PCR Workshop
on
Standardization of Ethylene Gas For Uniform Fruit Ripening in Low-cost Ripening Chamber

Presented By

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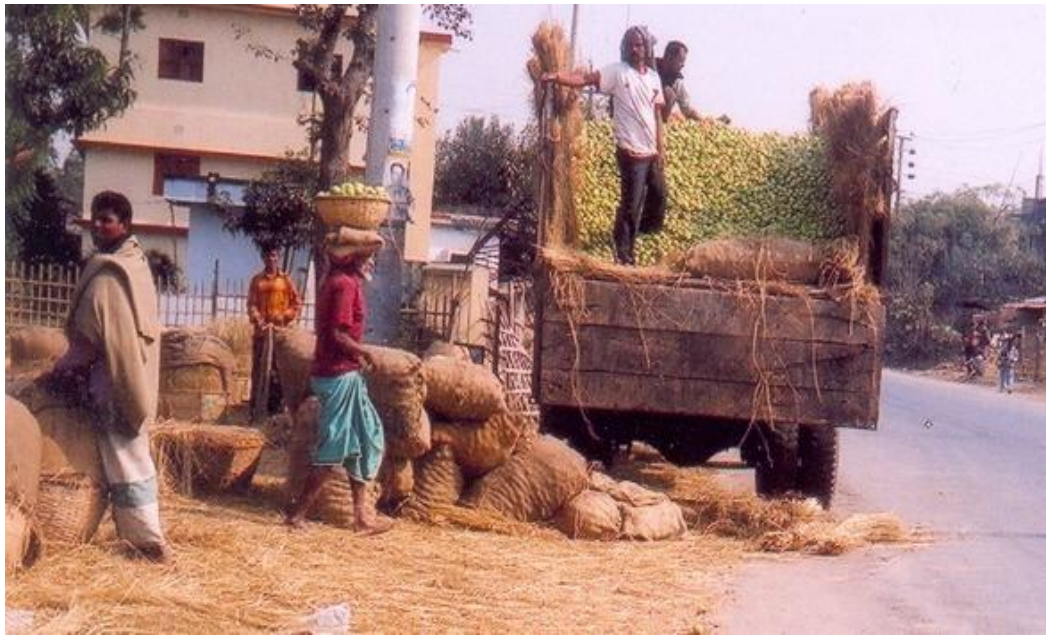
Background

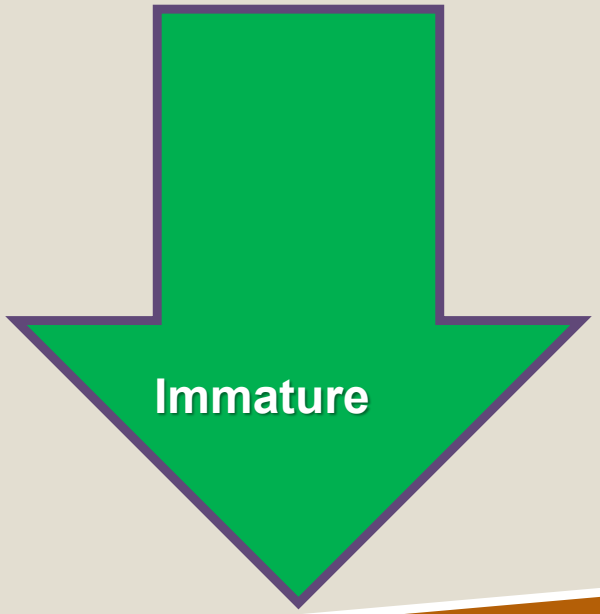
- Agriculture is the biggest industry in the world for its large volume of production provides food and nutritional security.
- Mango, banana, pineapple, papaya, tomato etc. are the high value agricultural commodity.
- The quality of the produce mainly depends on the optimum maturity.
- Proper maturity is one of the critical factor, which affects the ripening process, eating quality such as flavor and taste development in fruit (Lalel *et al.,* 2003).
- The immature harvested fruits are not nutritionally rich and will not develop typical flavour and quality (Brackmann *et al.,* 1993).


ইন্ডেন
TOM-TOP


2008 02 24 14 16



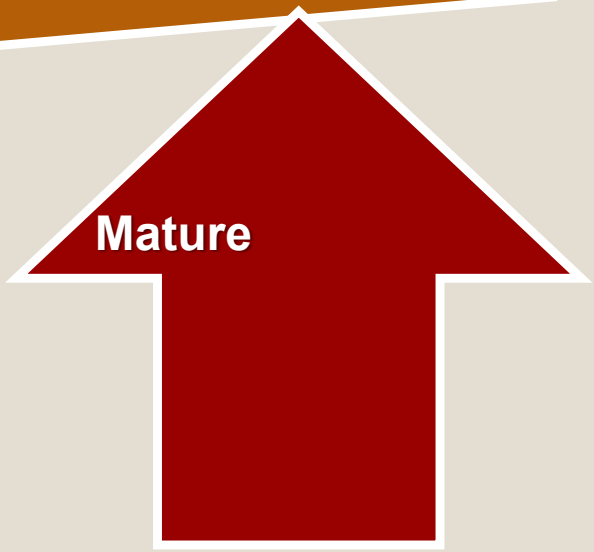
Natural Vs Artificial Ripening of Fruits/Vegetables



During natural ripening , a wide spectrum of biochemical changes takes place :

i. Chlorophyll degradation,
ii. Biosynthesis of carotenoids (antioxidants , immune system booster, anti-cancer agent),
iii. Anthocyanins (powerfull antioxidant) ,
iv. Essential oil and flavor, and
v. Aroma components

If artificial ripening is applied on immature fruits all these healthy chemicals changes which enhance the quality of fruit are lost with



Application of Calcium Carbide to Mango/Banana

✓Calcium carbide (CaC_2) is a chemical compound.

