

# Banana Ripening Study on 3D Clinostat



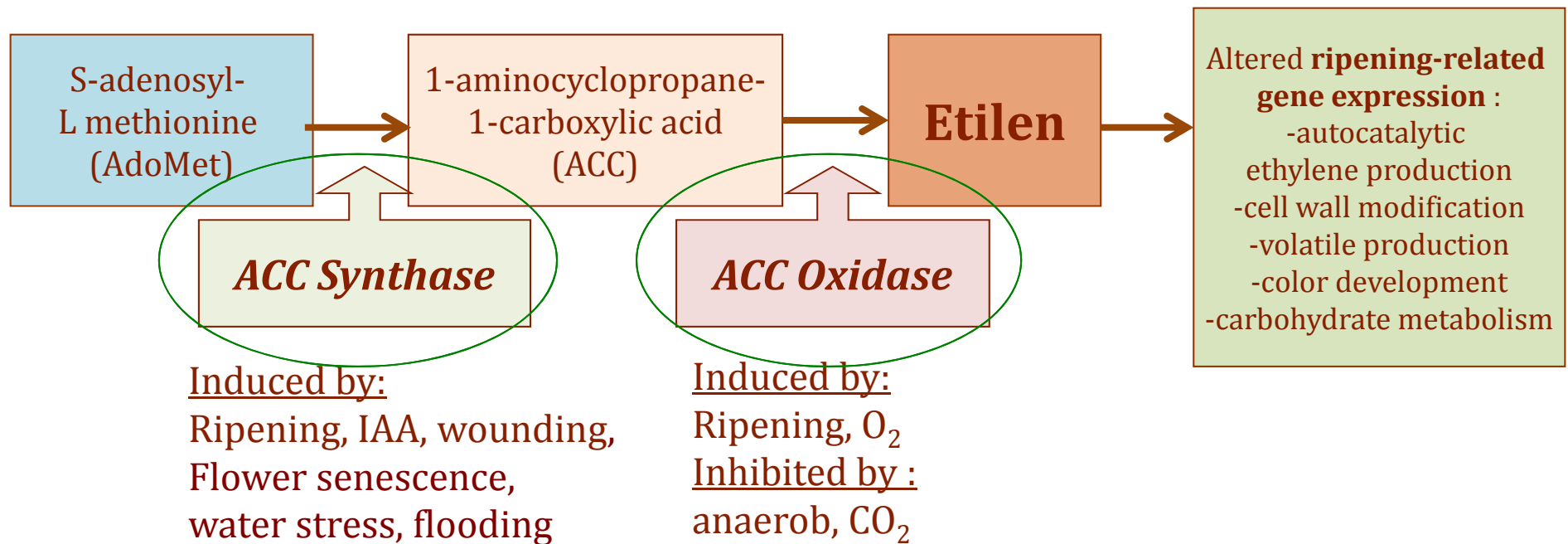
*School of Life Sciences and Technology, Bandung Institute of  
Technology*

