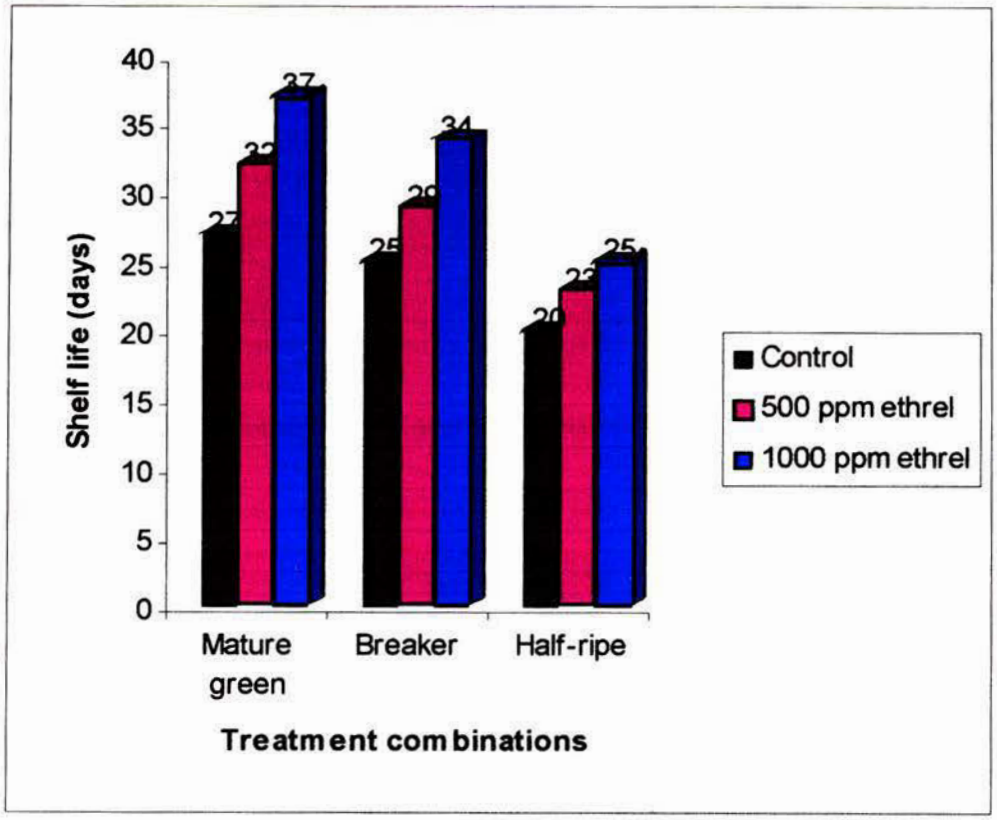


Fig. 8 Shelf life of tomato as influenced by combined effects of stages of maturity and ethrel

mature green tomatoes under the 1000 ppm ethrel treatment, followed by treatment of breaker tomatoes and half ripe 34.00 days and 25.00 days respectively, while it was found the lowest (20.00 days) in full ripe tomatoes under control treatment (Fig. 8)

Similar result indicating longer shelf life of mature green tomato was also reported by Hossain *et al.* (1996).

4.2 Changes in chemical characteristics of tomato fruit

4.2.1 Ascorbic acid content of tomato pulp

Ascorbic acid content of tomato pulp varied significantly in fruits of different maturity. Results showed that ascorbic acid content was decreased with the advancement of ripening of tomato fruits (Table 4). Half-ripe tomato contained the highest quantity of ascorbic acid (19.96mg/100g-tomato pulp) while the mature green tomato contained the lowest quality of ascorbic acid (7.73 mg/100mg tomato pulp) at harvest. As the storage time advanced the ascorbic acid content of tomato juice decreased in fruits of all maturity stages but the process was slow in mature green fruits. Half-ripe fruits had a sharp decrease in ascorbic acid with the advancement of storage time. At 12^{th} day of storage, the ascorbic acid contents were 12.23 mg per 100g tomato pulp and 4.86mg per 100g tomato pulp in half ripe and mature green tomatoes respectively. similar results about the highest content of ascorbic acid in half ripe tomato were also reported by Mallik et al. (1996).

The ascorbic acid content of tomato pulp also varied significantly due to different ethrel treatment irrespective of maturity stages (Table 5). However, it was found to decrease in all storage condition with the advancement of ripening process and in ordinary condition it reached to (8.00mg) at 12 days from initial value of storage (13.76mg/100g).

The combined effect of stages of maturity and ethrel concentration was found highly significant at all day of storage period (Appendix V). The maximum ascorbic acid content (12.46mg per 100g tomato pulp) at 12^{th} day of storage was recorded in half-ripe tomato treated with 1000 ppm ethrel while it was minimum (3.68mg/100g tomato pulp) in mature green tomato under control condition (Table 6).

The decrease in ascorbic acid content of tomato juice with the advancement of ripening stage of fruits and storage period might be due to the conversion of the acid to sugar with the activity of ascorbic dehydrogenase (Rahman *et al.*, 1979).

4.2.2 pH of tomato juice

The pH content of tomato pulps varied significantly in fruits of different maturity stage at all storage duration (Appendix VI). Result showed that it was increased with the advancement of ripening of fruits (table 4). The highest pH value (4.63) was observed in mature green tomatoes followed by breaker (4.38) and half-ripe fruits (4.27) respectively at 12 days of storage. Similar trend was also reported in pineapple by Singleton and Gorther (1965) and Botrel *et al.*(1993).

Table 4. Main effect of maturity stages on the Vitamin-C, pH and percent titrable acidity of tomato at different days of storage

Treatment	Vitamin-C (mg/100g)					PH					Titrable acidity (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1	7.73c	6.77c	5.91c	4.27c	3.86c	4.37	4.31a	4.43a	4.44a	4.63a	0.400 b	0.447a b	0.442 b	0.454c	0.446c
M_2	13.52a	11.12 b	10.11 b	9.04b	7.78b	4.19	4.23b	4.27b	4.29b	4.38b	0.409 b	0.442 b	0.463a	0.479a	0.464a
M_3	19.96 b	16.42a	15.76a	14.80a	12.23a	4.18	4.24b	4.25c	4.17c	4.27c	0.429a	0.454a	0.458a	0.466 b	0.455 b
CV %	0.42	0.93	1.20	1.24	1.72	1.88	0.23	0.31	0.39	0.45	4.04	1.49	0.42	0.71	0.42

Table 5. Main effect of ethrel treatment on the Vitamin-C, pH and percent titrable acidity of tomato at different days of storage