✓Mainly used in the Industry to produce of acetylene and calcium cyanamide.

✓The pure material is colorless

✓Technical-grade calcium carbide are grey or brown and consist of only 80-85% of CaC_2.

✓Message: Industrial Grade CaC_2 contains traces of heavy metals like As and Phosphorous, so it should be restricted for using as fruits ripening.

"Wash Fish, Fruits & Vegetables Properly Before Cooking & Eating"

- Naturally ripened fruit may become over-ripe, so, they are not edible as fresh consumption
- To reduce storage loss, fruits/vegetables producer sometimes prefer collecting the produce before fully ripe, and artificially ripen them for marketing to the consumers.
- Mixture of ethephon and sodium hydroxide in water, or a diluted ethylene glycol solution can be used as artificial ripening agents without having noticeable harmful effect on human health (Siddiqui and Dhua, 2010).
- Low-cost ripening chamber could be a good solution to ripe the produce safe and maintain quality.
- It is required for uniform ripening as per consumers demand and long distance transportation which should also be affordable and cost effective.

Specific Objective

- To design, fabricate and establishment of low-cost fruit ripening chamber and its performance test in the stakeholder's field
- To determine the appropriate doses of ethylene gas for uniform and safe ripening of selected fruits/vegetables
- To develop processing protocol for exposing ethylene gas in the fruit ripening chamber

Methodology

- **Variety:** Udayan
- **Source:** HRC, BARI

Treatment

T_1= 0 ppm (Control)
T_2= 50 ppm conc. C_2H_4
T_3= 100 ppm conc. C_2H_4
T_4= 150 ppm conc. C_2H_4
T_5= 200 ppm conc. C_2H_4

- Maturity of tomato: Breaker stage
- Sanitizer: 0.1% calcinated calcium
- Ripening Chamber: L 3.5 m×W 2 m×H 2 m
- Chamber condition: 20±2°C & 80±5% RH
- Exposure time of C_2H_4: 12 hrs.
- Storage condition : 26±2°C and 75±5% RH

Protocol of Commercial Ripening Practice of Matured Tomato


2024.02.22 10:05


AQ MONITOR
IAQ-2
14:58
A1
C2H4
150.8
PPM
100%
OK
POWER
STATUS
LOW
HIGH
2024.02.28 20:19

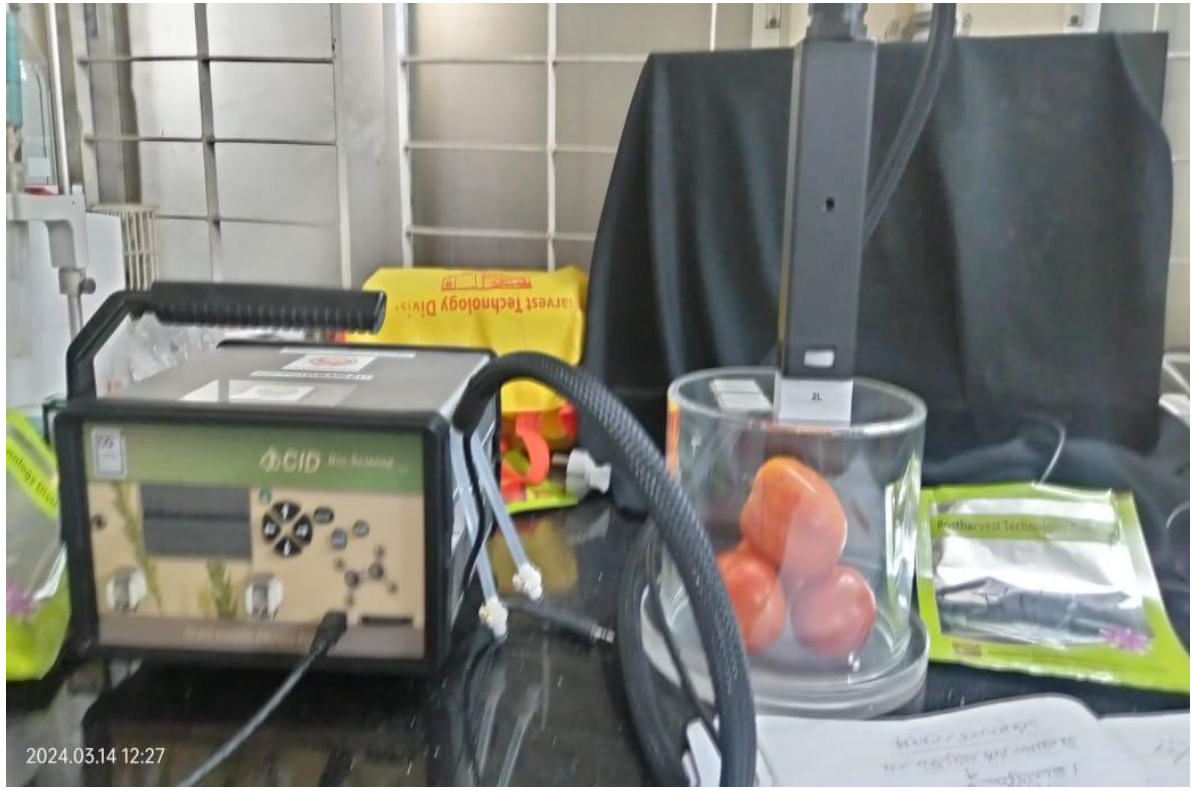

TEMPERATURE
20.4
°C
IN
19.2
°C
OUT
AM
3:06
66
%
RH
CLOCK/HUMIDITY
HTC-2
G H ZEAL LTD - LONDON - ENGLAND
2024.02.28 18:28


2024.07.09 20:01


2024.02.13 14:40


2024.02.15 15:34
lenovo

Measurement of Respiration and Ethylene



Respiration

Ethylene

After 1 day of storage

0 ppm (Control)