*Indonesia National Institute of Aeronautics and Space (LAPAN)*

# Background

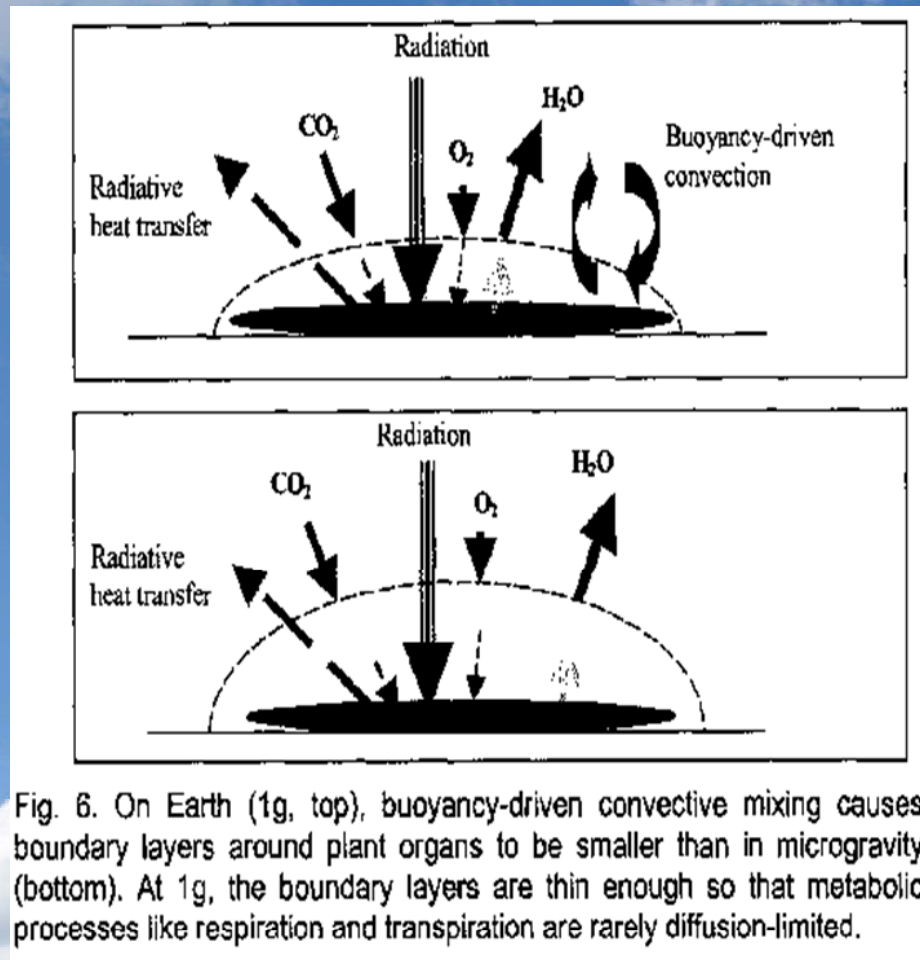
- 2005: APRSAF (Asia Pacific Regional Space Agency Forum), Fukuoka, Jepang, 2005 JAXA (Japan Aerospace Exploration Agency) offer little experiment ( $< 5$  kg) at JEM 'KIBO'
- LAPAN –ITB accepted the offer and proposed a research proposal
- 2007: Feasibility study at ITB
- 2008: Preliminary Experiment at JAXA
- 2009-2012: Ground based experiment

# Fruit Ripening Process





# Earth and Space Environment is Different



Elevated levels of ethylene or CO<sub>2</sub>, reduced levels of available O<sub>2</sub>, all contributed factors to metabolic stress in plants, are all common in closed environments such as those experienced in orbital vehicles

# 3D clinostat

- Research on the effect of space environment in ripening process has not been conducted.
- 3D clinostat, equipped with 2 rotation axes and closed chamber made from glass was made to mimic microgravity.



3D clinostat developed at ITB

**Topics**

## **The Effect of Clinorotation to the Growth of Tomato (*Lycopersicon esculentum*) and Mung Bean (*Vigna radiata*) Seedlings**

By Leonita SWANDAJA<sup>1)</sup>, Rizkita Rachmi ESYANTI<sup>1)</sup>, KHAIRURRIJAL<sup>2)</sup>, Fenny M. DWIVANY<sup>1)</sup> and Chunaeni LATIEF<sup>3)</sup>

<sup>1)</sup>*School of Life Sciences and Technology, Institut Teknologi Bandung, Bandung, West Java, Indonesia*

<sup>2)</sup>*Physics Department of Mathematics and Natural Sciences, Institut Teknologi Bandung, Bandung, West Java, Indonesia*

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(Received June 24th, 2013)

Plant growth and development are affected by abiotic factors such as light, temperature, water and gravity. Gravity ensures primary shoot grows upward towards sunlight to optimize photosynthesis, while the primary root grows downward into the soil to find water and mineral supply. Plants with impaired gravity response are poorly fit for survival in nature, since the roots may not be able to absorb the nutrient and the shoot may not be able to track sunlight. In the first study, the tomato seedlings on agar medium were treated on clinostat in light and dark condition. In dark, the tomato seedlings on the clinostat responded by bending their shoot and coiled their root. In the light condition, the shoot bending and root coiling were reduced significantly compare to the plants grew in the dark after seven days in clinorotation, which might indicate that phototropic response was stronger than gravitropic response in tomato seedlings. The mung bean on hanging mesh was tested on clinostat without light. Under this condition, instead of coiling, the root grew straight to the wet rockwool. The condition might indicate that mung bean seedling has stronger hydrotropic response compare to gravitropic response, as moisture gradient may trigger statolith degradation in columella cells.

**Key Words:** Microgravity, 3D Clinostat, Gravitropism, Tomato, Mung Bean





# **Objective**

To study the effect of microgravity in banana ripening process using 3D clinostat

# **Hypothesis**

3D clinostat will affect fruit ripening process

# Method

## Sample selection

- Green Cavendish banana (*Musa acuminata* AAA. Group)



## Packaging

- Carbon-lining pouch



## Placement

- Earth gravity and microgravity simulation



## Physiological measurement and Molecular Analysis

- Respiration, peel color, starch content
- MaACS and MaACO gene expression profile



The background of the slide is a photograph of a clear, vibrant blue sky. Several large, white, puffy cumulus clouds are scattered across the frame, with some appearing more prominent than others. The lighting is bright, suggesting a sunny day.

