AVRDC The World Vegetable Center

36th International Vegetable Training Course
"Vegetables: From Harvest to Table "
6 November-1 December 2017

FRESH-CUT VEGETABLES

Dr. Apita Bunsiri : rdiyop@ku.ac.th
Postharvest Technology Center, Faculty of Agriculture at Kamphaengsaen,
Nakhon Pathom 73140 THAILAND

10-November-2017

Convenience Foods

Food that needs little preparation :
Easy to Cook / Ready to Eat

Shorten the time of meal preparation at home:
Some can eat immediately or after adding water, heating or thawing: canned, dried, frozen produce and **Fresh-Cut Fruit and Vegetable**

Why Do The People Need Convenience Foods? (Fresh-Cut Fruit and Vegetables)

- **Price** — Cost reduction
- **Health** — Neutraceutrical
- **Hygiene** — Minimize risk and hazard
- **Lifestyle** — Efficiency : We are all busy, we want food on the go
- **Choice** — Exotic fruit and vegetable

Why do we NEED to do fresh cut?

- **Market (Consumers) Need**
  - The haste in daily life
  - Convenience food / easy to cook / easy to eat
    Too big fruit / Difficult to peel
  - Belief in quality and safety
- **Understandard produces (defect, size, color, etc.)**
  - Gain income / Value added
- **Reduce garbage transportation**
  - Value added from waste

AVRDC The World Vegetable Center

DEFINITION

(IFPA, 2000 ; Watada *et al.*, 1996 ; Rolle and Chism,1987)

Fresh-cut products :

Fruits or vegetables intended to be consumed raw that have been trimmed, peeled, sliced, shredded, cored and/or cut into 100% usable product that is subsequently packaged to offer consumers high nutrition, conveniences and flavor while maintaining highly perishable freshness. *The tissue is still alive*!!

KASETSART UNIVERSITY

WOUND FROM FRESH CUT

Mechanical/Physical Damage : Handlings

Fruit Pests and Rot

Physiological Changes

Quality Changes

Physiological Deterioration

Loss Problems of Fresh-cut Fruit and Vegetables

Disaster : Flooding, Insurrection,etc.

Food Safety physical, chemical, biological

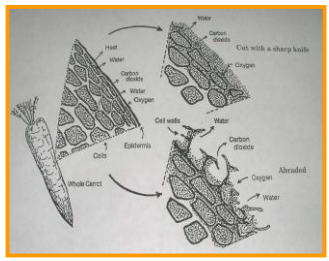
KASETSART UNIVERSITY

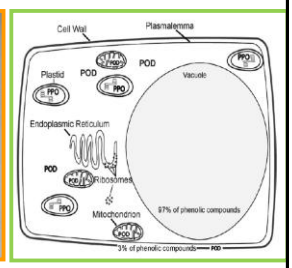
PHYSICAL RESPONSE (Salveit, 1998)

Immediate Physical Effects

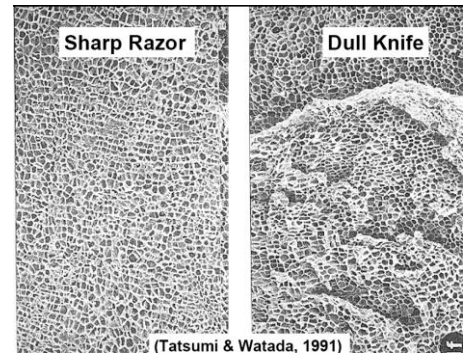
Removal of protective epidermal layer

1 CELL IS 1 LIFE

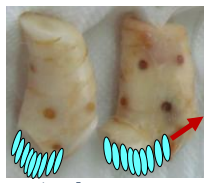




Provide entry for contaminants



KASETSART UNIVERSITY



Mechanical shock to tissue

Accelerates water loss

Provide substrate for microbes

Liquid on cut surface blocks pore

Reduced gas diffusion

Elevated CO_2

Reduced O_2

Fermentation

Soluble substances

Sugar

Acid

Phenolic acid

Enzymes

Browning

Free radicals

Toxic

H_2O

Etc.

KASETSART UNIVERSITY

KEY TO REMEMBER: FRESH CUT TISSUE IS STILL ALIVE!

