Inside Quality Evaluation of Fruit by X-ray Images

Introduction

The world is worrying about the quality of food supply. Because….

- The pesticide residue on imported food
- The toxic material by the microorganism
- The camouflage foods
- The BSE problem

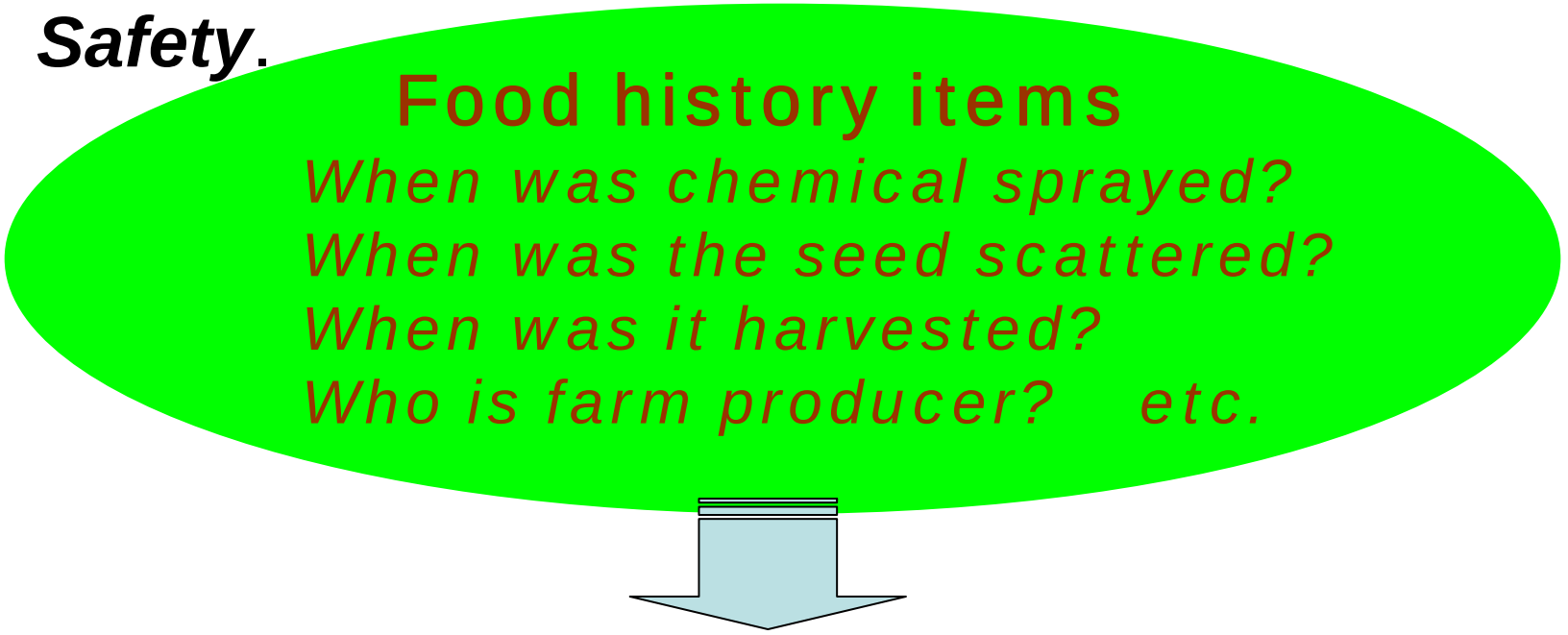
…..etc.