# **RESULT**

The background of the slide is a photograph of a clear, vibrant blue sky. Several large, fluffy white cumulus clouds are scattered across the frame, with some appearing more prominent than others. The lighting is bright, suggesting a sunny day.

# PRELIMINARY STUDY

## Effects of extreme conditions on *MaACS1* gene expression ripening stage



Fruit Ripening at Open Chamber



Fruit Ripening at Closed Chamber



3D Clinostat for microgravity simulation (developed at ITB)



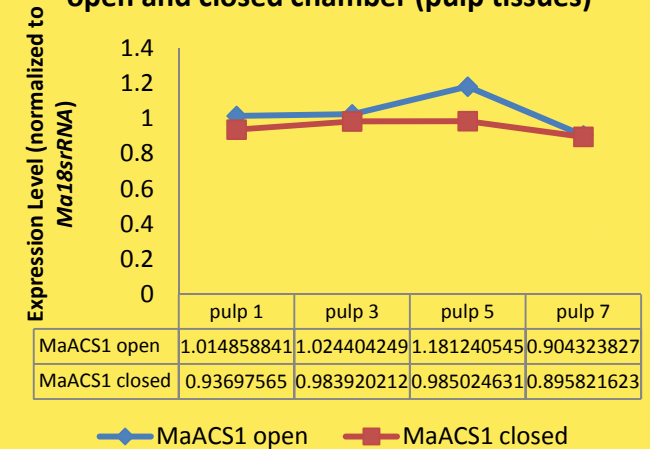
Open Ground  
Open Clinostat

Close Ground  
Close Clinostat

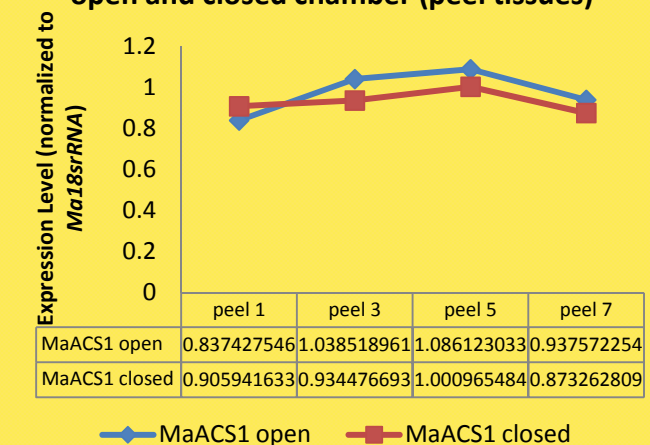


- Banana fruit ripening process in clinostat (microgravity condition) was much slower than normal condition (earth gravity).
- Moreover, pulp condition in clinostat was more juicy and non-edible.

### Expression Level of *MaACS1* gene in open and closed chamber (pulp tissues)



### Expression Level of *MaACS1* gene in open and closed chamber (peel tissues)





A photograph of a clear blue sky with several large, white, fluffy cumulus clouds. The clouds are scattered across the frame, with some appearing more prominent than others. The sky is a vibrant blue, and the clouds are bright white with some soft shadows. The overall scene is bright and clear.