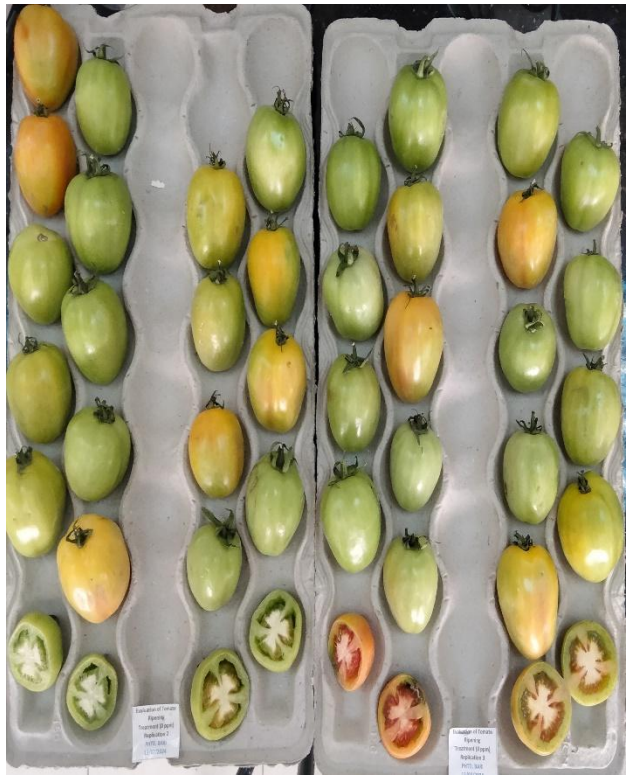
50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

200 ppm C_2H_4

After 4 days of storage



0 ppm (Control)

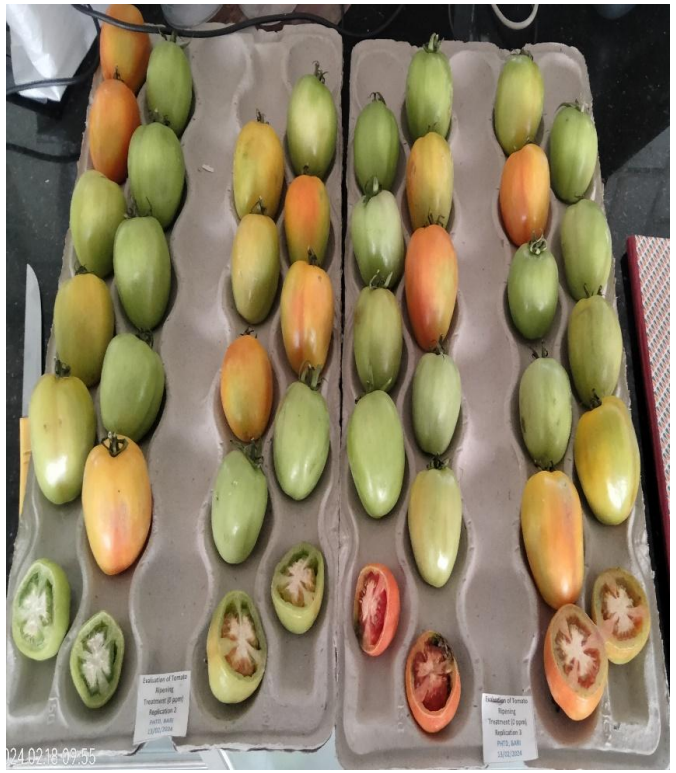
50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

200 ppm C_2H_4

After 8 days of storage



0 ppm (Control)

