Nondestructive Quality Evaluation Technology for Fruits and Vegetables

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Contents

Introduction (1)

- Many countries in Asia-Pacific region are facing with the significant changes in socio-economic conditions pertaining to agriculture.
  - Rapid industrialization and massive rural-urban migration
    → Stimulate the necessity of **Agricultural Mechanization**
  - Liberalization of Int'l trade and increase in trade volume
  - Growing demand for high quality/safety agri. products
    → Call for the advanced **Postharvest Technology**
- Postharvest technology includes several operations;
  - Pretreatment, sorting/**grading**, packing, storage, etc.

Introduction (2)

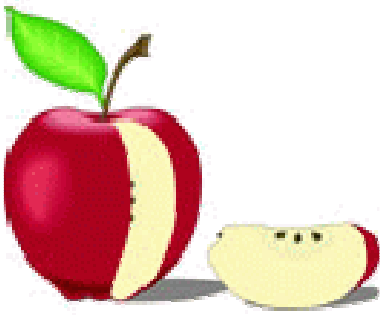
- Grading becomes essential for modern marketing since quality standard is strengthened and pricing is tied up to the quality
  - Fruits and vegetables have different size, color, sugar content, firmness, etc. on individual base
  - Various nondestructive techniques have been developed;
    - machine vision, **NIR spectroscopy**, X-ray, MR/MRI, etc.
- Introduction of principles, applications and examples of VIS/NIR spectroscopic tech.
  - peach grading, apple grading, citrus grading system
  - watermelon sorting system

Quality ?

- Defined as the degree of excellence & acceptability
- Determined by cultivation tech., climate, soil, etc.
- Quantified by several quality components

Appearance Quality Compo.:

color, shape, sunburn, decay, scald, scars,scab, insect damage, pesticide damage, etc.



Internal Quality Compo.:

sugar, acid, maturity, firmness, freshness, bruise, internal defects, etc

Quality Components in Grade Standards of Apple by Country

Country	Quality components	
	External	Internal
Korea	color, shape, weight, freshness, scab, sunburn, disease and insect damage, scars, pesticide damage, stem	sugar content, maturity, internal breakdown, internal browning
Japan	color, shape, weight, scab, sunburn, disease damage, insect damage, scars, stem	maturity, internal breakdown, internal browning
USA	color, shape, size, decay, scald, scab. Jonathan spot, insect damage, freezing injury, russeting, scars	maturity, firmness, internal breakdown, internal browning, bitter pit, water core, bruises

Necessity of Sorting/Grading (1)

- Quality characteristics of Fruit and vegetables
  - Wide variation in quality of individual fruit

- Size and sugar content distributions of peach samples harvested at an orchard

Class by weight		Substandard	Small	Medium	Large	Extra large
		Less than 180g	180 - 210	210 -250	250 -300	More than 300g
Sugar Content (Brix)	Min	5.2	5.5	5.9	6.9	8.2
	Max	7.8	10.1	11.2	12.7	15.7
	Average	6.6	7.7	8.5	9.4	10.8

Note: Chungdo Peach Experimental Station, 1999

Necessity of Sorting/Grading (2)