As a solution…

Construction of food traceability system

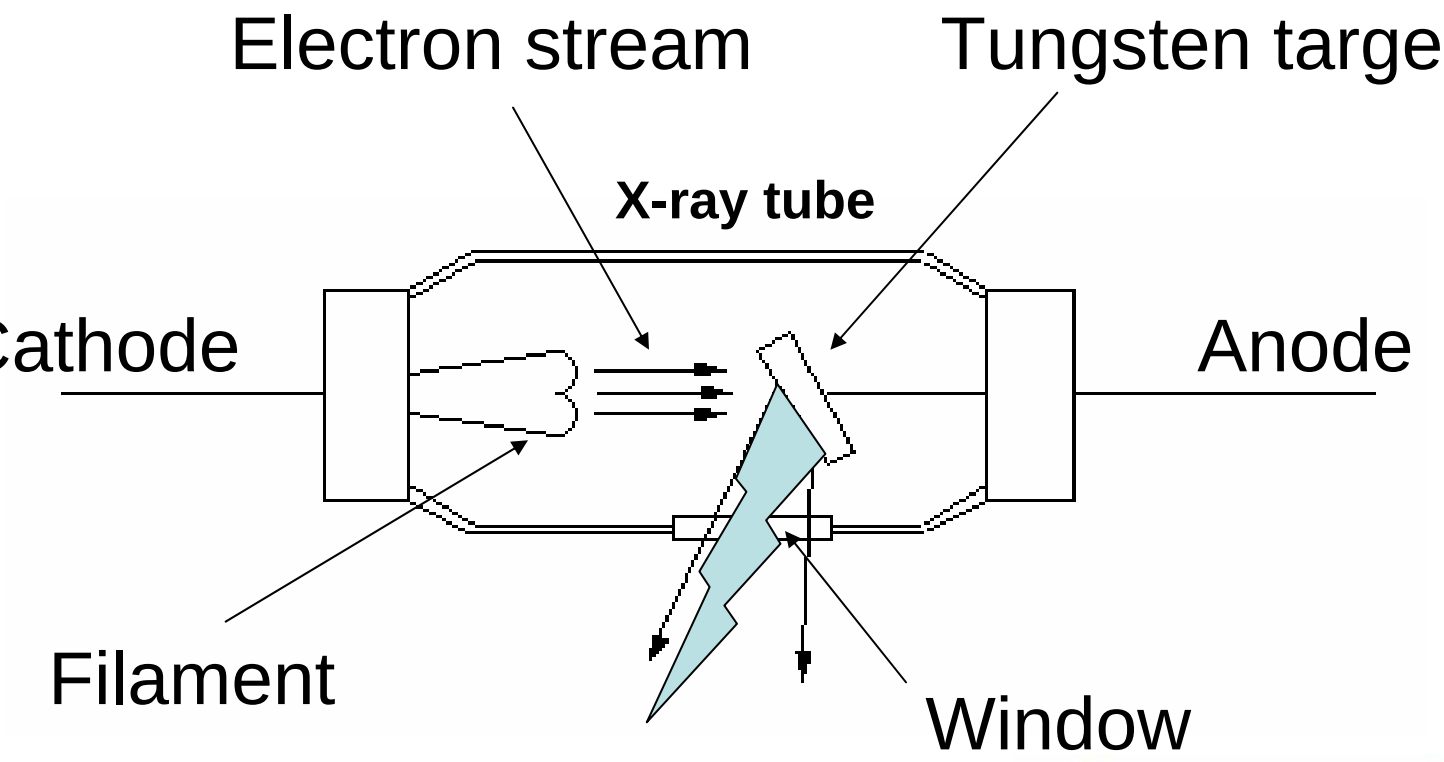
What is Food Traceability System

The traceability is a system to open ***the food history*** of agricultural products and to keep food ***Safety***.



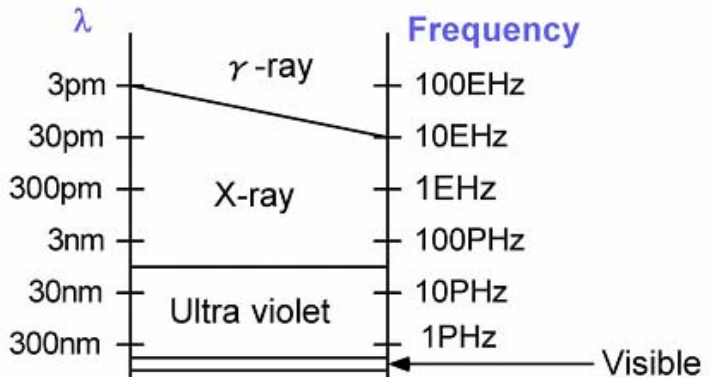
Internal quality is one of the informaiton