50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

200 ppm C_2H_4

Changes of Respiration and Ethylene during 12 days storage

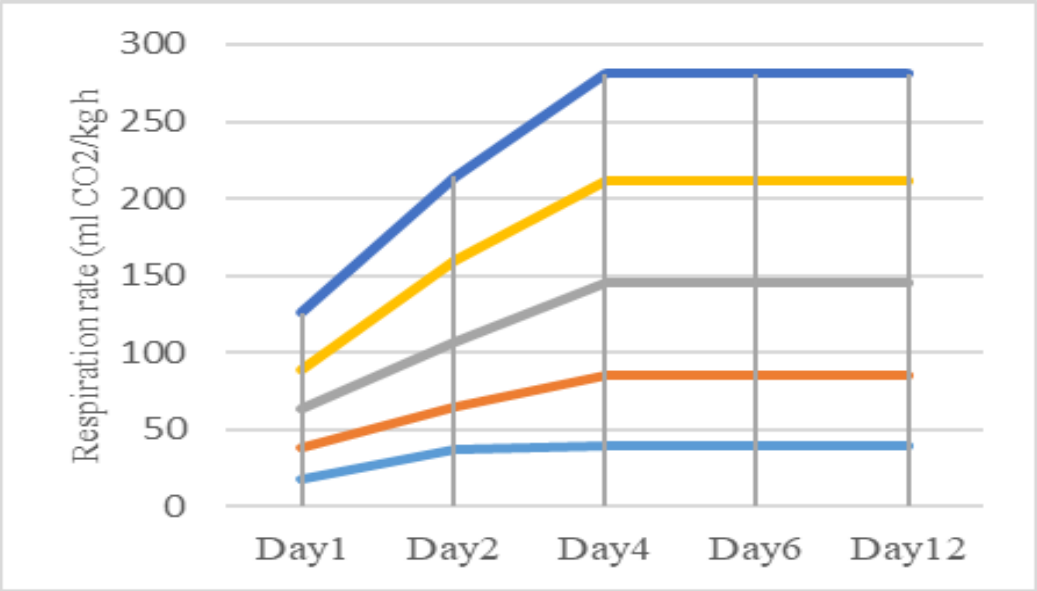


Figure 1(a). Changes of respiration rate

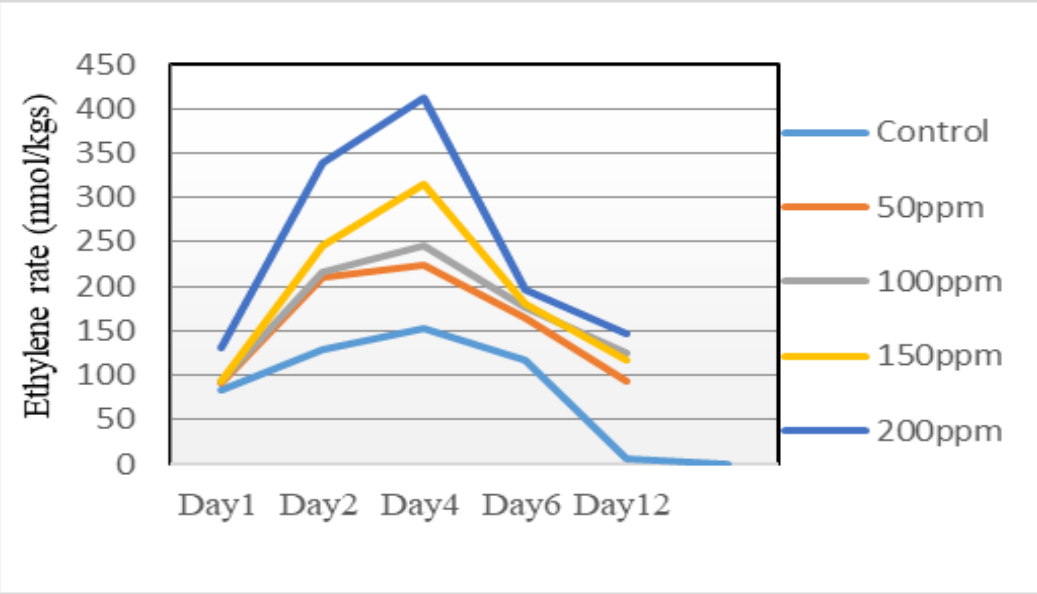


Figure 1(b). Changes of ethylene rate

Changes of weight loss, firmness (N) and carotenoids of tomatoes (var. Udayan)

Treatment	Storage (Day)	Weight loss (% PWL)	Firmness (N)	Total carotenoids (mg/100g)
T_1	2	-	17.58± 3.04a	-
	4	3.086±0.37a	17.79±0.86a	34.40±2.25c
	6	5.76±0.42a	14.63±0.39a	9.00±1.54b
	8	8.48±0.33a	9.28±0.20a	-
T_2	2	-	8.74±0.49b	
	4	3.29±0.20a	8.033±1.52b	46.97±3.14b
	6	4.11±2.76ab	7.45±0.13b	48.37±0.64a
	8	6.73±2.74ab	6.97±0.37b	8.32±0.09b
T_3	2	-	9.76±1.12b	-
	4	1.53±0.48b	9.46±0.76b	53.13±2.78a
	6	2.66±0.51ab	8.52±1.27b	48.79±0.29a
	8	5.97±1.12ab	8.47±1.03ab	12.66±3.50a
T4	2	-	11.09±0.10b	
	4	1.51±0.07b	10.47±1.27b	54.89±0.32a
	6	2.13±0.11b	8.54±0.85b	47.58±0.65a
	8	4.35±0.52b	7.58±0.35ab	10.49±0.73ab
T5	2	-	11.79±0.34b	-
	4	1.18±0.21b	9.52±0.77b	54.62±0.44a
	6	1.83±0.25b	9.08±1.73b	46.56±1.88a
	8	4.27±0.53b	8.73±0.79a	12.34±0.86a

Values are mean ± standard deviation of 3 replicates; Different lowercase letters in each column are differed significantly among the samples. Note: T_1= 0 ppm (Control); T_2 = 50 ppm; T_3 = 100 ppm; T_4 = 150 ppm; and T_5 = 200 ppm

Findings

- Optimum ripening of tomato achieved after 4 days of ripening at 20°C through exogenous C_2H_4 at 100 ppm.
- The optimum firmness was found 6.97 N in 100 ppm C_2H_4 treated tomato after 8 days of storage.

Methodology

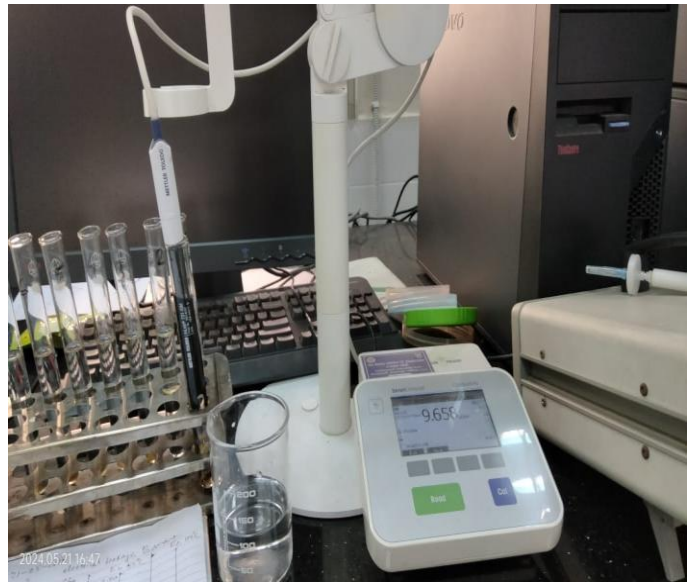
- **Variety:** BARI Kola-1
- **Source:** Gazipur