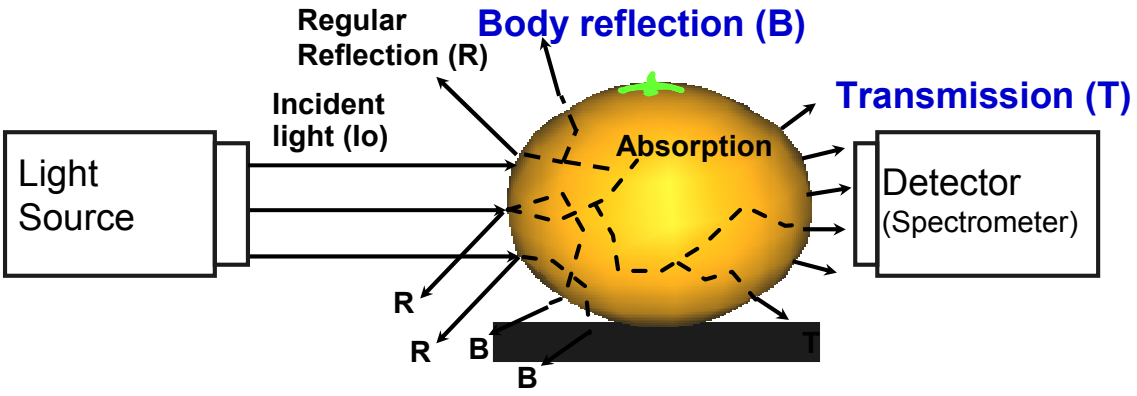
- Consumers' preference in purchasing fruits in Korea
  - Survey result in 1998;
    Sweetness(29.0%)>Freshness(27.2%)>Price(26.5%)>Safety..
  - Survey result in 2003;
    Sweetness(47.3%)>Freshness(28.6%)>Price(15.1%)>Safety..
- Increase in number of large scale stores and packinghouses
  - Foreign discount store : 50(2001) → 87(2004)
    Domestic hypermarket : 110(2001) → 217(2004)
  - Packinghouses: 11(2001) → 99(2005)
- Change of the government policy
  - From production-oriented to market & consumer-oriented

Nondestructive Technologies

❑ Nondestructive techniques for measurement of quality components of horticultural products

- Machine vision : size, shape, color, external defects
- **NIR spectroscopy** : chemical components and defects
- X-ray image and CT : inter. cavity and structure
- Sonic/Ultrasonic : inter. cavity & structure, density, firmness
- MR/MRI : chemical components, defects, and structure

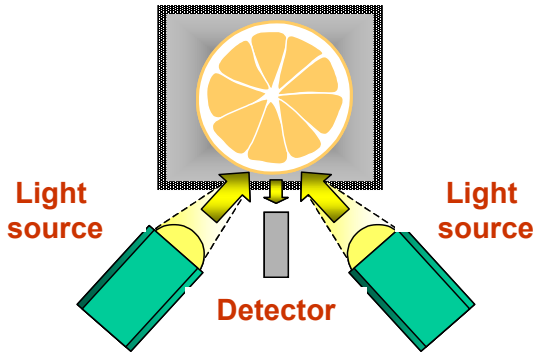
VIS/NIR Spectroscopic Method ?

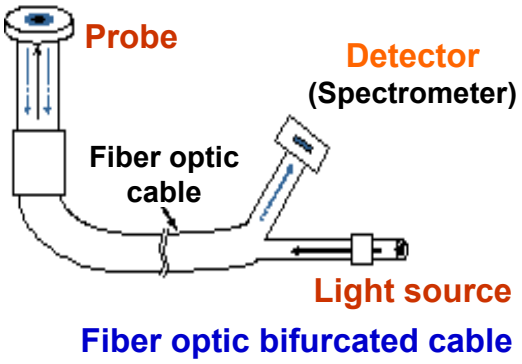


- Factors on reflectance and transmittance

- light intensity, fruit size, firmness, chemical components, cellular structure, etc