The X-ray emission method



Electromagnetic Wave = X ray

Soft X ray: less than 100keV Tube Voltage
Energy of soft X ray: 0.1-2 keV

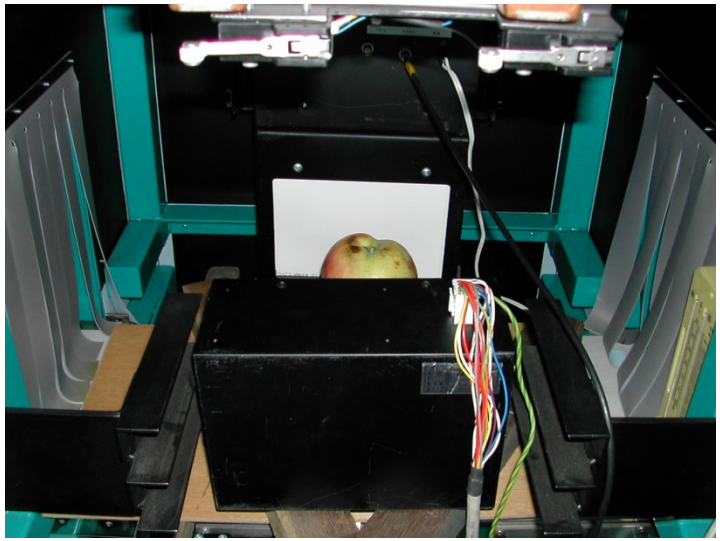


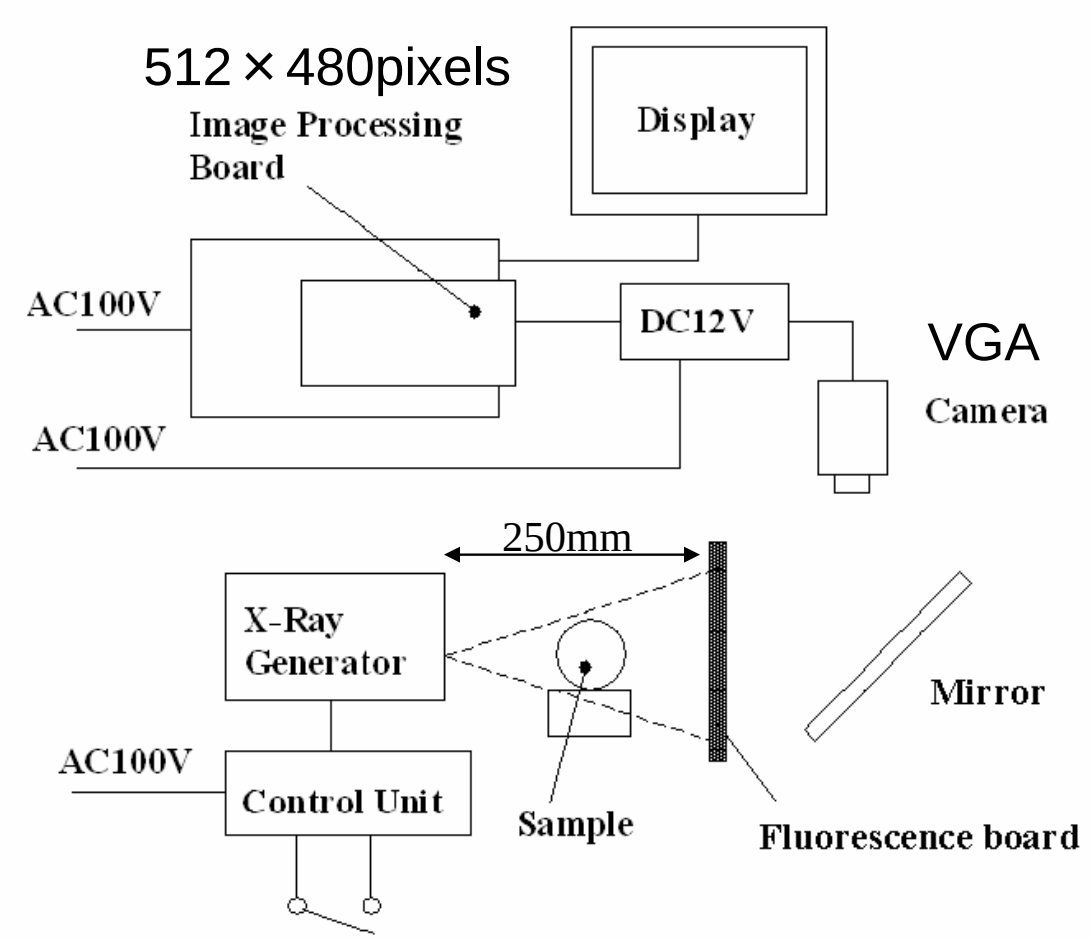
The safety of X-ray

"Healthiness" is a comprehensive safety concept in which includes poisonous safety, microbiological safety, and nutriological qualification of irradiated food.

International conference (JECFI) organized by World Health Organization (WHO), the United Nations Food and Agriculture Organization (FAO), and the International Atomic Energy Agency (IAEA) reported "No toxicological hazard is observed in any 10kGy irradiation food." in 1981.