Treatment

T_1= 0 ppm (Control)
T_2= 50 ppm conc. C_2H_4
T_3= 100 ppm conc. C_2H_4
T_4= 150 ppm conc. C_2H_4

- Banana : Mature green
- Sanitizer: 0.1% calcinated calcium
- Ripening Chamber: L 3.5 m×W 2 m×H 2 m
- Chamber condition: 20±2°C & 80±5% RH
- Exposure time of C_2H_4: 12 hrs.
- Storage condition : 26±2°C and 75±5% RH

Protocol of Commercial Ripening Practice of Matured Banana



After 1 day of storage

0 ppm (Control)

50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

After 2 days of storage

0 ppm (Control)

50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

After 4 days of storage

0 ppm (Control)

50 ppm C_2H_4

100 ppm C_2H_4

150 ppm C_2H_4

Changes of Respiration of Exogenous C_2H_4

Treatment	Respiration (ml CO_2 /Kg.hr)				Ethylene (nmol/kg.s)			
	Day 1	Day 2	Day 4	Day 6	Day 1	Day 2	Day 4	Day 6
T_1	20.2±0.7c	26.2±0.3d	42.2±0.3c	136.1±1.5c	92.7±4.5c	115.4±2.1c	323.5±0.7b	120.8±1.6c
T_2	29.4±0.8b	106.7±1.7c	114.5±0.2b	134.3±2.5c	210.1±0.8b	430.2±1.7b	331.3±7.2b	164.8±3.4b
T_3	63.9±6.8a	137.3±2.4b	143.3±2.4a	184.1±5.7a	213.9±0.4b	442.2±8.4b	325.8±4.2b	189.2±0.9a
T_4	66.7±0.7a	146.1±2.6a	146.7±3.0a	172.3±2.6b	265.9±2.3a	539.0±3.8a	409.4±4.1a	191.2±9.3a

Values are Mean ± SD (n=3); Means followed by different lowercase letters in each differed significantly ($P<0.05$) among the treatments. Note: T_1=Control; T_2=50ppm; T_3=100ppm; T_4=150ppm.

Physiological and biochemical changes of exogenous C_2H_4

Treatment	Storage (Day)	PWL (%)	TSS (°Brix)	Titratable acid (%)	Ascorbic acid (mg/100g)
T_1	4	3.11±0.02a	11.13±0.15d	2.36±0.28a	5.50±0.26a
	8	5.77±0.09a	12.63±0.15d	2.36±0.02a	4.76±0.05a
T_2	4	2.91±0.05b	20.13±0.55c	1.26±0.021b	4.58±0.26b
	8	5.49±0.18a	24.43±0.05c	1.03±0.01b	2.20±0.34b
T_3	4	1.55±0.02c	22.63±0.15b	1.44±0.03b	4.43±0.08b
	8	2.69±0.06b	25.77±0.63b	1.16±0.02b	2.11±0.01b
T_4	4	1.48±0.03c	25.07±0.06a	1.57±0.49b	3.00±0.20c
	8	2.16±0.06c	28.80±0.10a	1.17±0.03b	2.11±0.01b

Values are mean ± standard deviation of 3 replicates; Different lowercase letters in each column are differed significantly among the samples. Note: T_1 = 0 ppm, Control; T_2 = 50 ppm; T_3 = 100 ppm and T_4 = 150ppm; PWL = Physiological wt. loss

Findings

- ✓ Exogenous C_2H_4, particularly at higher conc. of C_2H_4 (100-150 ppm), significantly enhance the ripening process by increasing TSS and reducing weight loss.
- ✓ This accelerated ripening comes at the cost of faster degradation of titratable acidity and ascorbic acid.
- ✓ Depending on the desired shelf life and quality attributes, different concentrations of C_2H_4 could be used to optimize the ripening of bananas.

Methodology

- **Variety:** BARI Aam-2
- **Source:** Bagha, Rajshahi

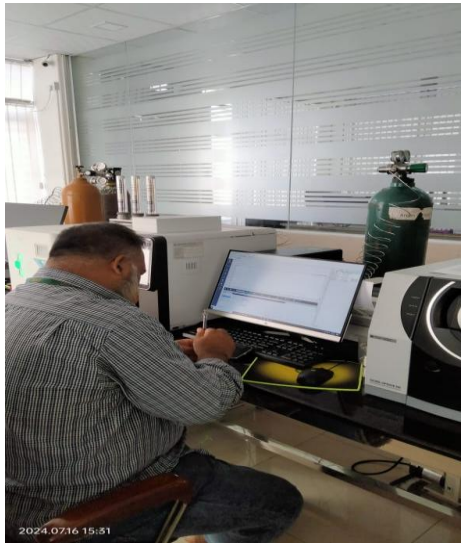
Treatment

T_1= 0 ppm (Control)
T_2= 50 ppm conc. C_2H_4
T_3= 100 ppm conc. C_2H_4
T_4= 150 ppm conc. C_2H_4