Whole Fruits

Physiological and Biochemical Changes

Freshcut

Respiration

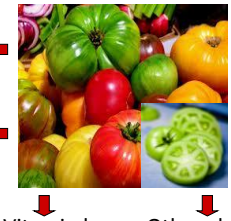
Ethylene production

Weight loss

Softening

Color change

Flavor change



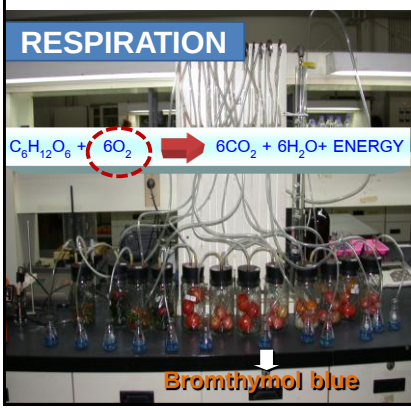
Vitamin loss

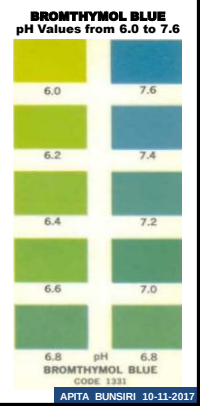
Other changes

KASETSART UNIVERSITY

RESPIRATION

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ENERGY$





APITA BUNSIRI 10-11-2017

ETHYLENE PRODUCTION

Methionine

↓

S-adenosyl methionine (SAM)

↓

1-aminocyclopropene-1-carboxylic acid (ACC)

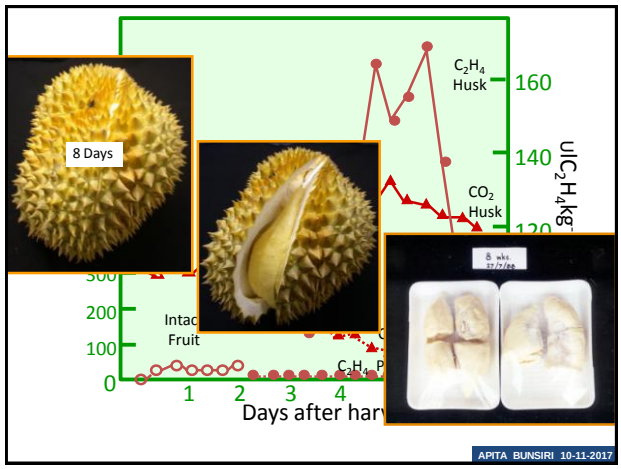
O_2 ↓ ACC oxidase

Ethylene (C_2H_4)

$3\ CH_2{=}CH_2(g) + 2\ KMnO_4(aq) + 4\ H_2O(l) \rightarrow 3\ CH_2OHCH_2OH(aq) + 2\ MnO_2(s) + 2\ KOH(aq)$

Ethylene | Potassium permanganate | Water | Ethylene glycol | Manganese oxide | Potassium hydroxide

APITA BUNSIRI 10-11-2017



APITA BUNSIRI 10-11-2017

Softening: middle lamella

Protopectin

↓ protopectinase

Pectin

$CH_3OH \leftarrow$ ↓ $\leftarrow H_2O$

Pectinic acid

pectin methylesterase

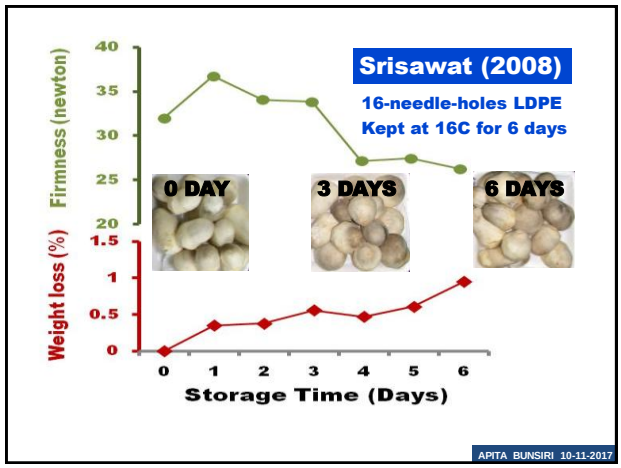
$CH_3OH \leftarrow$ ↓ $\leftarrow H_2O$

Pectic acid / Polygalacturonic acid

polygalacturonase ↓ $\leftarrow H_2O$

D-galacturonic acid

APITA BUNSIRI 10-11-2017



APITA BUNSIRI 10-11-2017

Color Change : Browning

Phenyalanine

↓ phenylalanine ammonia lyase

Monophenol

O_2 ↓ polyphenol oxidase

Diphenol

O_2 ↓ polyphenol oxidase

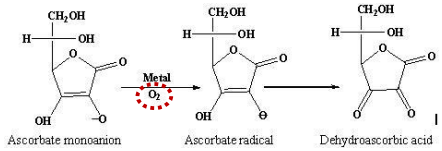
Quinone

↓

Melanin (Black/Brown color)