Treatment	Vitamin-C (mg/100g)					PH					Titrable acidity (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
E_0	13.76	11.57a	10.89a	9.57a	8.00a	4.26	4.28a	4.33	4.36a	4.44a	0.412	0.440 b	0.452 b	0.464 b	0.455 b
E_1	13.72	11.39 b	10.51 b	9.50a	8.06a	4.26	4.22b	4.32	4.31b	4.45a	0.415	0.451a	0.454 b	0.469a	0.453 b
E_2	13.73	11.35 b	10.38c	9.05b	7.81b	4.22	4.28a	4.32	4.23c	4.38b	0.412	0.451a	0.458a	0.466 b	0.458a
CV %	0.42	0.93	1.20	1.24	1.72	1.88	0.23	0.31	0.39	0.45	4.04	1.49	0.42	0.71	0.42

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

The effect of ethrel treatment on pH of tomato juice was found significant at all day of storage except 6 day of storage. The maximum pH value (4.45) was recorded in 500 ppm ethrel treated fruits and it was minimum (4.38) of use of 1000 ppm ethrel on 12th day of storage (Table 5)

The combined effect of stages of maturity and ethrel concentrations was also found significant (Table 6). However the highest pH content (4.71) was recorded in mature green tomatoes under treated with 500 ppm ethrel, while it was lowest (4.26) in full ripe tomatoes under the control treatment at 12th day of storage.

The increase in pulp pH recorded in this experiment might be due to continuous fall in acidity during ripening. The present finding is an agreement with the that of Kumar *et al.* (1993) who observed that pulp of mango was increased during storage.

4.2.3 Total titrable acidity content of tomato pulp

The Total titrable acidity (%) in tomato pulp varied significantly in fruits of different maturity (Table 4) stages irrespective of storage duration. The breaker staged tomato pulp contained the highest quantity of total titrable acidity (0.479%) followed by half ripe (0.466%) and mature green tomatoes (0.454%) at 9th day of observation. Results showed that the titrable acidity content of tomato juice was increased with the advancement of ripening of fruits and reached at peak stage on 9th day and thereafter again started to decrease. This result is observed to be similar to the findings of Sinage (1986) and Siddiqui *et al.* (1986).

Table 6. Combined effect of stages of maturity and ethrel on Vitamin-C, pH and percent titrable acidity of tomato at different days of storage

Treatment	Vitamin-C (mg/100g)					PH					Titrable acidity (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1E_0	7.85c	6.71e	5.91e	4.20g	3.68f	4.35	4.39a	4.42b	4.46b	4.65b	0.400	0.424d	0.438c	0.453 c	0.444b
M_1E_1	7.68d	6.73e	5.91e	4.42f	3.91ef	4.44	4.28c	4.46a	4.52a	4.71a	0.400	0.457a b	0.440c	0.454 c	0.443b
M_1E_2	7.65d	6.86e	5.91e	4.20g	3.98e	4.31	4.26c	4.42	4.35c	4.52c	0.401	0.459a	0.447b c	0.454 c	0.452a b
M_2E_0	13.55 b	11.43 c	10.30c	9.40d	7.91c	4.26	4.23d	4.32c	4.36c	4.41d	0.400	0.440c	0.460a b	0.472 ab	0.465a
M_2E_1	13.48 b	11.00 d	10.12c	9.26d	7.80cd	4.17	4.18f	4.24e	4.29d	4.37e	0.411	0.444a bc	0.461a b	0.482 a	0.462a
M_2E_2	13.57 b	10.93 d	9.90d	8.46e	7.62d	4.14	4.27c	4.26de	4.23f	4.37e	0.417	0.452a bc	0.458a b	0.462 bc	0.456a b
M_3E_0	19.92 a	16.56 a	16.45a	15.10a	12.41a	4.18	4.21e	4.24e	4.26e	4.26f	0.436	0.457a b	0.457a b	0.466 bc	0.455a b
M_3E_1	19.96 a	16.26 b	15.32b	14.49c	11.82b	4.16	4.20e	4.25de	4.13g	4.28f	0.433	0.452a bc	0.460a b	0.470 ab	0.454a b
M_3E_2	19.99 a	16.44 ab	15.50b	14.82b	12.46a	4.30	4.30b	4.27d	4.12g	4.26f	0.417	0.442b c	0.468a	0.483 a	0.465a
CV %	0.42	0.93	1.20	1.24	1.72	1.88	0.23	0.31	0.39	0.45	4.04	1.49	0.42	0.71	0.42

Maturity stages

M_1= Green matured tomato

M_2= Breaker stage of tomato

M_3= Half ripened tomato

Concentration of ethrel solusion

E_0= Control

E_1= 500 ppm ethrel

E_2= 1000 ppm ethrel

Table 6. Combined effect of stages of maturity and ethrel on Vitamin-C, pH and percent titrable acidity of tomato at different days of storage

Treatment	Vitamin-C (mg/100g)					PH					Titrable acidity (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1E_0	7.85c	6.71e	5.91e	4.20g	3.68f	4.35	4.39a	4.42b	4.46b	4.65b	0.400	0.424d	0.438c	0.453 c	0.444b
M_1E_1	7.68d	6.73e	5.91e	4.42f	3.91ef	4.44	4.28c	4.46a	4.52a	4.71a	0.400	0.457a b	0.440c	0.454 c	0.443b
M_1E_2	7.65d	6.86e	5.91e	4.20g	3.98e	4.31	4.26c	4.42	4.35c	4.52c	0.401	0.459a	0.447b c	0.454 c	0.452a b
M_2E_0	13.55 b	11.43 c	10.30c	9.40d	7.91c	4.26	4.23d	4.32c	4.36c	4.41d	0.400	0.440c	0.460a b	0.472 ab	0.465a
M_2E_1	13.48 b	11.00 d	10.12c	9.26d	7.80cd	4.17	4.18f	4.24e	4.29d	4.37e	0.411	0.444a bc	0.461a b	0.482 a	0.462a
M_2E_2	13.57 b	10.93 d	9.90d	8.46e	7.62d	4.14	4.27c	4.26de	4.23f	4.37e	0.417	0.452a bc	0.458a b	0.462 bc	0.456a b
M_3E_0	19.92 a	16.56 a	16.45a	15.10a	12.41a	4.18	4.21e	4.24e	4.26e	4.26f	0.436	0.457a b	0.457a b	0.466 bc	0.455a b
M_3E_1	19.96 a	16.26 b	15.32b	14.49c	11.82b	4.16	4.20e	4.25de	4.13g	4.28f	0.433	0.452a bc	0.460a b	0.470 ab	0.454a b
M_3E_2	19.99 a	16.44 ab	15.50b	14.82b	12.46a	4.30	4.30b	4.27d	4.12g	4.26f	0.417	0.442b c	0.468a	0.483 a	0.465a
CV %	0.42	0.93	1.20	1.24	1.72	1.88	0.23	0.31	0.39	0.45	4.04	1.49	0.42	0.71	0.42

Maturity stages

M_1= Green matured tomato

M_2= Breaker stage of tomato

M_3= Half ripened tomato

Concentration of ethrel solusion

E_0= Control

E_1= 500 ppm ethrel

E_2= 1000 ppm ethrel

The effect of ethrel concentration on the titrable acidity content of tomato juice was also found significant irrespective of maturity stage (Table 5). Results showed that titrable acidity content of tomato under all treatments was increased upto certain days of storage and then sharply declined with the advancement of storage period. At 9th day of storage the highest quantity of acidity content (0.469%) was recorded in 500 ppm treatment while it was minimum (0.464%) in control condition.