# GROUND BASED EXPERIMENT

# Experiment Design

Control:  
Banana  
placed on  
ground

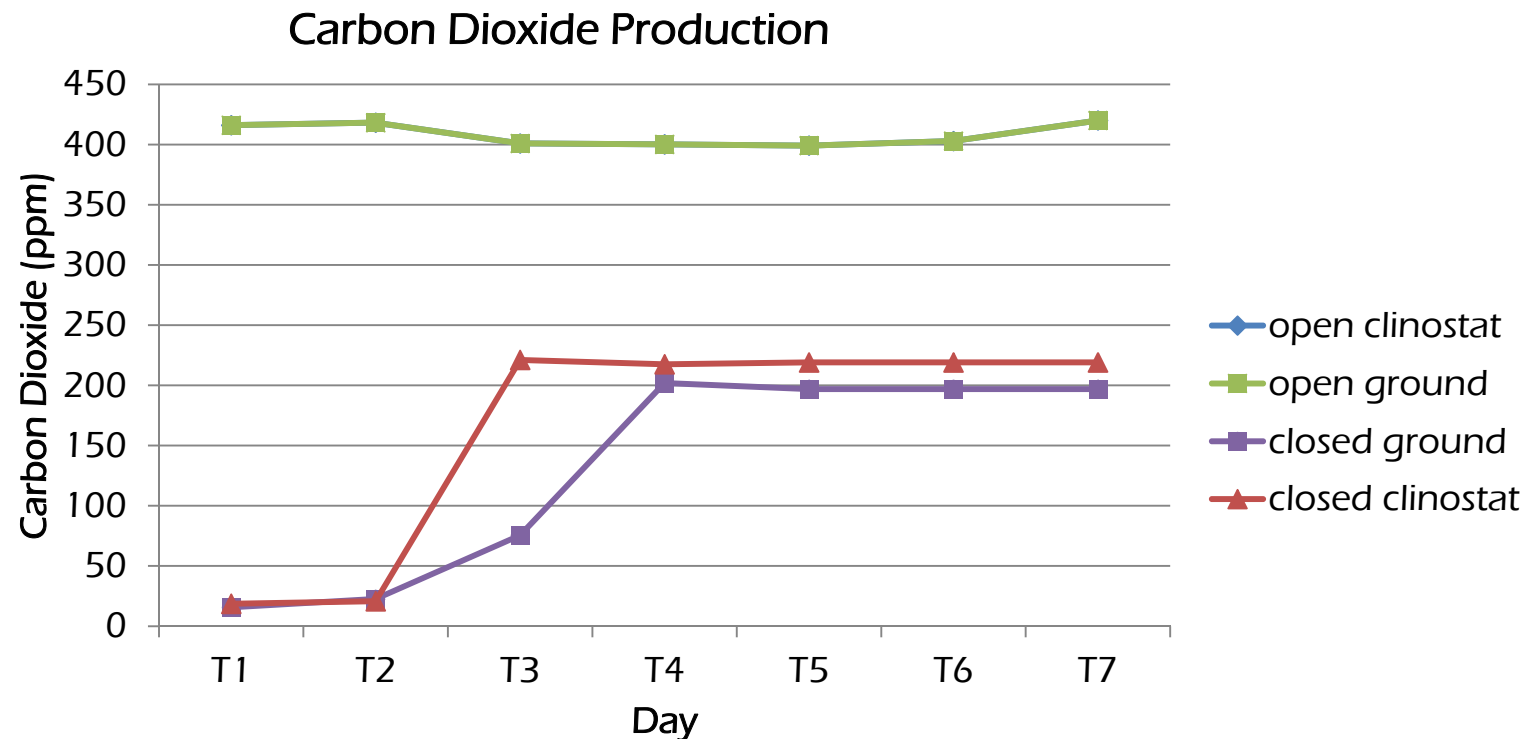
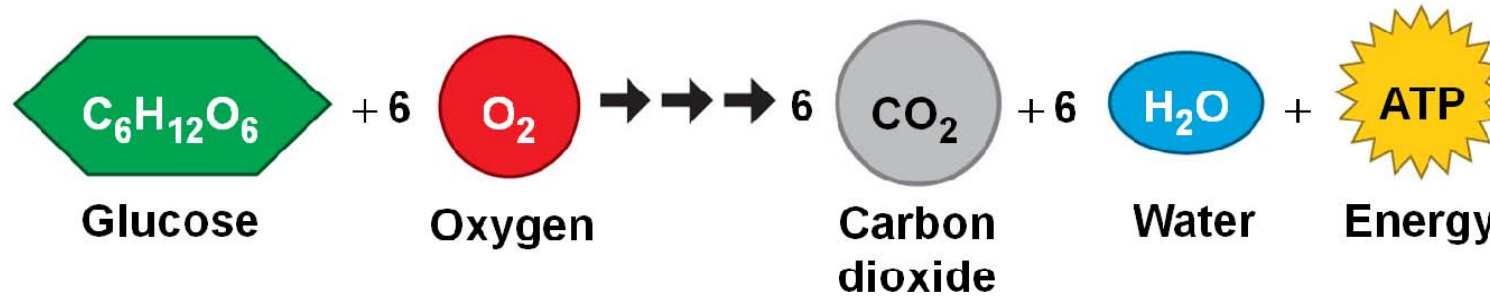