APITA BUNSIRI 10-11-2017

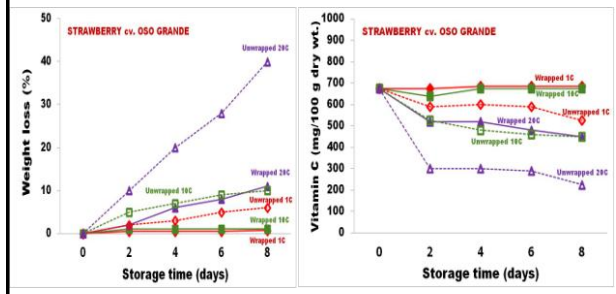
Ascorbic acid (Vitamin C) Degradation



APITA BUNSIRI 10-11-2017

Controlling Temperature and *Water Loss* to Maintain *Ascorbic Acid* Levels In Strawberries During Postharvest Handling

M. C. N. Nunes, J. K. Brecht, A. M. M. B. Morais, and S. A. Sar
JOURNAL OF FOOD SCIENCE —Volume 63, No. 6



APITA BUNSIRI 10-11-2017

Germination

APITA BUNSIRI 10-11-2017

Foodborne pathogen found on fresh-cut jackfruit with and without edible solution coating stored at 12°C for 12 days

Pathogen	Standard guideline	Treatments	Day0	Day12
Aerobic plate count	<6x10^5 CFU/g	Control	4.00x10^4	6.70x10^5
		RF-I	8.78x10^3	6.60x10^4
		RF-II	3.40x10^3	2.40x10^5
Coliform bacteria	<6x10^5 CFU/g	Control	4.00	1.10x10^5
		RF-I	0.00	1.20x10^4
		RF-II	0.00	2.40x10^1
Yeast	<10^4 CFU/g	Control	1.60x10^1	2.10x10^3
		RF-I	0.00	4.00
		RF-II	1.80x10^1	3.10x10^3
Mold	<10^4 CFU/g	Control	0.00	4.00x10^2
		RF-I	0.00	4.00
		RF-II	0.00	4.00

S. aureus E. coli Salmonella spp. Control RF-I RF-II *nd*

APITA BUNSIRI 10-11-2017

Residues (ppm) of pesticides in various portions of unwashed carrots

Portion	Cypermithrin	Diazinon	Parathion
Whole carrot	0.012 (1X)	0.016 (1X)	0.035 (1X)
Crown	0.12 (10X)	0.25 (16X)	0.82 (23X)
Peel	0.021 (1.8X)	0.039 (2.4X)	0.059 (1.7X)
Peeled carrot	nd (0X)	nd (0X)	nd (0X)

Burchat et al., 1998, Food Additives and Contaminants, 15(1):61

APITA BUNSIRI 10-11-2017

Mechanical/Physical Dam **Fruit Pests and Rot**

SOME :
Can Control

SOME :
Out of control

Insurrection,etc.

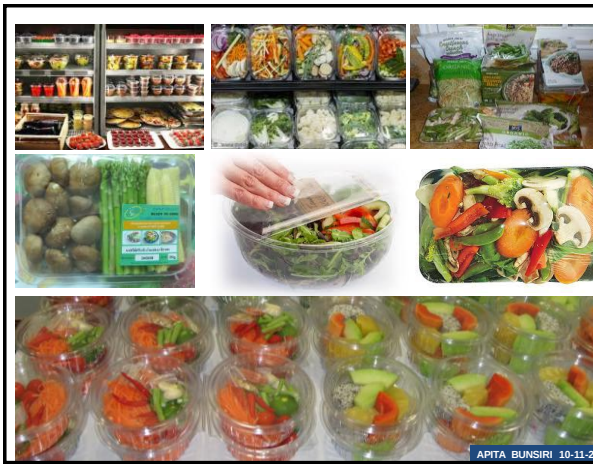
biological

APITA BUNSIRI 10-11-2017

How to produce

Good Convenience Foods

(Fresh-cut Fruit and Vegetables)



Fresh-cut Unit Operations

- Receiving&Storage
- Preliminary Washing &Sorting
- Peeling
- Size Reduction&Cutting
- Size&Defect Sorting
- Washing&Cooling
- Dewatering
- Packaging

FRESH CUT

Problem???

Easy technique
Save and Safe

Learn Understand Solve
Plants

What Kind of produce?

What are the problems that increase produce losses?

How can we solve these problems? (Directly/Indirectly)

Mechanical/Physical Damage : Handlings

Fruit Pests and Rot

Physiological Changes

Quality Changes

Physiological Deterioration

Loss Problems of

Fresh-cut Fruit and Vegetables

Disaster : Flooding, Insurrection,etc.