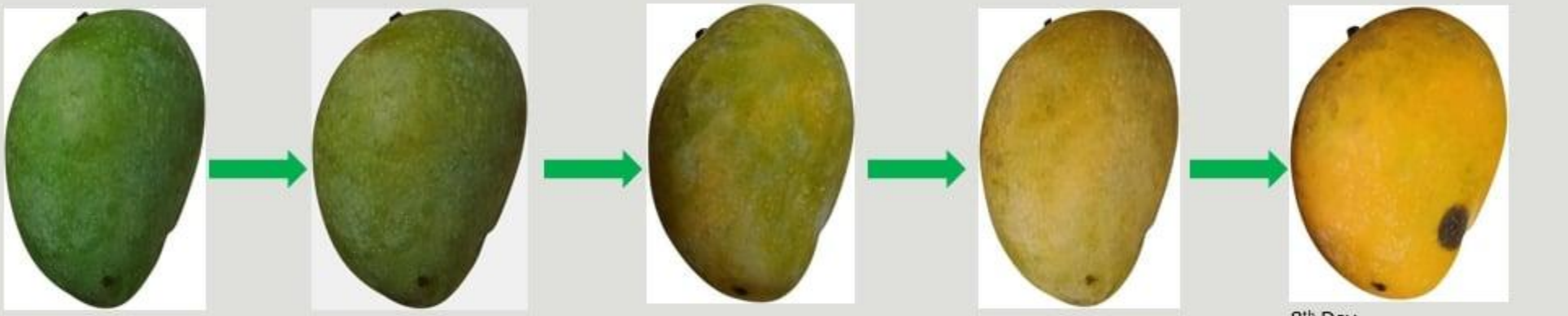
- Mango : Mature green (BARI Aam-2)
- Sanitizer: 0.1% calcinated calcium
- Ripening Chamber: L 3.5 m×W 2 m×H 2 m
- Chamber condition: 20±2°C & 80±5% RH
- Exposure time of C_2H_4: 12 hrs.
- Storage condition : 26±2°C and 75±5% RH

Protocol of Commercial Ripening Practice of Matured Mango

Protocol of Physico-chemical Evaluation of Mango



Ripening Stages Of Fresh BARI Am **2**



0 ppm (Control)

Ripening Stages Of BARI Am 2

1st Day
Deep green in color

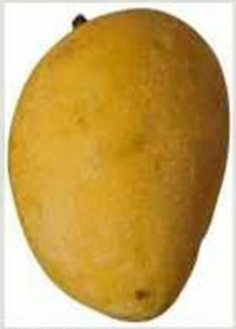
2nd Day
Light green in color

3rd Day
Yellowish green in color

4th Day
Light yellow and light green mixture in color

5th Day
Maximum yellow and little light green in color

6th Day
Greenish yellow in color

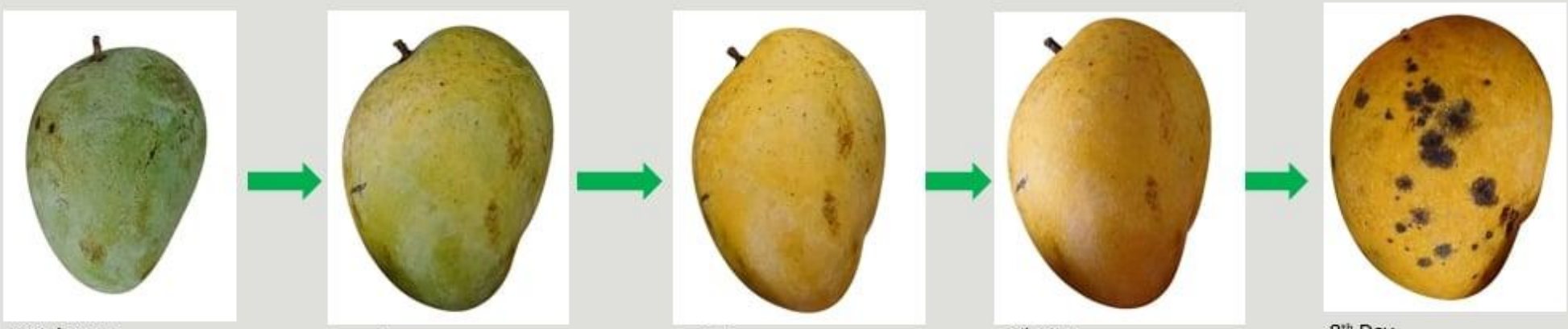


7th Day
Deep yellow in color

8th Day
Over ripe (light orange color)

50 ppm C_2H_4

Ripening Stages Of T2(100ppm) Ethylene Treated BARI Am 2



Initial Stage
Light green in color

2nd Day
Yellowish green in color

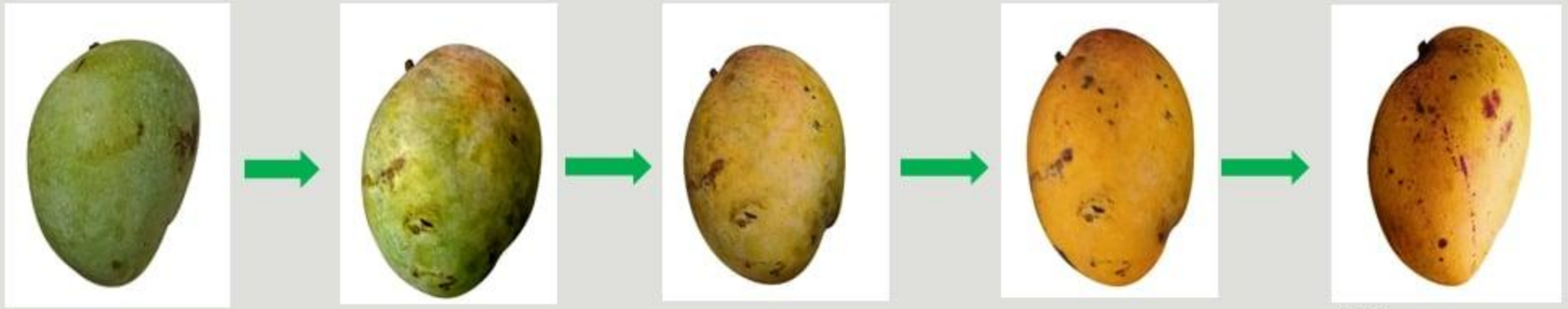
4th Day
Yellowish in color

6th Day
Deep yellow in color

8th Day
Over ripe (orange color)

100 ppm C_2H_4

Ripening Stages Of T3(150ppm) Ethylene Treated BARI Am 2



Initial Stage
Light green in color

2nd Day
Yellowish green in color

4th Day
Yellowish in color

6th Day
Deep yellow in color

8th Day
Over ripe (orange color)