*Closed  
Clinostat*



Treatment:  
Banana  
placed on  
3D  
clinostat

# Respiration



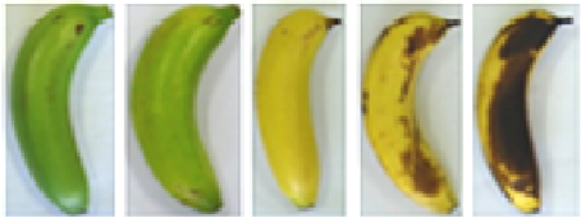


# Peel Color and Chlorophyll

Closed Clinostat



Open Clinostat



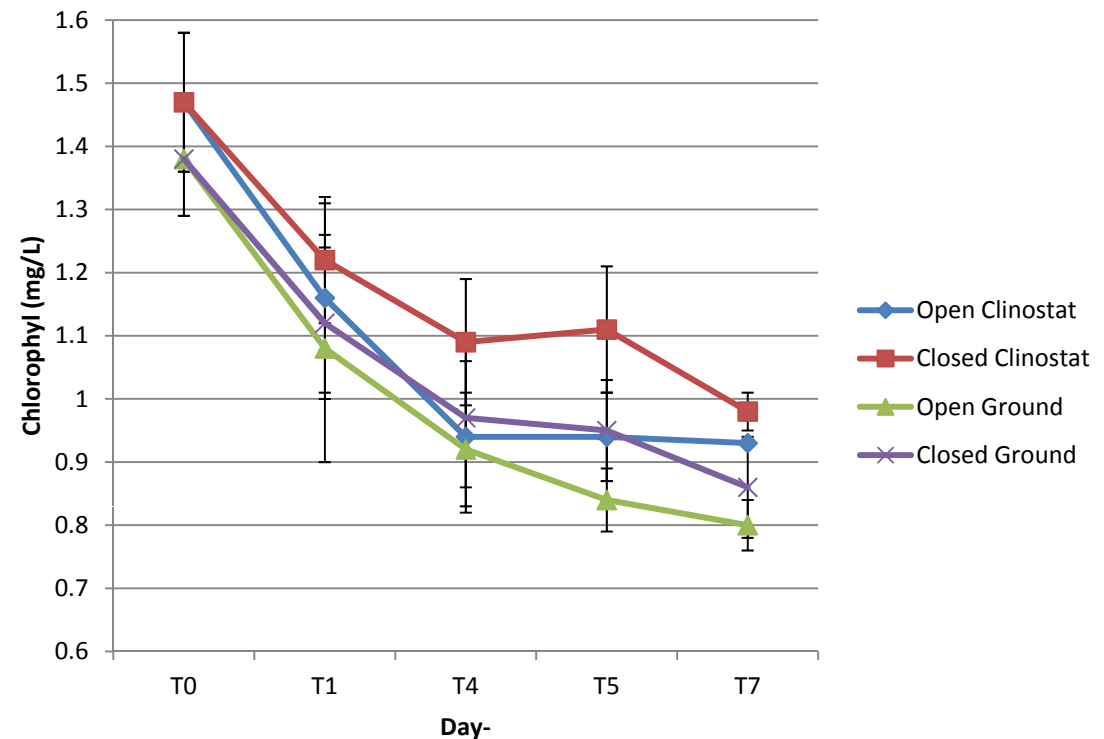
Closed Ground



Open Ground



Peel color changes gradually from green to yellow.

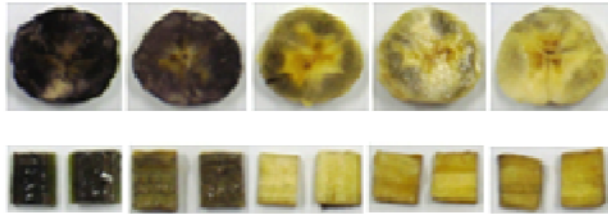


Chlorophyll decreases over time, as it normally does in ripening process. It indicates changes of peel color from green to yellow.

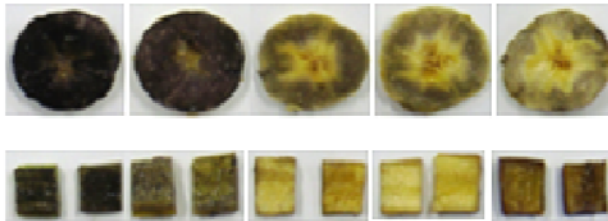
# Starch Content

- Black color from iodine reaction shows the presence of starch.
- As sugar content increases in ripen banana, starch decreases.