Food Safety physical, chemical, biological

Food Safety starts from the farm

Physical Damage, Physiological and Biochemical Changes protect by **Good Handlings** from farm to fork

Sanitization including modified atmosphere packaging under suitable temperature and relative humidity need for **DISEASE** control and **Quality** maintenance

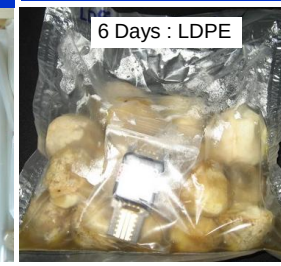
However, investment depends on producers' status

APITA BUNSIRI 10-11-2017

PROBLEM : JUICINESS / WATER SOAKING

Straw mushroom sold in the supermarket was deteriorated within 1 day at 5°C

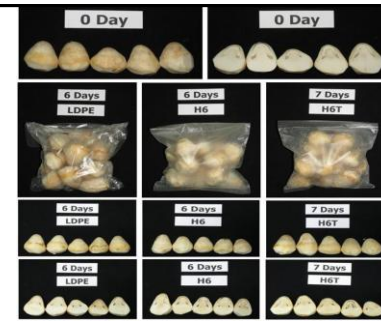
Water soaking of straw mushroom occurred after storing at 15°C for 6 days



APITA BUNSIRI 10-11-2017

Straw mushroom kept at 10, 12, 14, 16,18 °C and RT

APITA BUNSIRI 10-11-2017



Types of Bag	*Coliform*	*Aerobic plate count*	*Yeast and Mold*
Criteria	*ND*	*≤2 cfu/100 ml*	*≤1 cfu/100 ml*
LDPE	*0*	*0*	*0*
H6	*0*	*0*	*0*
H6T	*0*	*0*	*0*

APITA BUNSIRI 10-11-2017

		TPC *<6x10⁵ cfu/g*	TBC *<5x10⁵ cfu/g*	Yeast *<10⁴ cfu/g*	Mold *<500 cfu/g*
0 DAY		0.11x10⁵	0.05x10⁵	0	0
2 DAYS	LDPE	1.30x10⁵	0.28x10⁵	0	0
	H6T	0.30x10⁵	0.19x10⁵	0	0
4 DAYS	LDPE	3.28x10⁵	1.00x10⁵	0	0
	H6T	0.98x10⁵	0.30x10⁵	0	0
6 DAYS	LDPE	5.30x10⁵	3.10x10⁵	0	0
	H6T	1.30x10⁵	0.96x10⁵	0	0
7 DAYS	H6T	1.00x10⁵	0.60x10⁵	0	0

LDPE / H6T	*E. coli* *<20 cfu/g*	*Staphyllococcus aureus* *<200 cfu/g*	*Salmonella spp.* *ND in 25 g*	*Campylobacter spp.* *ND in 25 g*
0 DAY	0	0	0	0
2 DAYS	0	0	0	0
4 DAYS	0	0	0	0
6 DAYS	0	0	0	0
7 DAYS	0	0	0	0

APITA BUNSIRI 10-11-2017

29 DAYS

Jew's Ear (Jelly) / Oyster Mushroom : packaging

APITA BUNSIRI 10-11-2017

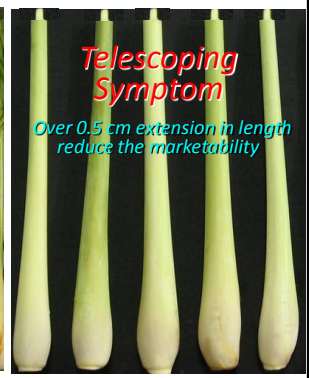
LEMONGRASS

PROBLEM

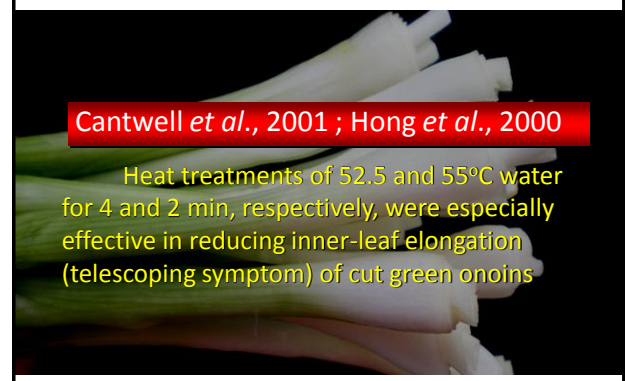
The Extension of internal leaves called telescoping symptom