Reflectance Measurement System

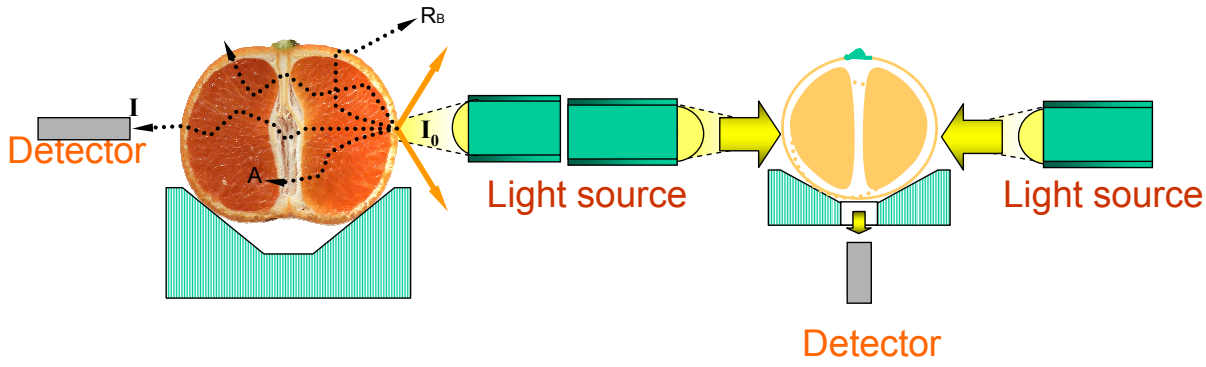




- Lamps and detectors are located at the same side.
- Measured is body reflection having limited penetration depth.
- Features: simple device, high S/N ratio, local values of chemical components, not for detecting internal breakdowns
- Applications: liquids, powders, grains, fruits having a thin peel
  - peaches, apples, pears, tomatoes

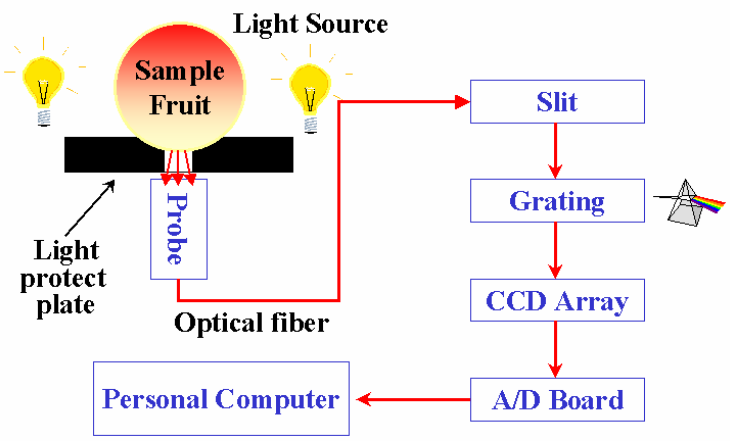
Transmittance Measurement System

Full-transmittance **Half-transmittance**



	Full-transmittance	Half-transmission
Applications	Thin-peel/ small-sized fruits(citrus, tomatoes, etc.), grain, milk,	Thick-peel/large-sized fruits and vegetables (apple, pear, watermelon, etc.)

Features of Transmittance mode



Outlook of Free tray

- Can detect internal breakdowns and measure average values of chemical components
- Needs high sensitivity detector and strong light source
- Low S/N ratio
- Leakage light should be blocked not to reach the detector

Current status of sorting technologies in Korea

Fruits / Quality Factors	Apple	Pear	Peach	Persi-mmon	Manda-rine	Melon	Tomato	Korean melon	Water-melon
Weight	○[1)]	○	○	○	○	○	○	○	○
Size	-[5)]	-	-	-	○	-	-	-	-
Colour	○	○△[2)]	○△	x[4)]	○	-	○	x	x
Sugar content	○	○	○	x	○	○	○	○	○
Acid content	△[3)]	△	△	-	△	-	x	-	-
Maturity	x	x	x	x	△	x	△	x	△
Firmness	x	x	x	x	-	-	-	-	-
Freshness	x	x	x	x	x	x	x	x	x
Internal breakdown	○	○	x	x	x	x	x	○	○
Water core	○	-	-	-	-	-	-	-	-
Sponge disor.	-	○	-	-	-	-	-	-	-