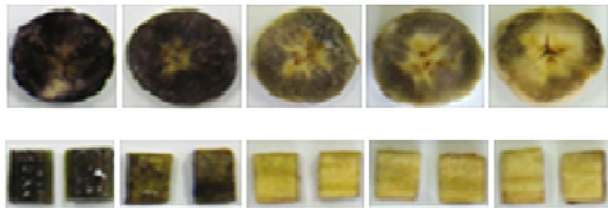
Open Ground



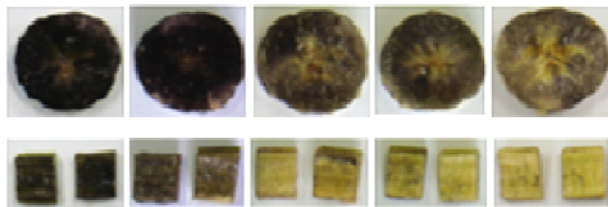
Open Clinostat



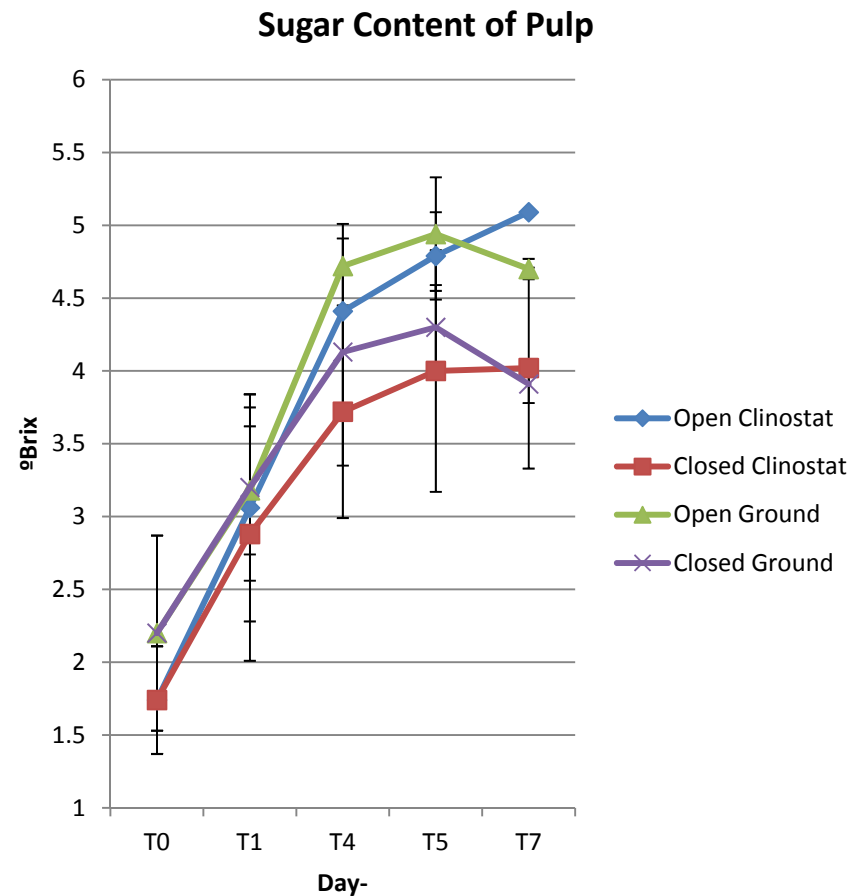
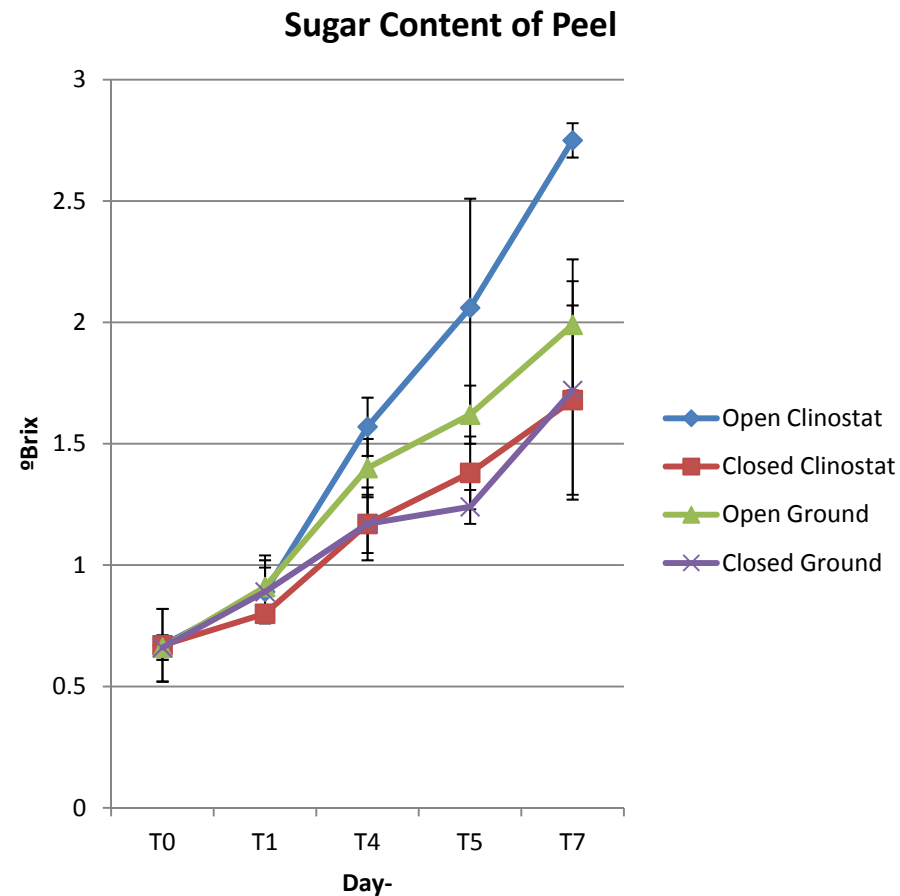
Closed Ground