APITA BUNSIRI 10-11-2017

APITA BUNSIRI 10-11-2017



APITA BUNSIRI 10-11-2017



Cantwell *et al*., 2001 ; Hong *et al*., 2000

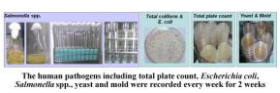
Heat treatments of 52.5 and 55°C water for 4 and 2 min, respectively, were especially effective in reducing inner-leaf elongation (telescoping symptom) of cut green onoins

APITA BUNSIRI 10-11-2017

Lemongrasses transported by refrigerated truck then washed and removed defect

Hot water dip at 52 or 55°C for 3 or 5 min and hydrocool at 3°C for 5 min compared with non-heat treatment (Control)

Cut lemongrass at a length of 20 cm and packed in polyethylene bags before kept at 5°C, 90+5%RH, for 2 weeks



The human pathogens including total plate count, *Escherichia coli*, *Salmonella* spp., yeast and mold were recorded every week for 2 weeks

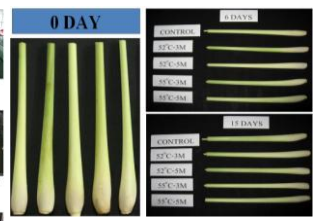


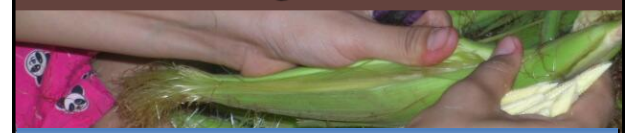
Table 1 *Salmonella* sp., Total plate count, Total coliform, *E. coli* and yeast of fresh-cut lemongrasses dipped in hot water at 52 or 55 °C for 3 or 5 min compared with control (without subjected to warm water) and then stored at 5 °C for 15 days

Trt.	*Salmonella* sp.	*Total plate count*	*Total coliform*	*E. coli*	*Yeast*
Established	per 25 g	cfu/g	cfu/g	cfu/g	cfu/g
guidelines *	N.D.	$<6x10^5$	$1x10^2$	<20	$<1x10^4$
Initial microbe	N.D.	$8.66x10^5$	19.60	4	10.67
WEEK 2					
Control	N.D.	$3.20x10^6b$	38.67a	0	$5.31x10^5a$
52-3	N.D.	$1.14x10^6a$	14.33b	0	$1.21x10^5b$
52-5	N.D.	$4.93x10^6c$	14.33b	0	$5.22x10^5c$
55-3	N.D.	$5.07x10^6c$	2.93c	0	$2.52x10^5c$
55-5	N.D.	$3.00x10^6c$	3.00c	0	$2.64x10^5c$

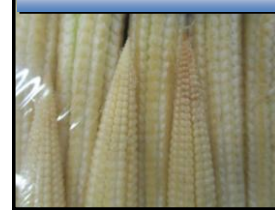
*The established guideline for fresh produce export of Taniyama Siam Co., Ltd. (Rungtai and Boonsiri,2007)

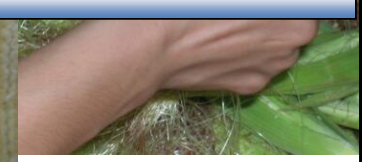
APITA BUNSIRI 10-11-2017

Browning : Water Loss



BABYCORN





APITA BUNSIRI 10-11-2017

PROBLEM : WATER LOSS

BROWNING

Ice Cooling

Reduce temperature can reduce respiration.

High moisture content can reduce transpiration.

APITA BUNSIRI 10-11-2017

Hydrocooling

Reduce temperature can reduce respiration.

High moisture content can reduce transpiration.

APITA BUNSIRI 10-11-2017

JACKFRUIT

Problem

Juiciness and Disease

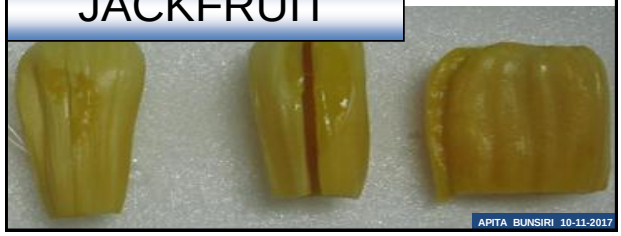
Disease : Cleaness

Sanitization

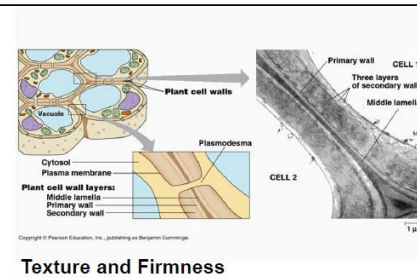
Juiciness :Ripeness

Ripening

Cell strength



APITA BUNSIRI 10-11-2017



Texture and Firmness

- structural components
- turgor pressure

Toivonen, P.M.A. and D. Brummell. 2008. Biochemical bases of appearance and textural changes in fresh-cut fruits and vegetables. Postharvest Biol. Tech. 48: 1-14.