The total titrable acidity content was significantly influenced by the combined effect of stages of maturity and ethrel treatments (Table 6). The maximum total titrable acidity content (0.483%) at 9th day of storage was recorded in half-ripe tomatoes with 1000 ppm ethrel treatment, while it was minimum (0.453%) in mature green tomatoes under the control treatment.

The interaction between the stage of maturity and ethrel concentration in total titrable acidity was also found significant at 3rd, 6th, 9th and 12th day of storage (Appendix VII). Organic acid can be considered as a reserve source of energy of the fruit and would, therefore be expected to decline during greater metabolic activity that occurs during ripening of fruits. For this reason, in most of the climacteric fruits acidity declines as ripening advances (Wills *et al.* 1987).

4.2.4 Reducing sugar content of tomato pulp

Significant variation among the tomato fruits of different maturity stages was recorded in respect of reducing sugar content of the fruit pulp. Result showed that reducing sugar content was increased with the advancement of ripening of fruits upto 12th days of storage. Half-ripe tomato contained the highest quantity of reducing sugar while the mature green tomato contained the lowest quantity of the reducing sugar (Table 7). Yamaguchi *et al.* (1960) and Dalal *et al.* (1965) also observed the similar results.

The change in reducing sugar content was significantly influenced also by the ethrel treatments. The highest quantity (4.18%) of reducing sugar content was recorded under 1000 ppm ethrel treatment at 12th day of storage, while the control was found to show less value (4.04%) in this regard (Table 8) at 12 day of storage.

The combined effect of stages of maturity and ethrel treatments significantly affected the reducing sugar content of the fruit (Table 9). However, the highest quantity of reducing sugar content (4.50%) at 12th day of storage was recorded in half ripe tomato fruits treated under 1000 ppm ethrel while it was minimum (3.85%) in mature green fruits under control treatment at 12th day of storage.

The interaction effect was also found to be significant on change in reducing sugar content during storage (Appendix VIII).

Table 7. Main effect of stages of maturity on the percent of reducing, non-reducing and total sugar content of tomato pulp at different days of storage

Treatment	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1	2.31c	2.92c	3.38c	3.75a	3.88c	0.910c	1.243 b	1.407c	1.24c	0.878a	3.21c	4.16c	4.79c	4.99	4.76c
M_2	2.63b	3.23	3.52b	3.69b	4.03b	0.953 b	1.253 b	1.483 b	1.30a	0.877a	3.63b	4.49b	5.00b	4.97	4.90b
M_3	2.95a	3.28	3.61a	3.72a	4.38a	1.027a	1.337a	1.653a	1.27b	0.585 b	3.98a	4.60a	5.26a	4.99	4.96a
CV %	0.73	0.53	0.55	0.90	0.81	0.69	0.78	2.20	1.31	0.43	0.62	0.45	0.33	0.77	0.68

Table 8. Main effect of ethrel on the percent of reducing, non-reducing and total sugar content of tomato pulp at different days of storage

Treatment	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
E_0	2.60c	3.09c	3.47b	3.69b	4.04c	0.953 b	1.287a	1.493 b	1.30a	0.787a	3.56c	4.37c	4.97c	4.99	4.82b
E_1	2.64b	3.15b	3.49b	3.72b	4.08b	0.967a	1.257 b	1.537a	1.27b	0.763 b	3.60b	4.41b	5.03b	4.96	4.84b
E_2	2.69a	3.18a	3.54a	3.75a	4.18a	0.970a	1.290a	1.513a b	1.24c	0.790a	3.65a	4.47a	5.05a	4.99	4.96a
CV %	0.73	0.53	0.55	0.90	0.81	0.69	0.78	2.20	1.31	0.43	0.62	0.45	0.33	0.77	0.68

Maturity stages

M_1= Green matured tomato

M_2= Breaker stage of tomato

M_3= Half ripened tomato

Concentration of ethrel solusion

E_0= Control

E_1= 500 ppm ethrel

E_2= 1000 ppm ethrel

Table 7. Main effect of stages of maturity on the percent of reducing, non-reducing and total sugar content of tomato pulp at different days of storage

Treatment	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1	2.31c	2.92c	3.38c	3.75a	3.88c	0.910c	1.243 b	1.407c	1.24c	0.878a	3.21c	4.16c	4.79c	4.99	4.76c
M_2	2.63b	3.23	3.52b	3.69b	4.03b	0.953 b	1.253 b	1.483 b	1.30a	0.877a	3.63b	4.49b	5.00b	4.97	4.90b
M_3	2.95a	3.28	3.61a	3.72a	4.38a	1.027a	1.337a	1.653a	1.27b	0.585 b	3.98a	4.60a	5.26a	4.99	4.96a
CV %	0.73	0.53	0.55	0.90	0.81	0.69	0.78	2.20	1.31	0.43	0.62	0.45	0.33	0.77	0.68

Table 8. Main effect of ethrel on the percent of reducing, non-reducing and total sugar content of tomato pulp at different days of storage

Treatment	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
E_0	2.60c	3.09c	3.47b	3.69b	4.04c	0.953 b	1.287a	1.493 b	1.30a	0.787a	3.56c	4.37c	4.97c	4.99	4.82b
E_1	2.64b	3.15b	3.49b	3.72b	4.08b	0.967a	1.257 b	1.537a	1.27b	0.763 b	3.60b	4.41b	5.03b	4.96	4.84b
E_2	2.69a	3.18a	3.54a	3.75a	4.18a	0.970a	1.290a	1.513a b	1.24c	0.790a	3.65a	4.47a	5.05a	4.99	4.96a
CV %	0.73	0.53	0.55	0.90	0.81	0.69	0.78	2.20	1.31	0.43	0.62	0.45	0.33	0.77	0.68

Maturity stages

M_1= Green matured tomato

M_2= Breaker stage of tomato

M_3= Half ripened tomato

Concentration of ethrel solusion

E_0= Control

E_1= 500 ppm ethrel

E_2= 1000 ppm ethrel

The increase in reducing sugar with the advancement of ripening as well as storage time was due to the degradation of starches to glucose and fructose by the activities of amylase and maltose (Wills *et al.* 1987).

4.2.5 Non-reducing sugar content of tomato pulp

Significant variations among different stages of tomato fruits were recorded in respect of non-reducing sugar content of the tomato pulp (Appendix IX). Tomatoes of all stages of maturity were found to increase in quantity of non-reducing sugar during process of ripening and were in highest value at 6 day of storage (1.653%) at half ripe tomato. It was then found to gradually decrease with advancing ripening and was lowest (0.585%) at 12th day (table 7). Sinaga (1986) observed similar results in tomatoes with the progressing process of ripening.