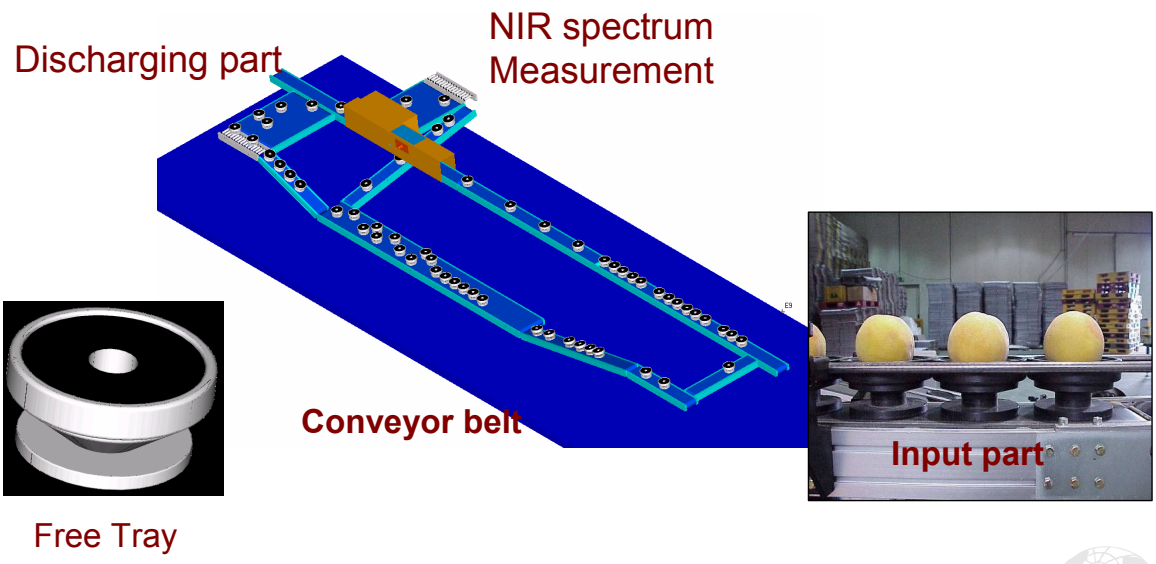
1) ○: Using at packing house 2) ○△: Technology is available but has not adopted at packing house
3) △: Under study for improving accuracy 4) x : Has not studied. 5) - : Not regarded as quality factor

Peach Grading System(1)

- Characteristics of Korean peaches
  - Relatively soft intact flesh
  - Large variation in sugar content among fruits
  - Large difference of sugar content within each fruit
- Considerations in devel. of peach grader
  - Minimizing damages during sorting process
    → **free tray system to avoid contact between fruits**
  - Minimizing the location effect in sugar content
    → **special design of reflection probe**
  - **High accuracy and large sorting capacity**
    → **real -time sorting**
    → **development of a robust calibration equation**

Peach Grading System(2)

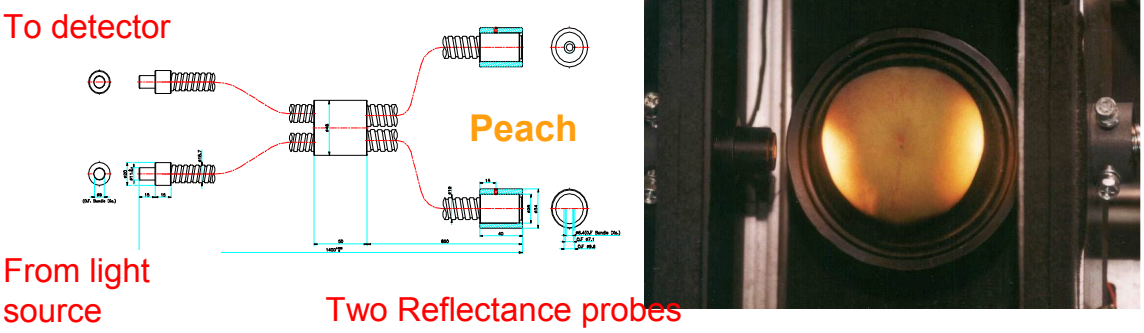
- Construction of peach grading system



Peach Grading System(3)

❑ Design of NIR reflectance probe

- Measuring the reflectance of both sides at one time
  with two reflectance probes made with bifurcated fibers