Area sensor system





Output Voltage and current: 60keV, 3mA

Materials

Side view

Side view

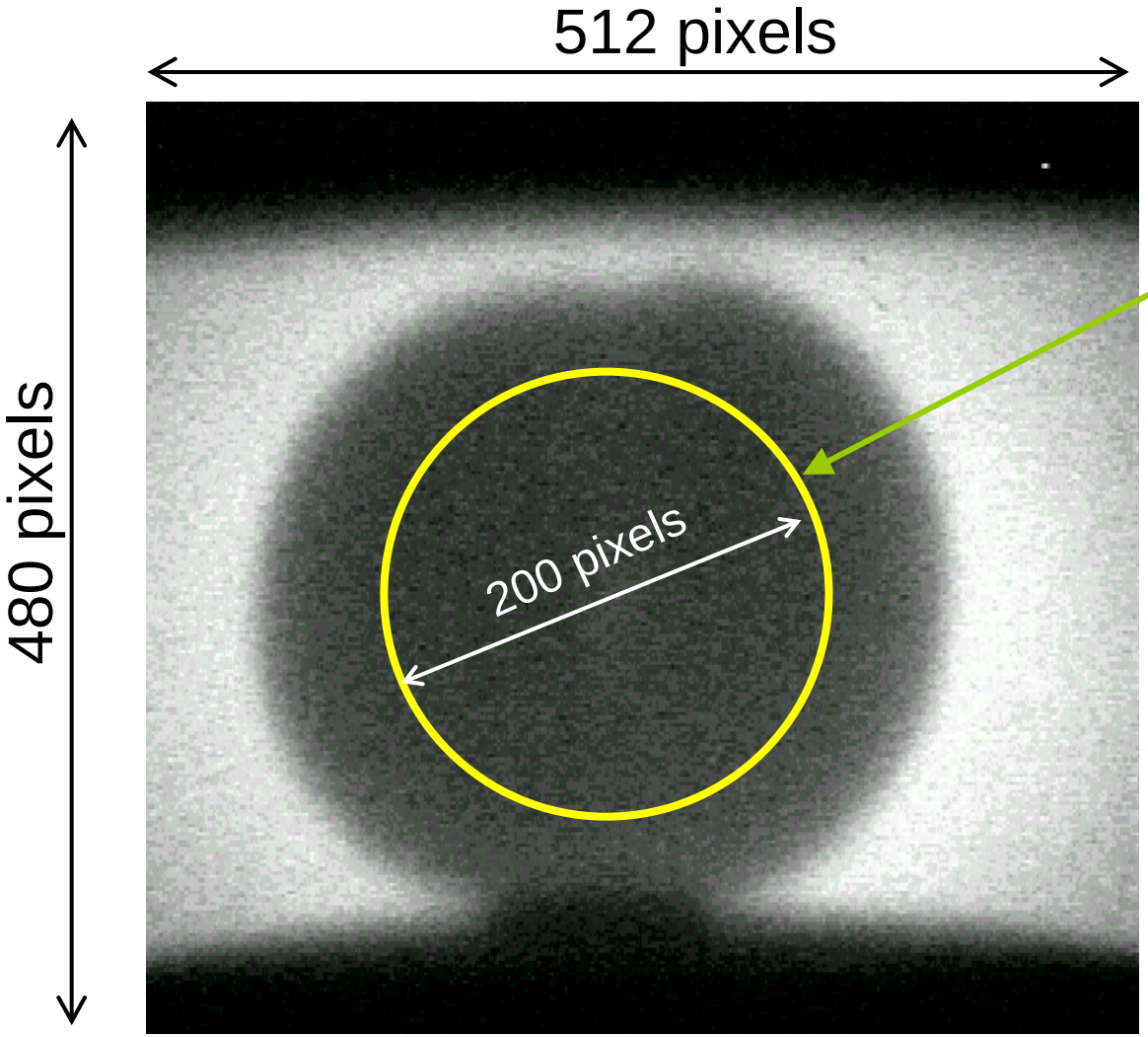
Top view

Sample fruit orientation

Three varieties of fruits were used;

63 apples of "*San-Tsugaru*", 41 pears of "*Kosui*", and 50 peaches of "*Akatsuki*"

Valuation method

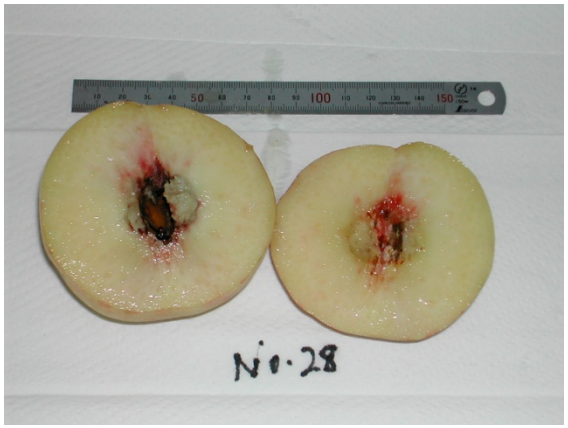


Region of interest

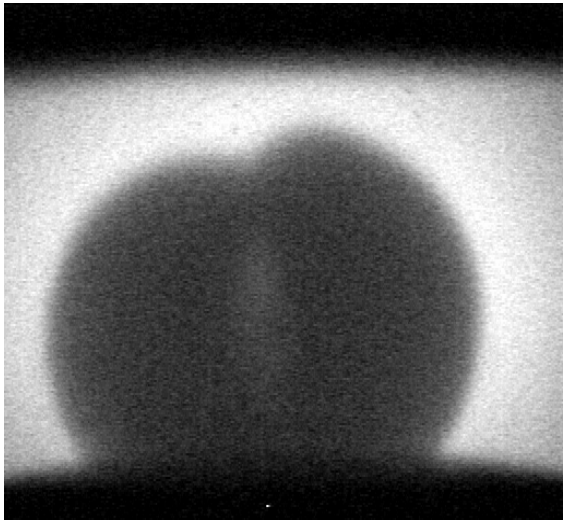
Maximum
Minimum
Average
Dispersion of
Gray level value