Ethrel treatments also significantly affected the non-reducing sugar content of tomato pulp during the storage period. However, tomatoes treated with 1000 ppm ethrel recorded somewhat more quantity (1.513%) in the content of non-reducing sugar at 6th day of storage and lowest (0.763%) at 12th day of storage at 500 ppm ethrel treatment (Table 9).

The conbined effect of stages of maturity and ethrel combinations was found significant on the change in non-reducing sugar content of tomato pulp. The highest quantify of non-reducing sugar content (1.70%) at 6th day of storage was found in half-ripe tomatoes under treated with 1000 ppm ethrel while it was the lowest (1.40%) in mature green fruits under control treatment at 6th day of storage (Table 9).

Table 9. Combined effect of stages of maturity and ethrel on the percent of reducing, non-reducing and total sugar content of tomato pulp at different days of storage

Treatment	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS	0 DS	3 DS	6 DS	9 DS	12 DS
M_1E_0	2.50	2.86f	3.32d	3.81a	3.85f	0.92f	1.30b	1.40d	1.25c	0.90a	3.20e	4.16f	4.72g	5.06a	4.75ef
M_1E_1	2.31	2.90e	3.31d	3.73c	3.90f	0.90g	1.20e	1.41d	1.22c	0.83c	3.19e	4.10g	4.75f	4.95cd	4.73f
M_1E_2	2.36	3.00d	3.50c	3.71c	3.90f	0.91fg	1.23d	1.41d	1.25c	0.90a	3.24e	4.23e	4.91e	4.96bcd	4.80df
M_2E_0	2.65	3.15c	3.50c	3.62e	3.99e	0.94e	1.25cd	1.43d	1.35a	0.88ab	3.59d	4.40d	4.93e	4.97bcd	4.85cd
M_2E_1	2.67	3.25b	3.55b	3.70cd	4.00e	0.95e	1.25cd	1.50c	1.30b	0.85bc	3.62cd	4.50c	5.05c	4.93d	4.85cd
M_2E_2	2.70	3.30a	3.50c	3.75bc	4.10d	0.97d	1.26c	1.52c	1.25c	0.90a	3.67c	4.56b	5.02d	5.00bc	5.00b
M_3E_0	2.90	3.25b	3.60a	3.65de	4.28c	1.00c	1.31b	1.65ab	1.30b	0.58de	3.90b	4.56b	5.25b	4.95cd	4.86c
M_3E_1	2.95	3.30a	3.60a	3.72c	4.35b	01.03b	1.38a	1.61b	1.22c	0.57e	4.00a	4.62a	5.30a	5.01abc	4.95b
M_3E_2	3.00	3.25b	3.62a	3.80ab	4.50a	1.05a	1.32b	1.70a	1.29b	0.60d	4.03a	4.63a	5.23b	5.02ab	5.07a
CV %	0.73	0.53	0.55	0.90	0.81	0.69	0.78	2.20	1.31	0.43	0.62	0.45	0.33	0.77	0.68

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

The non-reducing sugar content was increased from mature green to full ripe stage and such increase might be due to breakdown of starch and thereafter formation to non-reducing sugar.

4.2.6 Total sugar content of tomato pulp

Total sugar content of tomato pulp varied significantly except 9th day of storage in fruits of different maturity (Appendix X). Results showed that total sugar content was increased with the advancement of ripening of fruits irrespective of maturity condition. The highest quantity of total sugar (4.96%) was recorded in half-ripe tomatoes while it was the lowest quantity (4.76%) in mature green tomatoes at 12th day of storage. Winsor *et al.* (1962) obtained similar results too.

Ethrel treatments were also found to affect significantly on total sugar content of tomato at different storage duration (Table 8). The highest quantity of total sugar content (4.96%) was recorded in tomatoes under 1000 ppm ethrel treatment at 12th day to storage followed by the 500 ppm ethrel treatment (4.84%) and it was the lowest in mature green tomato (4.82%) under control condition.

The combined effect of stages of maturity and ethrel treatment significantly affected the total sugar content of tomato during storage (Table 9). At 12th day of storage the highest quantity to total sugar content (5.07%) was recorded in half-ripe tomatoes under 1000 ppm ethrel treatment and the lowest (4.73%) of green mature tomatoes under 500 ppm ethrel treatment.

The interaction effect was also found to be significant on percentage of total sugar content at all day of storage (Appendix X).

The gradual increase in total sugar content found in this experiment is agreement with the results of Tsuda *et al.* (1999). They stated that total sugar content of mango fruits increased during ripening period and storage. The increase in total sugar content might be due to conversion of starch in sugars.

4.2.7 TSS content of tomato pulp

TSS is one of the most important quality factors for most of the fruits. TSS of 4.80% to 8.80% indicates the highest quality of tomato (Singh, 1980). In the present experiment, the TSS content of tomato juice varied significantly in fruits of different maturity stages. Results showed that half-ripe tomatoes contained the highest quantity of TSS (4.82%) while it was the lowest (3.85%) in mature green tomatoes at the harvest time (Table 10). For all maturity stages, TSS increased gradually with the advancement of ripening process. Winsor *et al.* (1962) also reported similar trend of results.

Ethrel treatments were also found to have significant effects on change in TSS content of tomato juice at 3, 6, 9 and 12th day of storage (Table 11). The highest quantity of TSS content (5.20%) was recorded in treated with 1000 ppm ethrel while it was the lowest (4.92%) in control condition at 12th day of data recording.

The TSS content was also found to be significantly influenced by the combined effect of stages of maturity and ethrel treatments during the whole period of

Table 10. Main effect of stages of maturity on the percent TSS content of tomato pulp at different days of storage

Treatment	Total soluble solid (TSS %)				
	0 DS	3 DS	6 DS	9 DS	12 DS
M_1	3.85c	4.22c	4.53c	4.59c	4.68c
M_2	4.54b	4.60b	4.93b	4.99b	5.06b
M_3	4.82a	4.91a	5.22a	5.30a	5.38a
CV %	3.78	0.95	1.36	1.34	1.00

Table 11. Main effect of ethrel on the percent TSS content of tomato pulp at different days of storage

Treatment	Total soluble solid (TSS %)				
	0 DS	3 DS	6 DS	9 DS	12 DS
E_0	4.32	4.46c	4.78c	4.82c	4.92c
E_1	4.39	4.57b	4.89b	4.95b	5.00b
E_2	4.51	4.71a	5.01a	5.11a	5.20a
CV %	3.78	0.95	1.36	1.34	1.00

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

Table 12. Combined effect of stages of maturity and ethrel on the percent TSS content of tomato pulp at different days of storage