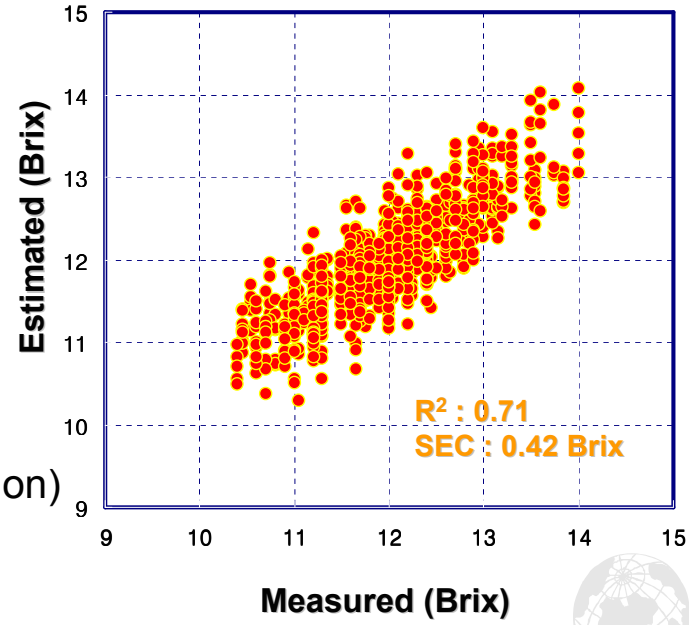


Lay out of reflectance spectrum measurement

Peach Grading System(4)

❑ Development of Calibration Equation

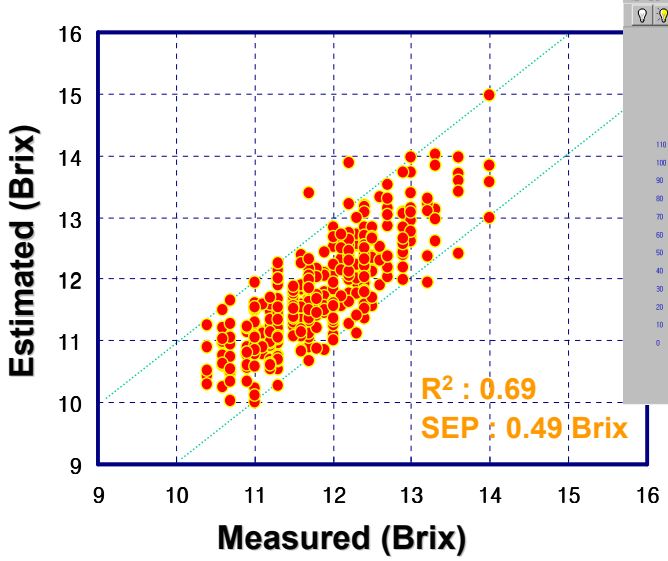
- Samples: 790 peaches
  (*Hwangdo* variety)
- Sorting speed: 52 cm/s
  (3 fruits/sec)
- Wavelength range :
  630~1100 nm
- Calibration model : MLR
  (Multiple Linear Regression)
- Calibration result

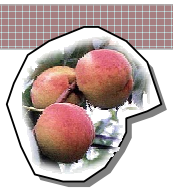


Peach Grading System(5)

❑ Validation of calibration equation

- Samples : 340 peaches (Hwangdo variety)
- Sorting speed : 52 cm/s





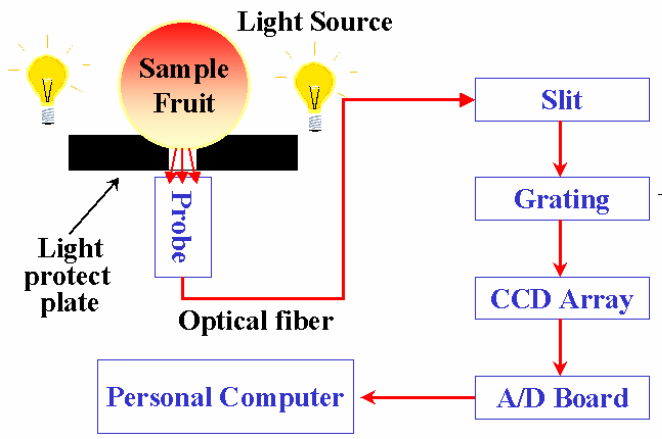
Peach Grading System(6)

❑ Prototype and performance test (Peach)

- Capacity : 7,200 peaches per hour
- Sugar content error of ±0.5 Brix
- Sorting accuracy of 91% in classifying two grades

Apple Grading System (1)