APITA BUNSIRI 10-11-2017

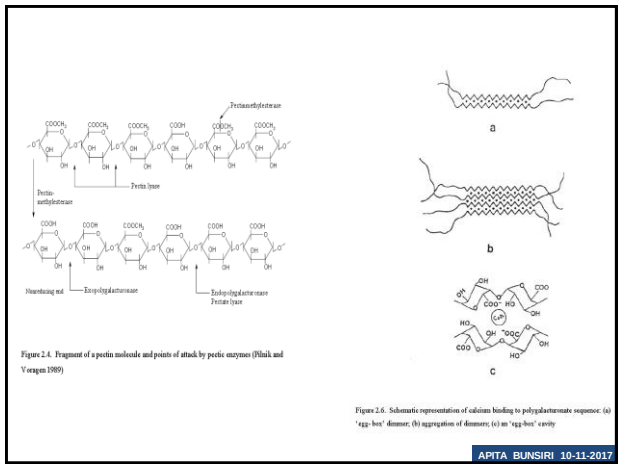


Figure 2.4. Fragment of a pectin molecule and points of attack by pectic enzymes (Pilnik and Voragen 1989)

Figure 2.6. Schematic representation of calcium binding to polygalacturonate sequence: (a) 'egg-box' dimmer; (b) aggregation of dimmers; (c) an 'egg-box' cavity

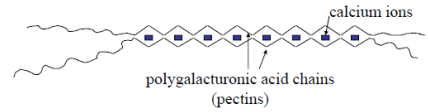
APITA BUNSIRI 10-11-2017

Tissue Firmness & Calcium

- Ca^{2+} stabilizes cell membranes (turgor, membrane permeability and integrity)
- Ca^{2+} forms ionic bonds between pectin molecules (firmness)

$$COO^- \; Ca^{2+} \; {}^-OOC$$

- Ca^{2+} interacts with cell walls & middle lamella: "Egg-box model": Ca^{2+} interacts w/ cell walls & middle lamella



APITA BUNSIRI 10-11-2017

APITA BUNSIRI 10-11-2017

Foodborne pathogen found in fresh cut jackfruit at 0, 6, 12 and 18 days

จุลินทรีย์ก่อโรคที่พบบนขนุนตัดแต่งลดทิ้งเคลือบด้วยฟิล์มเคลือบบริโภคได้อยู่ลายได้มาตรฐานกำหนดนาน 12 วัน ขณะที่ทรีทเมนท์ควบคุมอยู่ลายได้มาตรฐานกำหนดได้เพียง 6 วัน

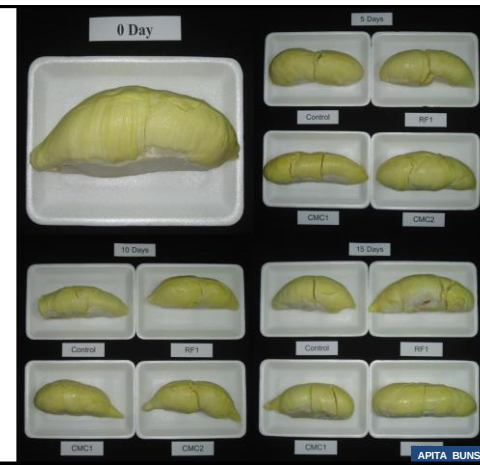
Pathogens	Standard Guideline	Treatments	ค่าเฉลี่ยเชื้อที่ตรวจได้ (CFU/g) Day 0	Day 6	Day 12	Day 18
Aerobic plate count	$< 6 \times 10^5$ CFU/g	Control	4.0×10^3	2.4×10^5	6.7×10^5	1.6×10^6
		Ready fresh-I	8.78×10^2	2.4×10^3	6.6×10^4	3.9×10^6
		Ready fresh-II	3.4×10^3	4.3×10^4	2.4×10^5	4.1×10^6
S. aureus	< 200 CFU/g	Control	0	0	0	0
		Ready fresh-I	0	0	0	0
		Ready fresh-II	0	0	0	0
Coliform bacteria	$< 6 \times 10^5$ CFU/g	Control	4	9.2×10^3	1.1×10^5	8.8×10^5
		Ready fresh-I	0	3.6×10^3	1.2×10^4	3.6×10^5
		Ready fresh-II	0	3.2×10^3	2.4×10^3	6.7×10^5
E. coli	< 20 CFU/g	Control	0	0	0	9.2×10^3
		Ready fresh-I	0	0	0	0
		Ready fresh-II	0	0	0	0
Yeast	$< 10^4$ CFU/g	Control	1.6×10^3	4.7×10^3	2.1×10^3	7.0×10^4
		Ready fresh-I	0	4	4	1.7×10^5
		Ready fresh-II	18	40	3.1×10^2	4.6×10^5
Mold	< 500 CFU/g	Control	0	0	400	>500*
		Ready fresh-I	0	0	4	>500*
		Ready fresh-II	0	0	4	>500*
Salmonella	Not detected in 25 g	Control	Not detected	Not detected	Not detected	Not detected
		Ready fresh-I	Not detected	Not detected	Not detected	Not detected
		Ready fresh-II	Not detected	Not detected	Not detected	Not detected