Treatment	Total soluble solid (TSS %)				
	0 DS	3 DS	6 DS	9 DS	12 DS
M_1E_0	3.82	4.13f	4.32f	4.36g	4.49g
M_1E_1	3.83	4.27e	4.54e	4.60f	4.65f
M_1E_2	3.91	4.26e	4.72d	4.81e	4.89e
M_2E_0	4.42	4.43d	4.89c	4.90de	4.96de
M_2E_1	4.51	4.52c	4.91c	4.96d	5.00d
M_2E_2	4.69	4.86b	5.00c	5.12c	5.21c
M_3E_0	4.71	4.83b	5.12b	5.20bc	5.30bc
M_3E_1	4.84	4.91b	5.21b	5.30ab	5.35b
M_3E_2	4.92	5.00a	5.32a	5.40a	5.50a
CV %	3.78	0.95	1.36	1.34	1.00

Maturity stages
M_1= Green matured tomato
M_2= Breaker stage of tomato
M_3= Half ripened tomato

Concentration of ethrel solusion
E_0= Control
E_1= 500 ppm ethrel
E_2= 1000 ppm ethrel

ripening (Table 12). The TSS content was found to increase with the progress of storage time. The highest quantity of TSS content (5.50%) at 12th day of storage was recorded in half ripe tomatoes treated with 1000 ppm ethrel whereas, it was minimum (4.49%) in mature green tomatoes under control treatment.

The interaction between the stage of maturity and ripening conditions was significant only at 3, 6, 9 and 12th day of storage (Appendix XI).

The trend of increase in percent TSS content found in the present experiment is similar to that of the findings of Aziz *et al.* (1975). They found gradual increase of TSS content during advancing stages of ripening and storage which was possibly due to hydrolysis of starch in to sugar.

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

An experiment was carried out in the laboratories of the Plant Physiology of Horticulture Research Centre (HRC) and Post Harvest Laboratories under the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during the period from January to March 2005 to study the changes in ripening and quality of tomato fruits during ripening process as influenced by stages of maturity and ethrel treatments. Fruits of three maturity stages, viz., mature green, breaker stage and half ripe were harvested and were kept in a laboratory room on the same day under the three ethrel concentrations viz., control, 500 ppm ethrel and 1000 ppm ethrel. The experiment having 9 treatments was laid out in a Randomized Complete Block (RCB) Design with three replications. The average maximum and minimum temperatures of the storage room were 26.6 and 14.9°C respectively. The atmospheric humidity was around 70.84%. Observations were made on colour, weight loss or gain, shelf life, vitamin-c (ascorbic acid), pH, titrable acidity, reducing sugar, non-reducing sugar, total sugar and TSS of tomato pulp. The data were collected at 3 days interval and were statistically analyzed following DMRT and F-test.

Different maturity stages, ethrel treatment and their combinations showed highly significant variation on ripening and quality of tomato studied. When considering the maturity stages, the highest values of quick colour development or ripening (5.33 days of storage), vitamin-c (19.96 mg/100g), reducing sugar (4.38%), total sugar (4.96%) and TSS (5.38%) were shown by half ripe tomatoes, highest weight loss (14.79%), shelf life (32.00 days) and

non-reducing sugar (0.878%) by mature green tomatoes and highest titrable acidity (0.464%) by breaker staged tomatoes at final day of observation (15 or 12 days of storage). On the contrary, the lowest values in weight loss (14.11%), shelf life (22.67days), pH (4.27) and non-reducing sugar (0.585%) were recorded in half ripe tomatoes, delay colour development or ripening (9.67 days), vitamin-c (3.86%), titrable acidity (0.446%), reducing sugar (3.88%), total sugar (4.76%) and total soluble solid (4.68%) by mature green tomatoes. The percentage of weight loss, pH, titrable acidity, reducing sugar, total sugar and TSS were found to increase with gradual advancement of time, irrespective of maturity stages while percentage of vitamin-C and non-reducing sugar were found to decrease with progressing time of storage.

The ethrel treatments also showed significant influence on different parameters studied. The highest values of weight loss (14.67%) were recorded in tomatoes of control treatment and quick colour development (4.33 days), shelf life (32.00 days), titrable acidity (0.458%), reducing sugar (4.18%), non-reducing sugar (0.790%), total sugar (4.96%) and TSS (5.20%) were recorded by 1000 ppm ethrel treatment and vitamin-C (8.06 mg/100g) and pH (4.45) by 500 ppm ethrel treatment at final day of observation (15 or 12 days). On the contrary, the lowest values of colour development (11.00 days), shelf life (24.00 days), reducing sugar (4.04%), total sugar (4.82%) and TSS (4.92%) were recorded by controlled tomatoes and weight loss (14.32%), vitamin-C (7.81 mg/100g) and pH (4.38) were recorded by 1000 ppm ethrel treatment and titrable acidity (0.453%) and non-reducing sugar (0.763%) by 500 ppm ethrel

treatment at final day of observation. The values of the above parameters except vitamin-C and non-reducing sugar were found to increase gradually with the advancement of ripening process irrespective of different treatment conditions.

The combined effect of maturity stages and ethrel treatment also influenced significantly different on ripening and quality of tomato during storage. The half ripe tomato treated with 1000 ppm ethrel gave quick colour development (3.00 days) and the highest vitamin-C (12.46 mg/100g tomato pulp), titrble acidity (0.456%) reducing sugar (4.50%), non-reducing sugar (1.70%), total sugar (5.07%) and TSS (5.50%) at final day of observation and the mature green tomato treated with 1000 ppm ethrel showed maximum days of shelf life (37.00 days) and showed the highest pH (4.71) at the 500 ppm ethrel treatment. One the other hand, the mature green tomato under control treatment showed highest weight loss (14.92%) at the final day of observation. The mature green tomato treated in control condition showed the delay colour development or ripening (15.00 days) and the lowest vitamin-C (3.68 mg/100g tomato pulp), reducing sugar (3.85%) and TSS (4.49%)at the final day of observation. Half ripe tomato treated with 1000 ppm ethrel showed the lowest weight loss (14.00%), pH (4.26) and non-reducing sugar at the final day observation and green mature tomato treated with 500 ppm ethrel showed the lowest titrable acidity (0.443%) and total sugar (4.73%) and half ripe tomato with control treatment showed the lowest shelf life (20.00 days).

From the investigation, it may be concluded that for early ripening, half-ripe tomato treated with 1000 ppm ethrel is the best and to extend the shelf life, mature green tomato treated with 1000 ppm ethrel is the best. On the other hand, the ascorbic acid, reducing sugar, non-reducing sugar, total sugar and TSS were found to be the highest when half ripe tomatoes were treated with 1000 ppm ethrel.

REFFERENCES

Abdullah, H., M. A. Rohaya and M. Z. Zaipun. 1986. Storage study of pineapple (*Ananas comosus* cv. Sarawak) with special emphasis on black heart disorder. MARDI Res. Bull., 14(2) : 132-138.

Agnihotri, B. N. and H. B. ram. 1970. Role of skin coatings on the storage life of tomatoes. Progressive Hort., 2(3) : 1-68.