Experimental result（sprit-pit of peach）

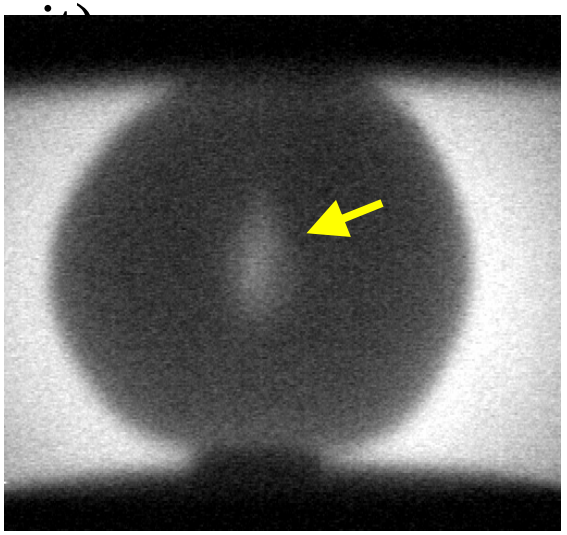
(a) Appearance



(b) Cut sample (Sprit-



(c) Side view



(d) Top view

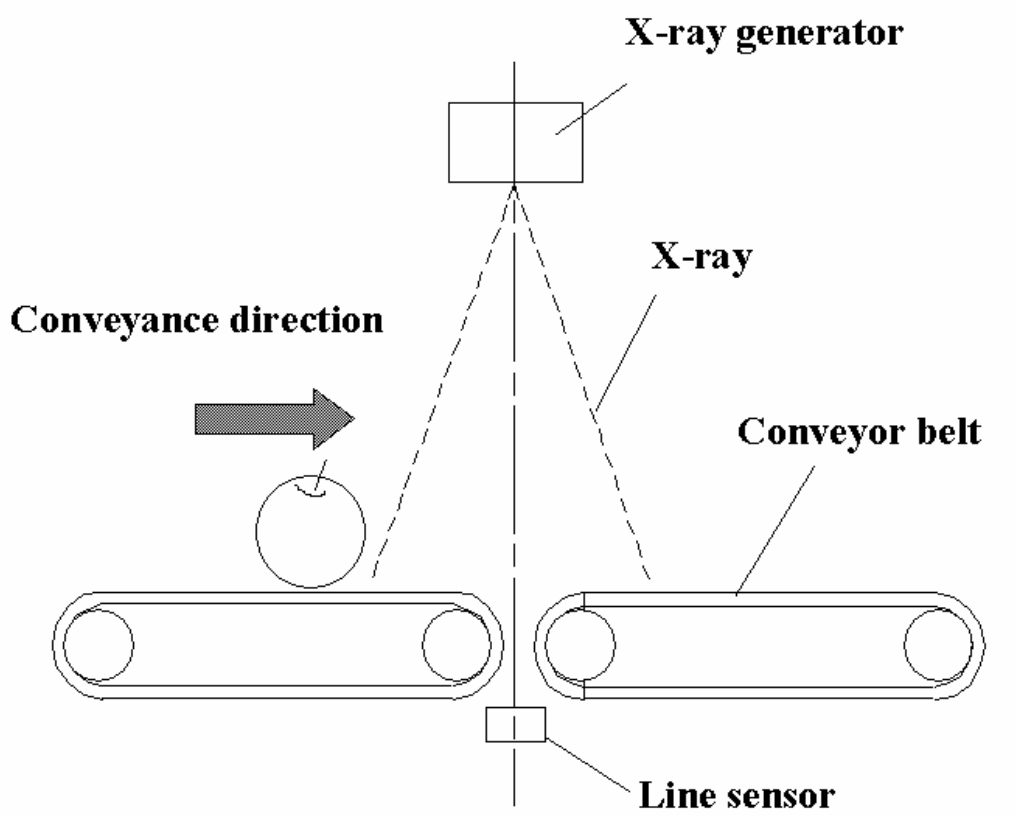
Gray level distribution with a split-pit of peach.

		Minimum	Maximum	Average	Dispersion
Sprit-pit	Top view	8.0	57.1	21.3	24.8
	Side view	6.4	49.1	19.1	13.4
Normal-pit	Top view	7.0	37.5	19.2	10.3
	Side view	5.3	33.0	17.3	9.9

Gray level distribution with a rotten core of pear.

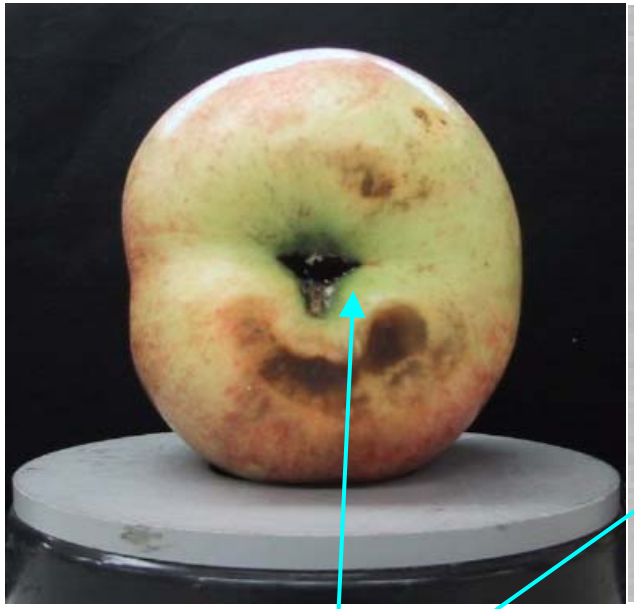
	Minimum	Maximum	Average	Dispersion
Rotten core	**9.5**	**44.5**	**23.6**	**28.7**
Crack	**12**	**39.9**	**25.5**	**13.0**
Normal	**9.0**	**43.7**	**21.5**	**14.2**