❑ Apple and Pear Sorter
(weight, color, sugar and internal defects)



Measurement of transmittance spectra

Apple Grading System (2)

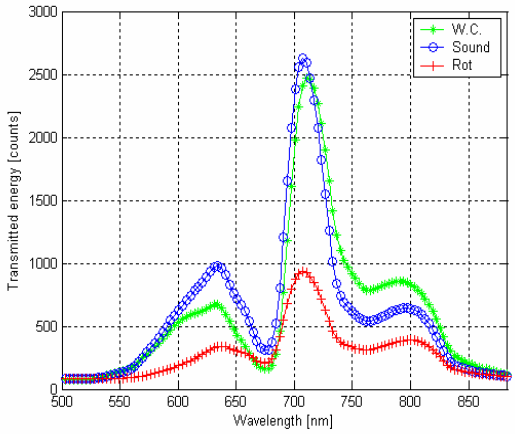
❑ Detection of Internal Defects of Fuji Apple

Internal rot

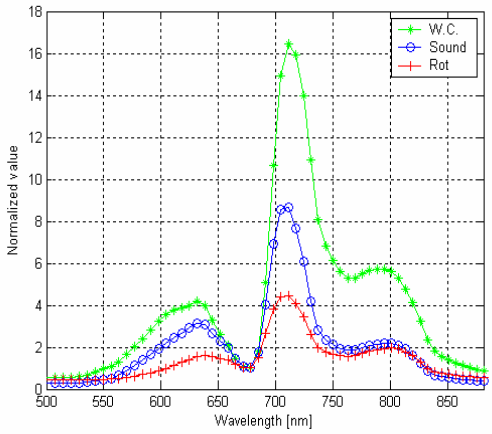
Cross section of water-core samples

Apple Grading System (3)

- Spectrum characteristics of Fuji Apple Samples

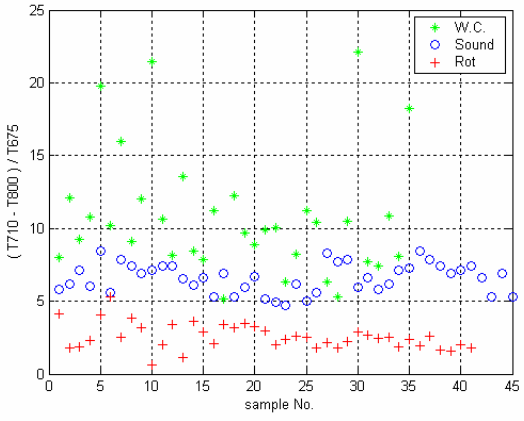


Mean transmitted energy spectra of the sound, water-core and internally rotted Fuji apples

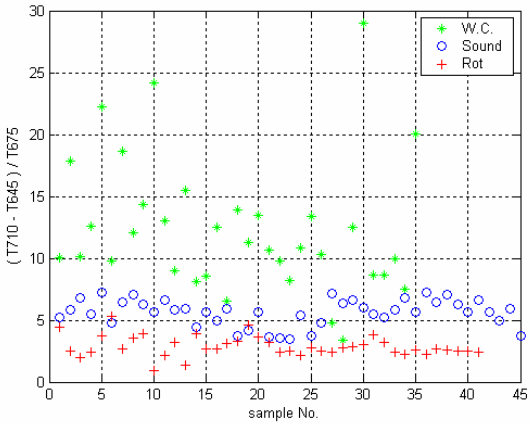


Mean transmitted energy spectra of Fuji apples normalized with the lowest value near 675 nm

Classification of Internal Breakdowns



Distribution of $(T_{710} - T_{800}) / T_{675}$ of Fuji apples (PD23)



Distribution of $|T_{645} - T_{710}| / T_{675}$ of Fuji apples (PD12)

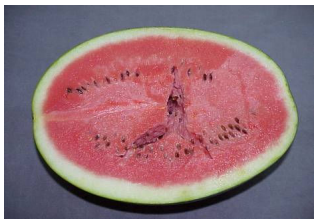
- Detection of the rotted sample by PD23 and the water-core by PD12
- Detection rate of the sound, the water-core and the rotted samples : 100 %, 91.4 % and 97.6%