APITA BUNSIRI 10-11-2017

DURIAN

Problem : Rotting from Bacteria

APITA BUNSIRI 10-11-2017



APITA BUNSIRI 10-11-2017

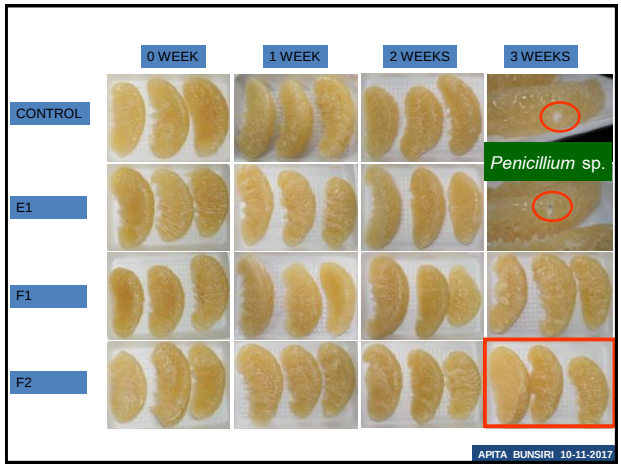
Table 1 Food borne pathogen in terms of total plate count, *S. aureus*, *E. coli*, mold, yeast and *Salmonella* sp. and total coliform bacteria of durian arils non-coated (control) and coated with RF1, CMC-com and CMC-Dr before storing at 5°C for 15 days

Samples	Days	Total Plate Count	*S. aureus*	*E. coli*	Mold	Yeast	*Salmonella* sp.	Total Coliform Bacteria
Standard (cfu/g)		$<6x10^5$	*<200*	*<20*	<500	$<10^4$	ND	$<6x10^5$
Initial Samples	0D	ND	ND	ND	ND	ND	ND	ND
CONTROL	0D	ND	ND	ND	ND	ND	ND	ND
	5D	ND	ND	ND	ND	ND	ND	ND
	10D	$9.6x10^2$	ND	ND	ND	$1x10^2$	ND	ND
	15D	$1.8x10^6$	ND	ND	$1x10^3$	$1x10^3$	ND	ND
CMC-COM	0D	ND	ND	ND	ND	ND	ND	ND
	5D	ND	ND	ND	ND	ND	ND	ND
	10D	ND	ND	ND	ND	ND	ND	ND
	15D	$4.0x10^2$	ND	ND	ND	ND	ND	ND
CMC-Dr	0D	ND	ND	ND	ND	ND	ND	ND
	5D	ND	ND	ND	ND	ND	ND	ND
	10D	ND	ND	ND	ND	ND	ND	ND
	15D	$5.0x10^2$	ND	ND	ND	ND	ND	ND
RF1	0D	ND	ND	ND	ND	ND	ND	ND
	5D	ND	ND	ND	ND	ND	ND	ND
	10D	ND	ND	ND	ND	ND	ND	ND
	15D	$1.0x10^3$	ND	ND	ND	ND	ND	ND

APITA BUNSIRI 10-11-2017

POMELO

APITA BUNSIRI 10-11-2017



Guideline for the microbiological quality of fresh-cut asparagus for export at Taniyama Siam Co., Ltd. (Runglai and Boonsiri, 2007)

Pathogen	*Samonella* spp.	Yeast *	Mold*	Coliform*	E.coli*	TPC*
	per 25 g	cfu/g	cfu/g	cfu/g	cfu/g	cfu/g
Standards	N.D.	$< 10^4$	< 500	$< 6 \times 10^5$	< 20	$< 6 \times 10^5$