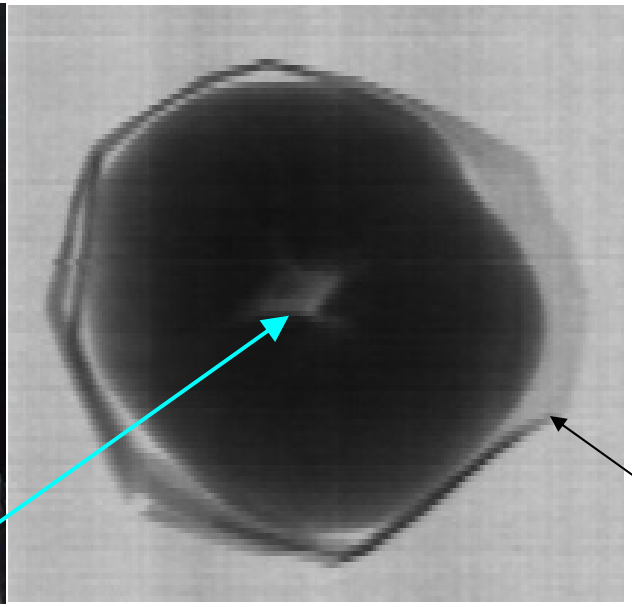
Line sensor system



Output Voltage: 70-100keV
Output current: 1-3 mA

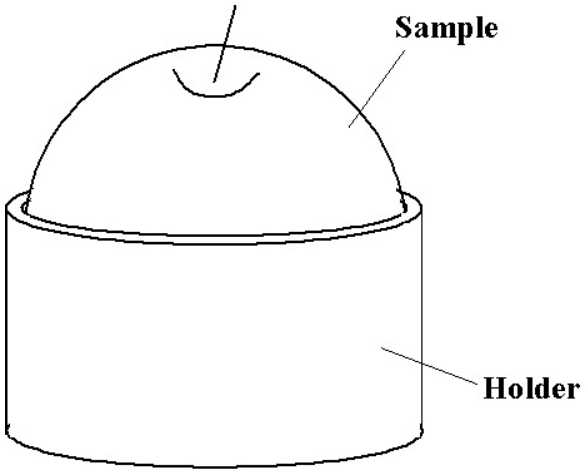
Transmittance Image





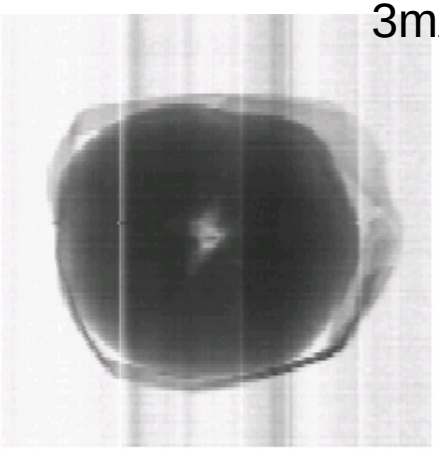
Holder

Rotten core

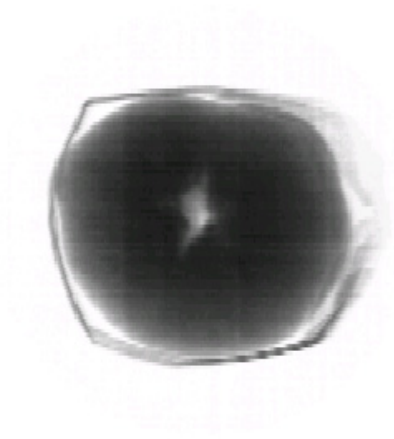


Transmittance images when X-ray power changed

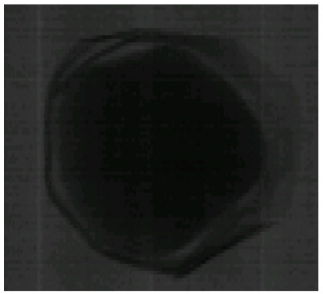
3mA



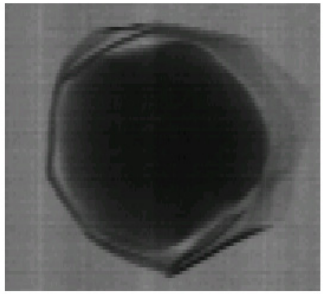
(a) 70keV



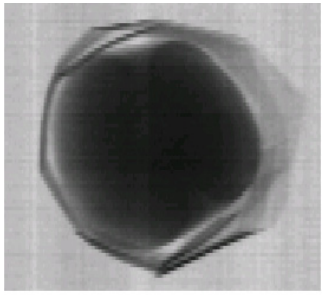
(b) 80keV



(e) 1mA