Closed Clinostat



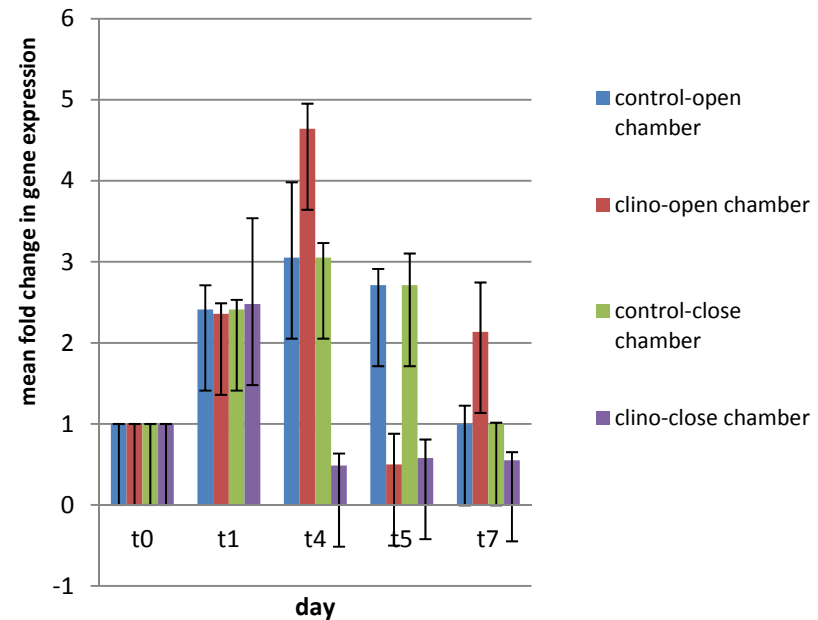
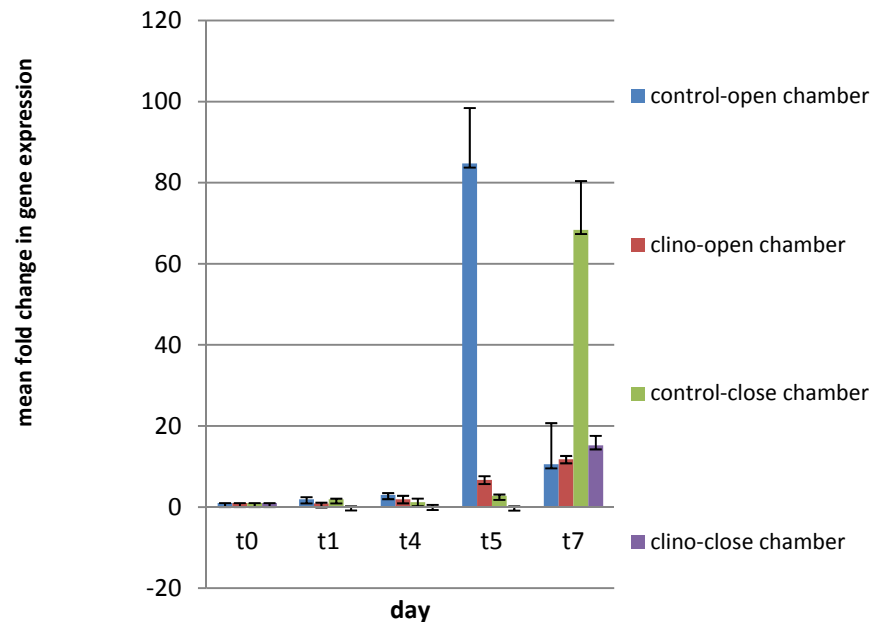
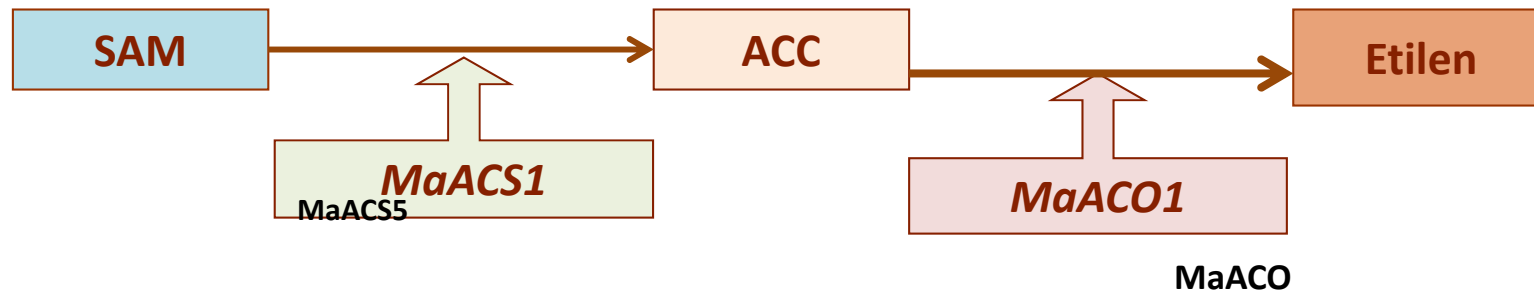
# Sugar Content