Watermelon Sorting System(1)

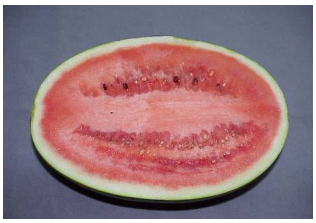
❑ Quality components

Weight, sugar content, maturity,
internal defects (cavity and blood flesh)

Immature

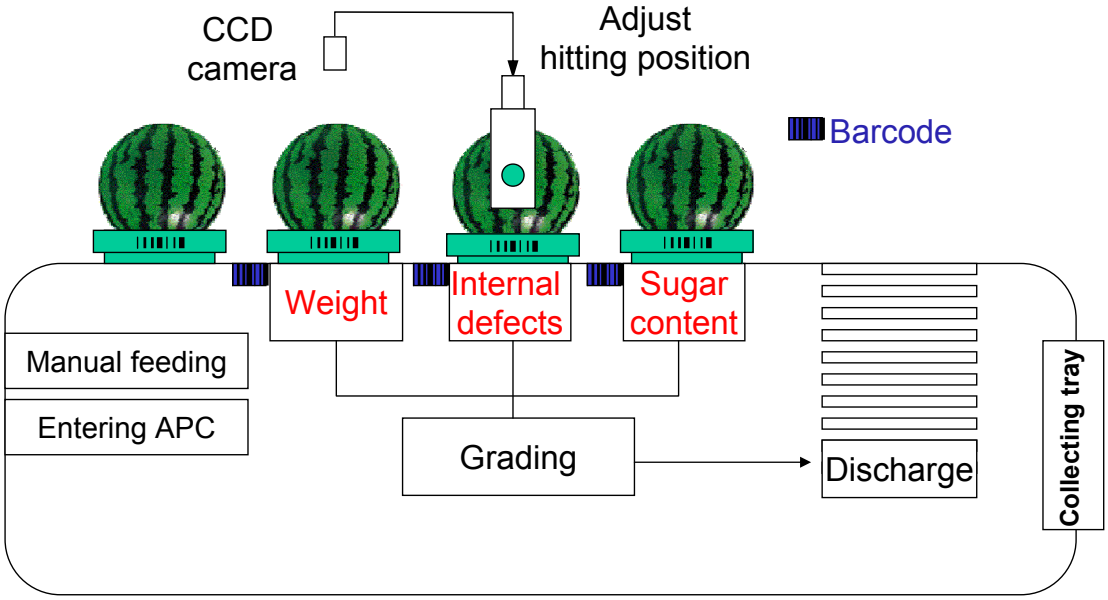


Internal cavity



Blood flesh

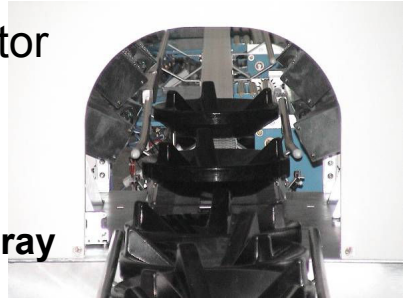
Layout of the watermelon sorting system



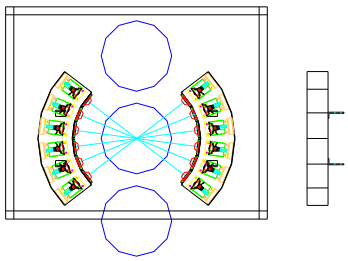
- Manual feeding to free trays
- Sizing by CCD camera and Automatic weighing
- **Acoustic device for sound analysis**
- Optical device for **NIR half-transmittance measurement**