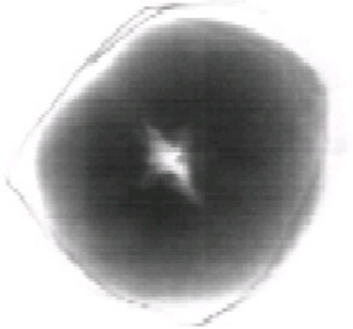


(f) 2mA



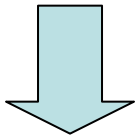
(g) 3mA

70keV



(c) 90keV

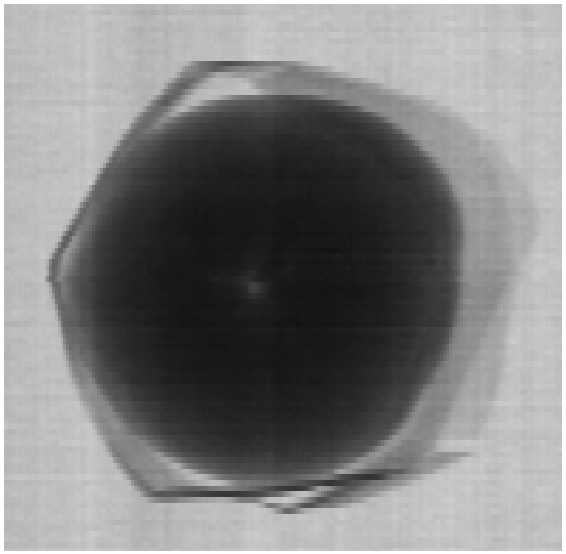
(d) 100keV



70keV, 3mA is suitable for apple

Disease of flesh

(a)



(b)

(c)

X ray was not efficient for this flesh disease because of no enough change of water content for transmittance image.

X-ray CT

The appearance

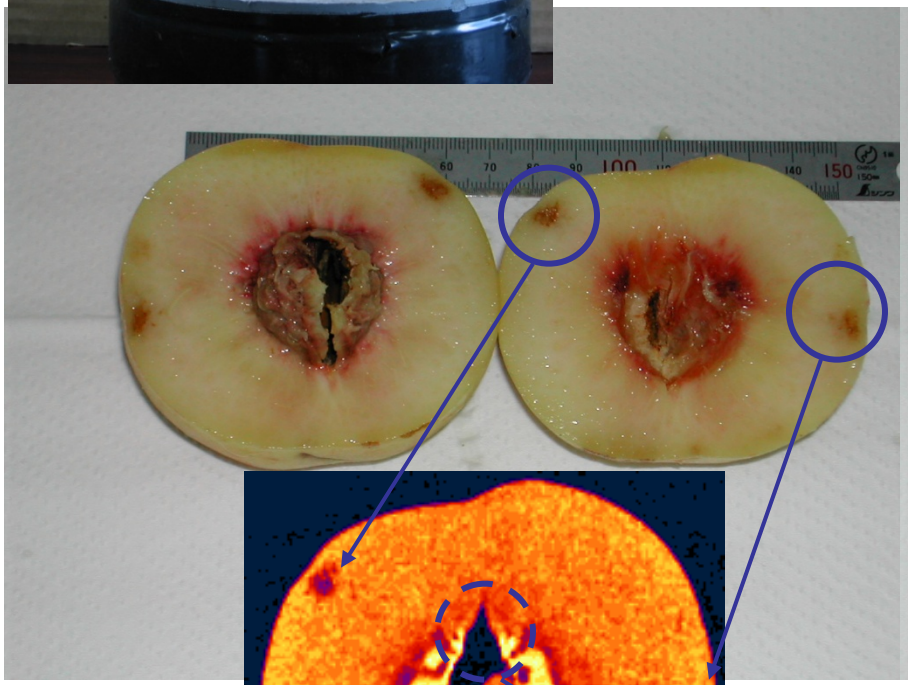
(Toshiba, TOSCANER-20000)

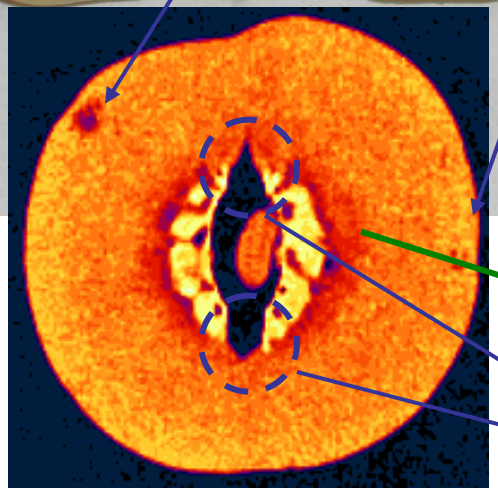
Control unit

[experimental set up]