Anju-Kumari, M.K. Bhardwaj, S.P.S Guleria and a. Kumari. 1993. Influence of stage of harvest on shelf life and quality of tomato. Hort. J. 6(2) : 89-92.

Awasthi, C.P., R.C. Jaiswal, S. Ajay and I.S. Singh. 1992. Biochemical composition of promising tomato (*Lycopersicon esculentum*) cultivars. Himachal J. Agril, Res., 18 (1&2) : 173-177.

Aziz, A.B.A., S.M. El-nabaws and H.A. Zaki. 1975. Effect of different temperatures on the storage of papaya fruits and respirational activity during storage. Scientia Hort., 3(2): 173-177.

Bajaj, K.L., R. Mahajan, P.P. Kaur and D.S. Cheema. 1990. Chemical evaluation of some tomato varieties. J. Res. Punjab Agril. Univer., 27; 226-230.

Balla C., T. Saray, K. Horti, A. Konez and K. Polyak. 1994. Study of the colour development of tomato during post harvest handling. Quality criteria Proc. of a workshop. Bled slowevia. 19-21 Ap. 81-92 (cited form Post harvest News and Information, 7 (5) : 300, 1996.

BBS. 2005. 2004 Year book of Agricultural Statistics of Bangladesh, Bangladesh Bureau of statistics, Statistics Division, Ministry of planing, Govt. of the peoples Republic of Bangladesh, Dhaka, p. 108.

Boe, A.A., J.Y. Do and D.K. Salunkhe, 1967. Tomato ripening : Effects of life frequency, magnetic field and chemical treatments. Econ. Bot., 24 : 124.

Borooah, S. and N. K. Mohan. 1975. Correlation study between fruit size and ascorbic acid conternt. Current Res. Banglore, India 5(5) : 82.

Botrel, N., V. D. De-Carvalho And V. D. Capriade. 1993. Effect of fruit weight on internal browning and quality in pineapple smooth cayenne. in Internal browning, total soluble soilds, total titrable acidity, pH and Sugars. Pesquisa Agropequaria Brasiliera, 28 (9) : 1055-1064 [Cited form Post harvest News and Information, 9 (2) : 329, 1995].

Cabibel, M. and F. Perry. 1980. Effect of storage temperature on keeping quality of tomato. Annales de Technologie agricole. 29: 27-45.

Cerne, M., M. Resnik, and B. J. Bieche. 1994. Fruit quality of tomato cultivars. Acta Hort., 376 : 313-318.

Dalal, K. B., D. H. Salunkhe, A. A. Boe and L. E. Olsen. 1965. Certain physiological and biochemical changes in the developing tomato fruits (*Lycopersicon esulentum* Mill.) J. Food Sci., 30 : 504-508.

Davies, J. N. 1966 Changes in non-volatile organic acids of tomato fruit during ripening. J. Sci. Food. Agric., 17 : 396-400.

Davies, J. N. and R. J. Kempton, 1975. Changes in the indidvidual sugars of tomato fruit during ripening. J. Sci. Food. Agric., 26 : 1103-1110.

Dennis, C., K. H, Browne and F. Adamic. 1979. Controlled atmosphere storage of tomatoes. Proc. Symp. On quality of vegetables. Acta Hort., 9375.

Dod, V. N. and . P. B. Kale. 1977. Performance of some tomato varieties under vadarbha conditions. PKV Res. J., 21 (2) : 201-203.

Dong Huiru, B. Jin., D. Quio, L. Lu and H. Lin 1996. Study on changes in some organic materials in tomato fruits during growth and development Acta Hort., 12 (1) : 41-44.

Gomez., K. A. and A. A. Gomez. 1984. Statistical Procedure for Agricultura Research (2nd ed.) John Wiley & sons, Singapore. pp. 18-192.

Gupta. O. P. N. Methan and M. L. Pandita. 1988 Effect of ethrel on the storage behaviour of tomato fruits at various storage conditions. Hariana J. Hort Sci. 17 (3-4) : 265-272.

Hamauzu, Y. Y. Miyamoto and k. Chachin, 1995 Effect of high temperature on the change of carotenoid contents in tomato fruits after harvest. J Japan. Soc. Hort. Sci., 63 (3) : 675-684.

Hobson, G.E. and J.N. Davies. 1971. The tomato. The biochemistry of fruit and their products. Vol. 2. Ed. By A.C. Hulme. Academic Press. Pp 337-482.

Hossain, M. A., Goffer, J. C. S. Chowdhury and M. S. Mollaoh. 1996 SHelf life of fruits of some tomato lones under ordinary storage condition. BARI Annual Report. pp. 5-8.

Inaba, M. and D.G. Crandall. 1986. Cold shock treatment of mature green tomatoes to delay colour development and increase shelf life during

room temperature storage. Proc. of the Florida State Hort. Soc. 99 : 143-445. [Cited from Hort. Abstr., 58(5): 2925, 1988].

IPGRI. 1992. Sigma colour. International Plant Genetic Resources Institute. Rome, Italy.

Islam, M. S., T. Mafsui and Y. Yoshida. 1996, Physical, Chemical and physiological changes in storage tomatoes under various temperature Tech. Bull. Faculty Agric. Kagawa Univ., 48 (1) : 7-16.

Jana, S. C. and T. K. Chattapadhyay. 1989. Studies on the post harvest physiology in tomato. Hariana. J. Hort. Sci. 18(3-4) : 305-308.

Jobling J. 2000. Post harvest ethylene: a critical factor in quality management. Collected from website www. Postharvest.com.au

Kader, A.A., L.L. Moris, M.A. Stevens and M. Albright. 1978. Composition and flavor quality of fresh market tomatoes as influenced by some postharvest handling procedures. J. Amer. Soc. Hort. Sci. 103(1) : 6-13.

Kallo. 1985 Tomato. Published by R. H. Saehdevfor Allied Publishers Pvt. Ltd. India. p. 33.

Kaynes, K. and N. Surmeli 1995. Characteristic changes at various ripening stages of tomato fruits stored at different temperatures. Turkis J. Agric Forestry, 19 (4) : 277-285.

Kim, Y. Kubo A. Inaba and Nakamura. 1996. Effect of storage temperature on keeping quality of tomato and strawberry fruit. J. Kor. Soc. Hort. Sci 37 (4) : 526-526 [cited form Post harvest News and Information, 8 (1) 24, 1997].

Konsler, T. R. 1973. Three mutants appearing in 'Manapal' tomato. HortScience., 3 : 331-333.

Kumar, S., D.K. Das, A.K. Singh and U.S. Prasad. 1993. Changes in not volatile organic acid consumption and pH during maturation and ripening of two mango varieties. Indian J. Plant Physiol., 36(2) ; 85-90.