Optical Device for NIR transmittance measurement

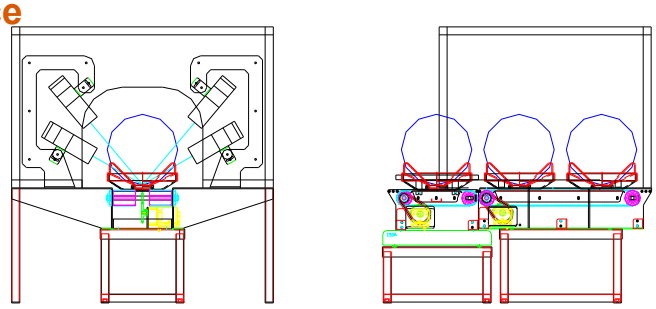
❑ Arrangement of lamps and detector



Tray



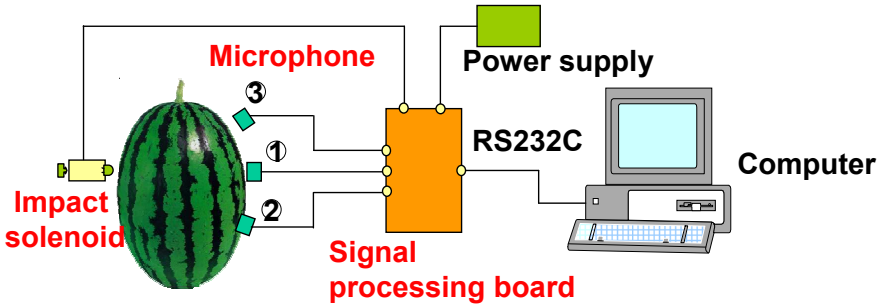
Light source

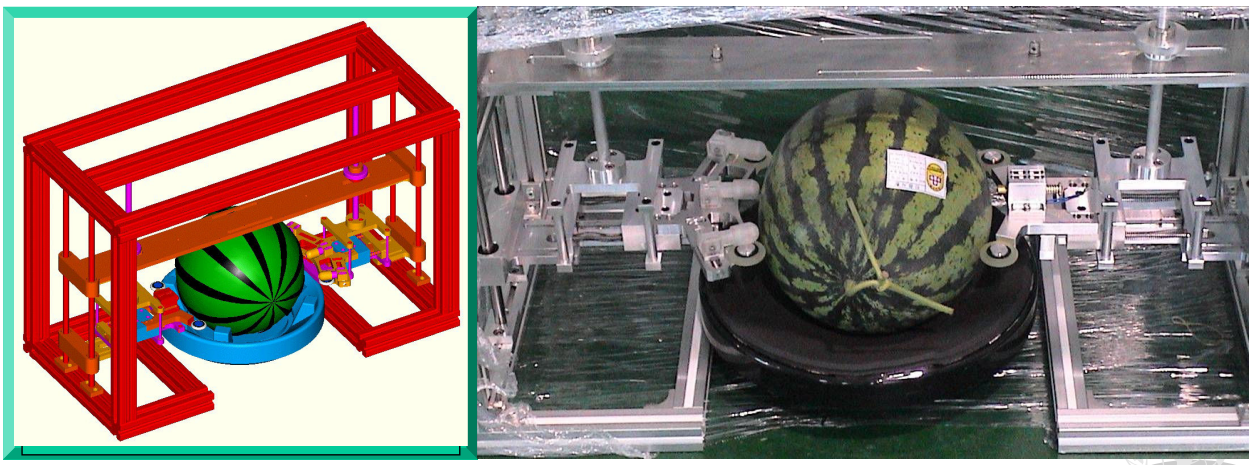


Detector

Conveyor

Acoustic Device for Sound Analysis





Prototype and performance test

- Capacity : 1,500 watermelons per hour
- Sugar content error: ±0.8 Brix
- Accuracy of Internal defects : 90 %

Conclusions and Remarks(1)

❑ With practical application of NIR spectroscopic method in1989, many changes have been occurred in marketing and production of fresh products.

(1) Consumers' choice in purchasing fruits is turned from appearance qualities to the internal,

(2) Quality guarantee system is being more strengthened in domestic market and international trade,

(3) Marginal value of better quality products is increased,

(4) Production and post-harvest technologies of fruits and vegetable are being advanced rapidly.

Conclusions and Remarks(2)

- In the near future, Computer can tell the taste of fresh products on sorting line.

Thank you very much for your attention!

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