RESULT

Yeast and Mold (X 10^3) — **99% YEAST**

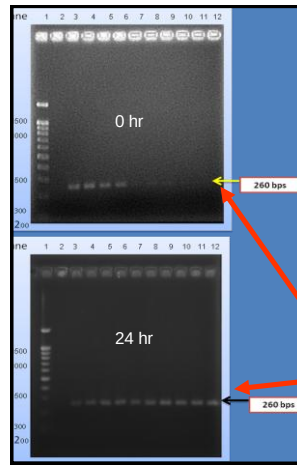
Treatments	Week0	Week1	Week2	Week3
Non-coated	0.013	0.044	8.2	74.7
E1	0.013	0.014	0.03	56
F1	0	0.014	0.035	99.15
F2	0.003	0.016	0.061	122.68

APITA BUNSIRI 10-11-2017

USING RAPID TECHNIGUE TO TELL THE MICROBIAL CONTAMINATION INSTEAD OF USING PLATE COUNT

From.. Seksun Samosornsuk

APITA BUNSIRI 10-11-2017

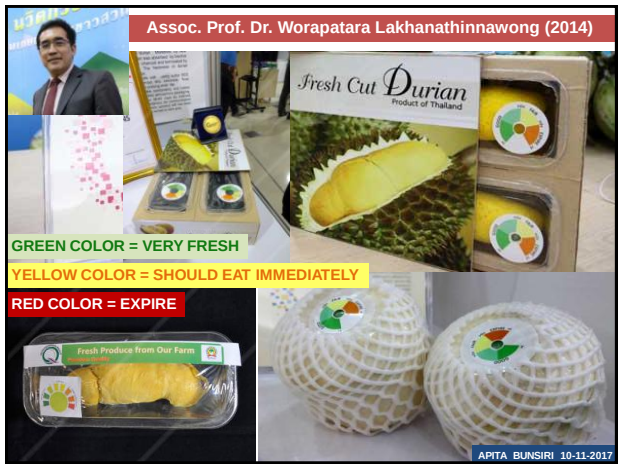


10µl sample + 10xloading dye 2 µl
2% Agarose gel in 1xTAE tris-acetate run 100 vole 35 min.

Lane ที่
1: 100 bps DNA ladder (load 2 µL)
2: Negative control
3: Positive control (*Salmonella* group.B 52603145)
4: *Salmonella* 10^8 CFU/ml
5: *Salmonella* 10^7 CFU/ml
6: *Salmonella* 10^6 CFU/ml
7: *Salmonella* 10^5 CFU/ml
8: *Salmonella* 10^4 CFU/ml
9: *Salmonella* 10^3 CFU/ml
10: *Salmonella* 10^2CFU/ml
11: *Salmonella* 10^1CFU/ml
12: *Salmonella* 10^0 CFU/ml

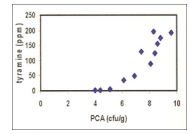
From.. Seksun Samosornsuk

APITA BUNSIRI 10-11-2017



MICROBIAL INDICATOR

Metabolite :
Alcohol (ethanol)
Amine (thiramine)
+ *Enzyme* ➡ *Substrate* + *Color Dye*



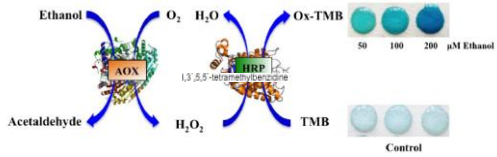
http://www.tistr.foodprocess.net/download/article/food_safety_issues_th.htm

APITA BUNSIRI 10-11-2017

Paper Based Analytical Device For Alcohol Using Enzymatic Detection

กนกวรรณ พีสันเทียะ, และ ยุภาพร สมีน้อย*
Kanokwan Feesanthia, and Yupaporn Sameenoi* (2014)
ภาควิชาเคมี คณะวิทยาศาสตร์ มหาวิทยาลัยบูรพา

วารสารวิทยาศาสตร์บูรพา ฉบับพิเศษ การประชุมวิชาการระดับชาติ วิทยาศาสตร์วิจัย ครั้งที่ 6 วันที่ 20 – 21 มีนาคม พ.ศ. 2557



AOX =alcohol oxidase

HRP =Horseradish peroxidase

TMB =3,3',5,5'-tetramthylbenzidine

Maintain quality & shelf life of fresh product

1. Use highest quality raw material
2. Minimize mechanical damage/sharp knife
3. Rinse cut surface/remove excess water
4. Maintain strict sanitation/chlorinated water
5. Use appropiate package and atmosphere
6. Maintain product quality at 1-5ºC

Demonstration of

Fresh-Cut Fruits and Vegetables