Lopez-lago, I. J. Diaz-Varela and L Merno-De-Cacares. 1997. Quality of tropical tomato on scale in the market. Alimentaria, 1 (34) : 272, 59-60 [Cited from Post harvest News and information, 5 (3) : 280, 1998].

Mallik, S. E., B. Bhattacharja and B. Bhattacharja. 1996. Effect of stage of harvest on storage life and quality of tomato Environ. Ecol., 14 (2) : 301-303.

Masarirambi, H. T., J. K. Breeht, S. A. Sargent and C. A. Sims. 1995. Tomato colour development following exposure to ethylene at high temperatures. 108th annual meeting of the Florida State Hort. Sco. Proc Florida State Hort. Soc., 108 : 268-272.

Matthews, R. F., P. Crill and D. S. Burgis. 1973. Ascorbic acid content of tomato varieties. Proc. Florida State Hort. Soc., 85 : 242-245.

Murray, M. and T.K. Hartz. 2001. Using ethaphone effectively for enhancing early season processing tomato fruit maturity in California. Acta Horticulturae 542: 373-376.

Park, H. J. M. S. Chinnan and R. L. Shewfeld. 1994. Edible coating effects on storage life and quality of tomatoes. J. Food. Sc., 59 (3) : 568-570.

Rahman, M.A., M.A. Quddus and M.S. Haque. 1979. Studied on pineapple: part III- the effects of different physical treatments on the changes in physiological and biochemical characteristics in stored pineapples. Bangladesh J. Sci. Ind. Res., (411-412): 109-112.

Rangana. 1979. Manual of analysis of fruits and vegetables products. Tata McGraw-Hill Co. Ltd. New Delhi. 2-95, 634.

Reymundo, L. E. C. O. Cheshester and K. N. Simpson. 1976. Changes in qualitative components of two tomato varieties. Agri. Food. Chem. 24 : 59-64.

Reynard, G. B. and M. S. Kanapause. 1942. Ascorbic acid (vitamin-C) content of some tomato varieties and species. Proc: Amer. Soc. Hort. Sci., 41 : 298-300.

Rick, C.M. and L. Bulter. 1956. Cytogenetics of tomato. Hort. Genet. 8: 267-382.

Rosa, J. G. 1926. Ripenning and storage of tomatoes. Proc. Amer Soc. Hort Sci., 23 : 233-240.

Russo J.T. 1968. Hastening of tomato ripening with folier spray of 2-chloroethyl phosphonic acid. Punjab Agril. Univ. J. Res. 13: 286-289.

Saimbhi, M. S. D. S. Cheema, S. Singh and K. S. Nandpuri. 1995. Physic chemical chracteristics of some tomato hybrids. Trop. Sci., 35 (1) : 9-12.

Saimbhi, M. S., R. Mahainan, S. Singh and B. S. Gill. 1987. Physico-chemica constituents of some root knot nematode resistant tomato lones and varieties for processing. J. Res. Punjab Agril. Univ., 24 : 229-238.

Salunkhe, D. K. and B. B. Desai. 1984. Psot harvest Biotechnology of Fruits Vol. 2. CRC Press. Inc. Roca. Florida. P. 7.

Sandooja, J. K., R. K. Sharma, M. L. Pandita and B. R. Batra. 1987. Studies of shelf life of different maturity stages of tomato as affected by varion chemicals. Haryana Agril. Univ. J. Res., 17 (1) : 39-46.

Sands, C. E. 1995. A review of chemical investigation of the tomato, U. S. Dept. Agric. Tech. Bull., p. 859.

Sargent. S. 2000. Ripening tomatoes with ethylene. Collected from website. http:/ edis.ifas.ufl.edu

Sharfuddin, A. F. M. and M. A. siddique 1985. Sabjibijan, Bangladesh Agricultural University, Mymensingh, Bangladesh, 32 p.

Siddiqui, S., O.P Gupta and V. E. Pandy. 1986. Assessment of quality of tomato varieties at various stages offruit maturity. Prog. hort. 18 (1-2) 97-100.

Sinaga, R. M. 1986. Effect of maturity stages on quality of tomato cv. Money maker. Bulleting Penelitian Horticultura. 13 (2) : 42-53 [Cited form Post harvest News and Information, 7 (2) : 225-227, 1987].

Singh, K.K. 1980. Processing of tomatoes for reduction of postharvest losses. Punjab Hort. J. 20 (3 and 4) : 98.

Singleton, V L. and W. A. Gortner. 1965. Chemical and physical development of the pineapple fruit II Carbohydrate and acid constityents. J. Food Sci. 30 (1) : 19-29.

Stevens, M. A. and M. A. Long 1971. Inheritance of malate in tomatoes J. Amer. Soc. Hort. Sci. 96 : 120-122.

Subburamu, K., M. Singaravelu, A. Nazar and I. Irulappan. 1990 Effect of stage of harvest in tomato cultivars in improving the shelf life and fruit quality. South Indian Hort., 38 (4) : 199-203.

Suthar, V. P. and R. Bhatnagar. 1999. Biochemical changes in tomato fruits during storage. J. Mahrastra Agril, Univ., 24 (3) : 229-238.

Syamal, M. M. 1981. Biochemical composition of tomato fruits during storage Acta Hort., 287 : 369-374.

Taranov, V. and A. Krustakalne. 1974 Yourmalas a tomato variety for cultivation under plastic. plant Breed Abste., 44(5) : 296.

Tauqur, A., I. Javain and U.K. Musahib. 1989. Effect of calcium carbide on physical changes in mango fruits during ripening. J. Agril. Res. 27(2): 121-128.

Tomes, M. L. 1963. Temperature inhibition of carotene synthesis in tomato Bot. Gaz., 124 : 180-185.

Tsuda, T., K. Chachin and Y. Ueda. 1999. Studies on keeping capacity of imported caraboo mango fruit from the Philippines. J. Jap. Sco. Hort. Sci., 68 (3) ; 669-674.

Wann, E. V., EL. Jourdain, R. Pressey and B. G. Lyon. 1985. Effect of mutant genotypeshp of and of on tomato fruit quality. J. amer. Soc. Hort. Sci., 110 : 212-215.

Wills, R. H. H. T. H. Lee, D. Graham, N. B. Glusson and E. G. Hall 1987m

Postharvest : An introduction to the physiology and handling of friut and vegetable. Granda publishibng Ltd. London, 161p.

Winsor, G. W., J. N. Davies and D. M. Massey 1962. Composition of tomato fruit juices from whole fruit and locules at different stages of ripens. J. Sci. Agric.,

Yamaguchi, M., F. D. Howard B. S. Luh and S. J. Leonard. 1960. Effect of ripeness and harvest dates on the quality and composition of fresh canning tomatoes. Proc. Amer. Soc. Hort. Sci., 76 : 560-567.

Yoltas, T., Y. Tuzel, A. Gul, K. E. Cockshull, Y. Tuzel and A. Gul, 1994. Effects of Semperfresh application on ripening of romato harvested at mature stage. Acta Hort., 366 : 469-474.