- Ripening is indicated by increase of sugar content.
- Rapid increase of sugar content is observed in open group.



# Gene Expression



Microgravity simulation using 3D clinostat can affect the *MaACO1* and *MaACS1* gene expression. Following approach of this research is transcriptomics study.

# Conclusion

- The result showed that banana shelf life was longest at microgravity simulation condition
- Microgravity simulation using 3D clinostat can affect the ripening related gene expression.

# Future Direction

Built networking with researchers and research institutions in Japan and other Asia Pacific countries to conduct fruit ripening process study in real microgravity condition.



# Acknowledgement



National Institute of Aeronautics and Space (LAPAN), Indonesia



Japan Aerospace eXploration Agency



Indonesian Directorate General for Higher Education



Bandung Institute of Technology, Indonesia

# Newspaper Publications

Tempo Newspaper,  
November 8<sup>th</sup>, 2012



Tempo Magazine,  
January 2014



# Published & Incoming Paper from Ground Based Experiment

## Environment Effect on Fruit Ripening Related Gene to Develop a New Post Harvest Technology

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**Abstract.** Ripening process of fruits is a very complex process, which involves ethylene production, causing alteration on molecular and physiology level. Environmental stress caused by biotic and abiotic stress conditions (such as pathogen, mechanical stress, physical and physiology stress) can stimulate ethylene production. High levels of ethylene in turn can also inhibit growth, cause premature ripening and induce the onset of senescence, which then potentially reduce plant productivity. The ACC Synthase (ACS) and ACC Oxidase (ACO) genes are genes that have role in the ethylene production. By regulating those genes, especially ethylene biosynthesis genes, we might improve the quality of fruit at post harvest condition. Therefore, in this research we studied fruit ripening related genes expression on banana such as *MaACS* family at different environment

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Topics

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**Key Words:** Microgravity, 3D Clinostat, Gravitropism, Tomato, Mung Bean

## Effect of Microgravity Simulation using 3D Clinostat on Cavendish Banana (*Musa acuminata* AAA Group) ripening process

Fenny Martha Dwivany<sup>1</sup>, Rizkita R. Esyanti<sup>1</sup>, Adeline Prapaisie<sup>1</sup>, Listya Puspa Kirana<sup>1</sup> and Chunaeni Latief<sup>2</sup>

<sup>1</sup>The School of Life Sciences and Technology, Institut Teknologi Bandung, Indonesia

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### Abstract

This research aimed to determine the effect of simulated microgravity by 3D clinostat on Cavendish banana (*Musa acuminata* AAA group) ripening process. It has been studied that microgravity conditions resulting in a change in the composition of O<sub>2</sub> and CO<sub>2</sub> as well as movement of heat and water vapor in the surface around the plant since air convection is limited. Ripening process in climacteric fruit such as banana are marked by rise in respiration and increasing of ethylene. Ethylene is an important hormone which has a role in fruit ripening process. Ethylene biosynthesis depends on two important enzymes, ACC oxidase and ACC synthase which are encoded by ACO gene and ACS gene family, respectively. The expression of these two gene families is regulated by various environmental factors, such O<sub>2</sub> and CO<sub>2</sub>. In this study, we used ethylene treated bananas that have been placed in four different conditions for seven days: control -open chamber (placed outside such as bananas in general), control- closed





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# Thank You