150 ppm C_2H_4

Changes of respiration (ml CO_2 /Kg.hr.) of C_2H_4 treated Mangoes

Treatment	Initially	Day-2	Day-4	Day-6	Day-8
T_1	26.61±3.72c	39.22±0.27c	48.31±3.76c	65.17±1.92b	32.28±1.83c
T_2	34.9±0.05b	63.62±0.61b	75.88±1.94b	54.13±2.48c	17.54±2.2b
T_3	39.93±3.93a	68.64±2.64b	81.17±2.41a	76.71±2.21a	18.49±1.86b
T_4	39.95±0.52a	80.67±4.68a	81.98±3.04a	56.20±2.28c	41.59±0.23a

Values are Mean ± SD (n=3); Means followed by different lowercase letters in each differed significantly ($P<0.05$) among the treatments. Note: T_1=Control; T_2=50ppm; T_3=100ppm; T_4=150ppm.

Physiochemical changes of C_2H_4 treated Mangoes

Treatment (ppm, C_2H_4)	Storage (Day)	PWL (%)	TSS (°Brix)	Titratable acid (%)	Vitamin A (mg/100g)
T_1	4	4.11±0.02a	13.23±0.25d	0.11±0.01c	9.59±0.32c
	8	7.73±0.15a	15.40±0.10	0.12±0.02b	10.29±0.27d
	12	11.78±0.28a	16.4±0.10	0.08±0.00ab	12.71±0.15
T_2	4	1.69±0.02b	14.23±0.25c	0.15±0.01b	11.77±0.26b
	8	3.77±0.02a	15.70±0.10	0.20±0.01a	13.75±0.04c
	12	4.2±0.17c	17.33±0.28	0.05±0.01c	8.51±0.38a
T_3	4	1.08±0.01d	16.86±0.15a	0.17±0.05a	12.35±0.34b
	8	3.65±0.04b	16.93±0.15	0.16±0.02ab	16.62±0.10b
	12	6.35±0.53b	18.16±1.27	0.11±0.00a	19.34±0.11b
T_4	4	1.55±0.03c	14.97±0.25b	0.12±0.01c	13.26±0.17a
	8	3.15±0.04c	16.50±2.43	0.13±0.02b	18.04±0.22a
	12	6.50±0.25b	18.17±1.55	0.08±0.02ab	9.03±0.02bc

Values are Mean ± SD (n=3); Means followed by different lowercase letters in each differed significantly ($P<0.05$) among the treatments. Note: T_1=Control; T_2=50ppm; T_3=100ppm; T_4=150ppm.

Findings

- **Mango treated with 100 ppm C_2H_4 may provide an optimal balance, enhancing sweetness and preserving nutrients while minimizing weight loss, making it suitable for managing postharvest quality.**
- **This application led to 100% ripening for 12 hrs. in approximately 04 days compared to control mangoes.**

Methodology

- **Variety:** Shahi papaya
- **Source:** Pabna

Treatment

T_1= 0 ppm (Control)
T_2= 50 ppm conc. C_2H_4
T_3= 100 ppm conc. C_2H_4
T_4= 150 ppm conc. C_2H_4

- Papaya : Mature papaya
- Sanitizer: 0.1% calcinated calcium
- Ripening Chamber: L 3.5 m×W 2 m×H 2 m
- Chamber condition: 20±2°C & 80±5% RH
- Exposure time of C_2H_4: 12 hrs.
- Storage condition : 26±2°C and 75±5% RH

Control at 3 DAS

50 ppm at 3 DAS

100 ppm at 3 DAS

150 ppm at 3 DAS

Control at 3 DAS

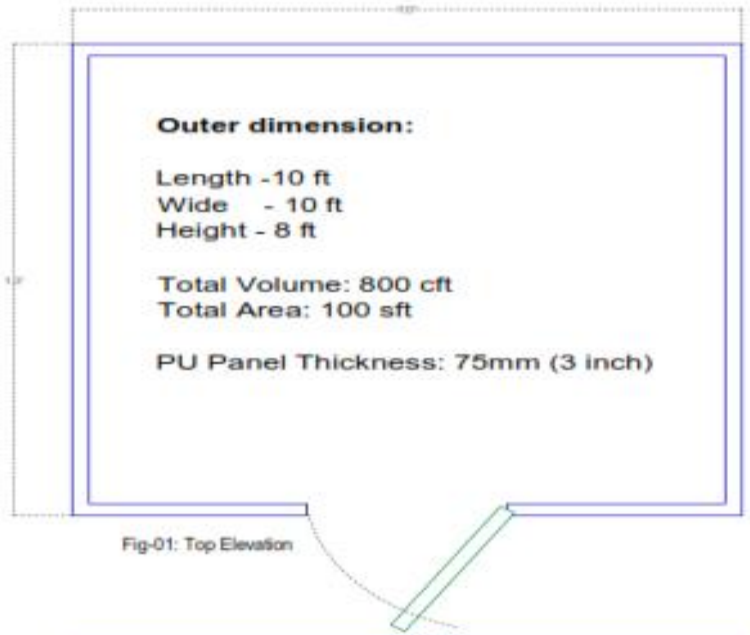
50 ppm at 3 DAS

100 ppm at 3 DAS

150 ppm at 3 DAS

Operating Procedure of semi-commercial low-cost ripening chamber

- **Temperature Control System:** AC (18-22 °C)
- **Humidity Control System:** Water spay (80-95%)
- Application of C_2H_4 gas: Conc. C_2H_4 generator
- Controlling C_2H_4 application process: C_2H_4 detector
- Air Circulation System: Potable fan