APPENDICES

Appendix I. Daily temperature and relative humidity of the storage room recorded during the period of study

Date	Room temperature		Relative humidity (%) (9 am)
	Maximum	Minimum	
18.01.05	24.1	14.1	74
19.01.05	25.1	16.5	75
20.01.05	23.8	11.7	69
21.01.05	23.7	10.7	67
22.01.05	21.7	10.6	67
23.01.05	21.9	11.2	73
24.01.05	23.1	12.4	73
25.01.05	23.9	12.9	73
26.01.05	24.7	13.2	74
27.01.05	25.1	12.6	70
28.01.05	24.9	11.7	70
29.01.05	25	16.3	79
30.01.05	27.1	15.1	70
31.01.05	28.7	14.5	71
01.02.05	24.4	17.9	69
02.02.05	25.2	16	75
03.02.05	23.7	10.5	77
04.02.05	25.4	10.2	74
05.02.05	26.5	11.6	69
06.02.05	27.2	11.7	64
07.02.05	28.1	15.1	75
08.02.05	29.5	15.2	67
09.02.05	29.9	15.7	68
10.02.05	28.9	16.2	63
11.02.05	28.7	156	67
12.02.05	31.1	15.9	68
13.02.05	31.9	18.2	68
14.02.05	29.9	18.9	69
15.02.05	30.5	17.7	61
16.02.05	30.1	20.5	78
17.02.05	31.7	23.2	74
18.02.05	31.6	21.8	76

Appendix II. Analysis of variance of data on colour development (days) of tomato as influenced by stages of maturity and ethrel .

Sources of variation	Degrees of freedom	Mean square of ripening
Replication	2	0.444
Factor A	2	43.00**
Factor B	2	103.00**
AxB	4	5.00**
Error	16	0.444

Appendix III. Analysis of variance of data on % weight loss of tomato as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % weight loss of tomato at different days of storage				
		3rd day	6th day	9th day	12th day	15th day
Replication	2	0.004	0.003	0.000375	0.027	0.011
Factor A	2	0.792**	14.527**	0.391**	4.856**	1.041**
Factor B	2	0.024*	0.142**	0.086**	0.417**	0.340**
AxB	4	0.031**	0.058**	0.013**	0.690**	0.075**
Error	16	0.004	0.024	0.000375	0.017	0.005

Appendix IV. Analysis of variance of data on shelf life (days) of tomato as influenced by stages of maturity and ethrel.

Sources of variation	Degrees of freedom	Mean square of shelf life
Replication	2	0.444
Factor A	2	208.00**
Factor B	2	144.00**
AxB	4	5.50**
Error	16	0.444

Factor A : Stages of maturity of tomato
Factor B : Ethrel concentrations

** :Significant at 1% level of probability
* : significant at 5% level of probability

Appendix V. Analysis of variance of data on % ascorbic acid content of tomato as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % ascorbic acid content (mg/100g tomato pulp) of tomato at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.083	0.018	0.001	0.0001	0.019
Factor A	2	336.856**	210.343**	219.737**	250.227**	157.967**
Factor B	2	0.008**	0.120**	0.630**	0.711**	0.155**
AxB	4	0.029**	0.094**	0.298**	0.194**	0.182**
Error	16	0.003	0.011	0.016	0.013	0.019

Appendix VI. Analysis of variance of data on pH of tomato juice as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of pH of tomato at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.006	0.00013	0.00019	0.00025	0.00038
Factor A	2	0.099**	0.019**	0.088**	0.169**	0.304**
Factor B	2	0.006^{NS}	0.010**	0.0001	0.037**	0.012**
AxB	4	0.010*	0.010**	0.004**	0.008**	0.009**
Error	16	0.006	0.00013	0.00019	0.00025	0.00038

Appendix VII. Analysis of variance of data on % total titrble acidity content of tomato pulp as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % total titrble acidity content of tomato pulp at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.0005	0.0001	0.00005	0.00005	0.00001
Factor A	2	0.002**	0.0005**	0.001**	0.001**	0.934**
Factor B	2	0.0002	0.0005**	0.00001**	0.00002*	0.017**
AxB	4	0.00025	0.0005**	0.00002**	0.00001*	0.001**
Error	16	0.00025	0.000063	0.000063	0.000063	0.00038

Factor A : Stages of maturity of tomato
Factor B : Ethrel concentrations

** :Significant at 1% level of probability
* : significant at 5% level of probability

Appendix VIII. Analysis of variance of data on % reducing sugar content of tomato pulp as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % reducing sugar content of tomato pulp at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.0005	0.0005	0.0005	0.001	0.001
Factor A	2	0.934**	0.329**	0.122**	0.008**	0.578**
Factor B	2	0.017**	0.022**	0.011**	0.008**	0.037**
AxB	4	0.001	0.007**	0.013**	0.015**	0.007**
Error	16	0.00038	0.00025	0.00038	0.001	0.001

Appendix IX. Analysis of variance of data on % non-reducing sugar content of tomato pulp as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % non-reducing sugar content of tomato pulp at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.00005	0.00005	0.001	0.0005	0.00005
Factor A	2	0.031**	0.024**	0.143**	0.008**	0.256**
Factor B	2	0.001**	0.003**	0.004*	0.008**	0.002**
AxB	4	0.001**	0.005**	0.004*	0.003**	0.003**
Error	16	0.00006	0.00013	0.01	0.0003	0.0003

Appendix X. Analysis of variance of data on % total sugar content of tomato pulp as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % total sugar content of tomato pulp at different days of storage				
		0th day	3rd day	6th day	9th day	12th day
Replication	2	0.001	0.0005	0.0005	0.001	0.001
Factor A	2	1.318**	0.468**	0.492**	0.002	0.095**
Factor B	2	0.015**	0.023**	0.019**	0.003	0.048**
AxB	4	0.003**	0.007**	0.014**	0.008**	0.006**
Error	16	0.001	0.00038	0.0003	0.001	0.001

Factor A : Stages of maturity of tomato
Factor B : Ethrel concentrations

** :Significant at 1% level of probability
* : significant at 5% level of probability

Appendix XI. Analysis of variance of data on % TSS content of tomato pulp as influenced by stages of maturity and ethrel

Sources of variation	Degrees of freedom	Mean square of % TSS content of tomato pulp at different days of storage				
		0^{th} day	3^{rd} day	6^{th} day	9^{th} day	12^{th} day
Replication	2	0.028	0.002	0.004	0.004	0.003
Factor A	2	2.239**	1.086**	1.083**	1.141**	1.129**
Factor B	2	0.082	0.134**	0.126**	0.190**	0.189**
AxB	4	0.008	0.030**	0.017*	0.016*	0.008*
Error	16	0.028	0.002	0.004	0.004	0.003

Factor A : Stages of maturity of tomato
Factor B : Ethrel concentrations

** :Significant at 1% level of probability
* : significant at 5% level of probability