Semi-commercial low-cost ripening chamber

Validation and dissemination through operation and sharing

বাংলাদেশ প্রতিদিন

নতুন পদ্ধতি উদ্ভাবন, দেশে এখন কেমিক্যাল ছাড়াই ফল পাকানো যাবে নিরাপদে

অনলাইন ডেস্ক

সংগৃহীত ছবি

ক্ষতিকর কেমিক্যাল ছাড়াই ইথেফ মতো নিরাপদ ও বাণিজ্যিকভাবে ফল পাকানোর জন্য বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউটের (বারি) একজন গবেষক আধুনিক 'রাইপিং চেম্বার' নামের একটি প্রযুক্তি উদ্ভাবন করেছেন।

বারি'র পোস্ট হারভেস্ট টেকনোলজি বিভিশন বা ফলমোডক প্রযুক্তি নিয়ামের উদ্ভাবন বৈজ্ঞানিক কর্মকর্তা ড. পোলাম কেবরেলীল চৌধুরী এ পদ্ধতিটি উদ্ভাবন করেন।

এর ফলে বিভিন্ন ফল পাকানোর জন্য দেশে যেসব ক্ষতিকর কেমিকেল ব্যবহার করা হয়, তার পরিবর্তে ব্যবহার করে যাবে।

অন্যদিকে ফল উৎপাদনকারী ফতিরা বাণিজ্যিকভাবে লাভবান হবে বলে জানিয়েছেন উদ্ভাবক।

বাংলাদেশ কৃষি গবেষণা ইনস্টিটিউট সূত্র জানায়, দেশে প্রতিবছর অধুর পরিমাণে বিভিন্ন ধরনের ফল উৎপাদন হয়। দেশের বিভিন্ন গাছের উৎপাদিত ফল একসঙ্গে পাকে না। গাছে পর্যাপ্তভাবে ফল পাকার কারণে ইথেফ থাকা সত্ত্বেও কিছু ফল কাঁচা থাকার কারণে সবগুলো ফল খাওয়ার জন্য সংগ্রহ করা যায় না। তাই অনেকে এগুলো কাঁচা সংগ্রহ করে বিকল্প পদ্ধতিতে নানা ধরনের ক্ষতিকর কেমিক্যাল প্রয়োগ করে পাকানোর চেষ্টা

Figure 10. Validation trial at Sona Dighi, Godagari, Rajshahi

Economic Analysis of Low-Cost Commercial Ripening Chamber (Capacity: 1.5-2.0 Tons)

1. Initial Investment (Fixed Cost)

Component	Estimated Cost (Taka)
Construction materials	150000 - 160000
Ethylene generator	100000 - 110000
Thermometer, hygrometer etc.	4000 - 4500
Ventilation system (fans)	2000 - 3000
Plastic crates for fruits	3000 - 3500
Rack	16000 - 18000
Total Initial Investment	275000 - 299000

2. Operational Cost (Variable Cost)

Component	Estimated Cost/batch (Taka)	Estimated Cost/ month (Taka)
Concentrate ethylene	300 - 400	4000
Electricity cost	80-100	900
Labor (loading, monitoring, unloading)-2 persons	500 – 700	12000
Maintenance (cleaning, minor repairs)	-	500
Total Operational Cost		17400

Economic Analysis

Revenue

- Ripening about 1500-1800 kg of fruits (e.g., banana~720 dozens)/cycle; 12 cycles/month
- Selling price increase due to uniform ripening: 2 Tk/kg.
- Monthly Benefit (Revenue) = 1500 kg × 12 cycles/month × 2 Tk/kg =36,000 Tk/month

Payback Period

- Total Initial Investment: 275000 – 299000 Tk
- Monthly Net Profit = Monthly Benefit – Operational Costs (Variable Cost).
  = 36000 – 17400 = 18600 Tk/month
- Payback Period = Initial Investment/Monthly Net Profit
- Life of ripening chamber = 10~12 yrs
- Payback Period = 299000/18600 = ~16 months

Break-Even Point Analysis of Low-Cost Commercial Ripening Chamber

Revenue per kg after Costs

Net Revenue per kg = 2-0.96=1.04 Tk/kg

BEP (kg) = 299000/1.04=287500 kg=287.500 ton

Break-Even Point in Time

To determine how many months are needed to reach the break-even point:

BEP (month) = Fixed Cost/Net Monthly Profit

Net Monthly Profit = Monthly Revenue − Monthly Variable Cost
= (1500*12*2) - (17400) =18600 Tk/month

BEP (month) = 299000/18600=16 months

The chamber must require to ripe 287.50 tons of fruit for approximately 18 months to recover the investment.

Recommendations

- Ethylene gas may be used for commercial ripening at conc. between 100 ppm and 150 ppm (100µl/L)
- A low-cost commercial ripening chamber can be conveniently created by locally available materials
- To automate temperature and humidity adjustments, some basic devices may add
- The chamber size may be customized based on the volume of produce
- The chamber should be clean to avoid fungal or bacterial contamination
- Ensuring consistency results, continuously monitoring of temperature and humidity by sensors are necessary.

Policy Recommendations

- SOP of fruit ripening using C_2H_4 gas should be introduced to the stakeholders
- C_2H_4 gas or sachets import should be included in the SRO of the NRB, allowing traders to available in the country
- Financial assistance or incentive should be provided to local manufacturers/ traders to establish ripening chamber
- Low-cost ripening technology should be promoted through awareness creation
- Immature fruits ripening using harmful chemicals should be strictly stopped by the law and enforcement agencies as well as regulatory body
- Commercial ripening technology should be inspected and certified by the regulatory body to ensure safe and uniform mature fruit ripening
- Awareness creation activities are necessary during fruits/vegetables early harvesting season to stop immature fruit ripening by harmful chemicals and unauthorized practices which is scientifically not accepted and internationally not permitted or recommended

Acknowledgements

Expert Engineering

Thank you!