Single slice, Slice width:2mm, Matrix size:512x512pixel, Area:300mm, 150kV, 3mA

CT image of peach

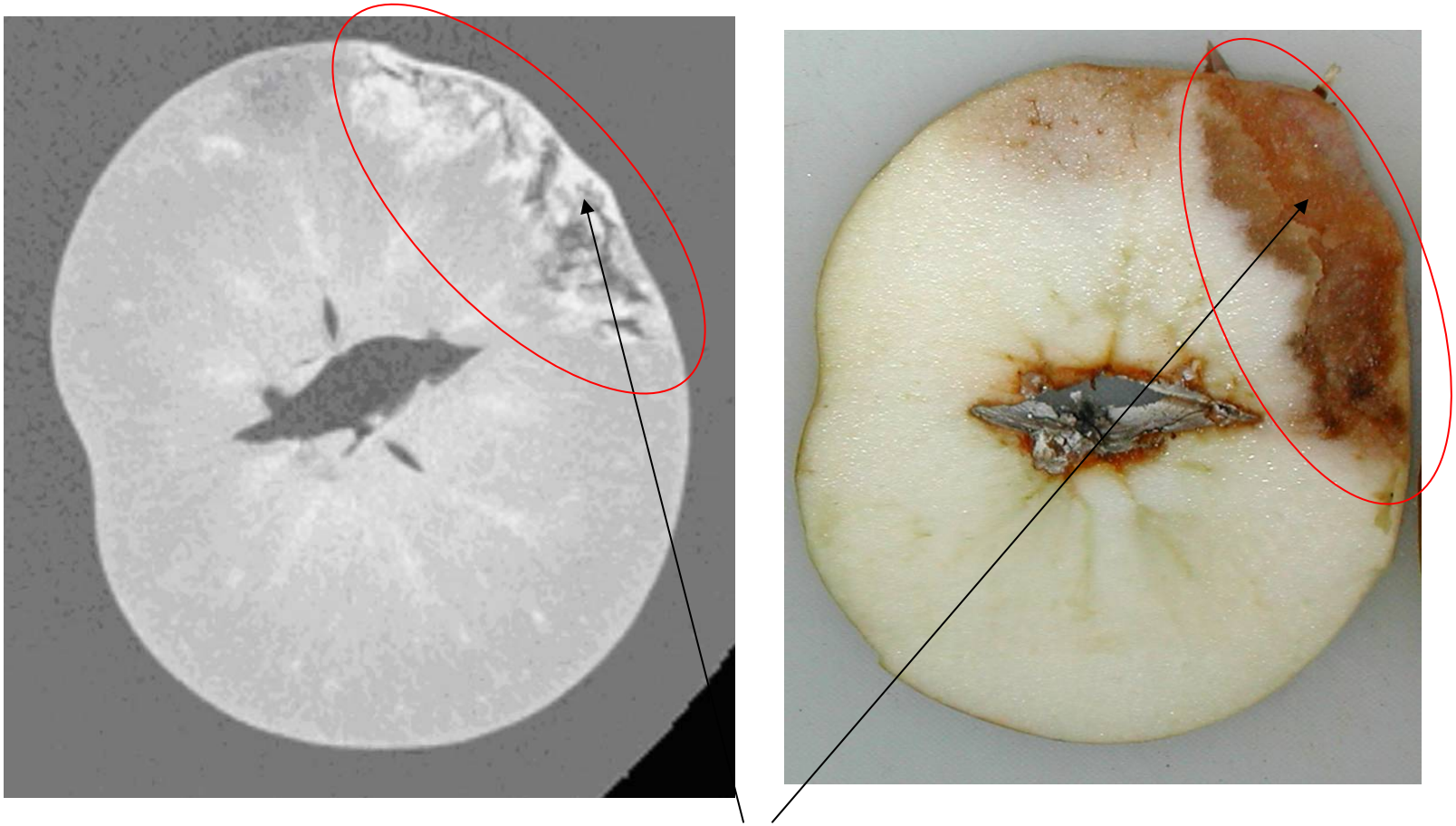




Low CT value (red part)

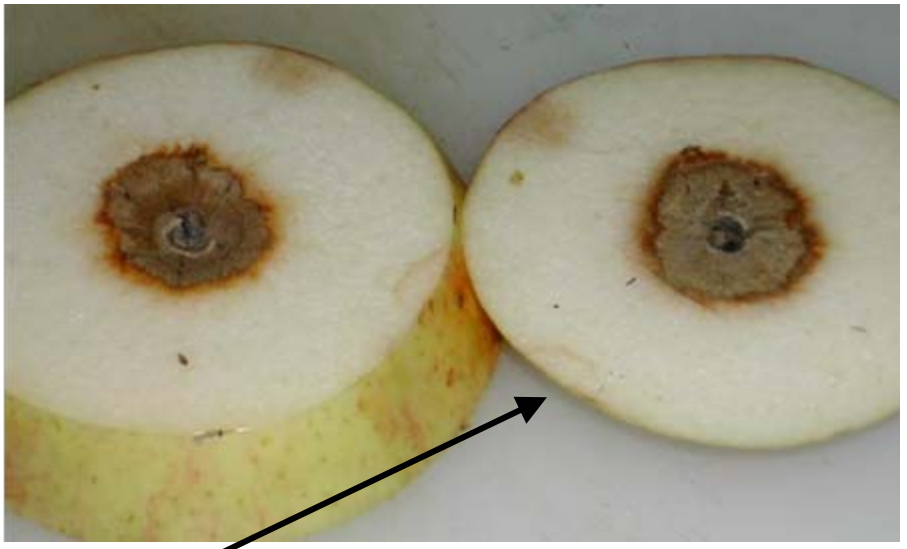
sprit-pit

CT image of apple



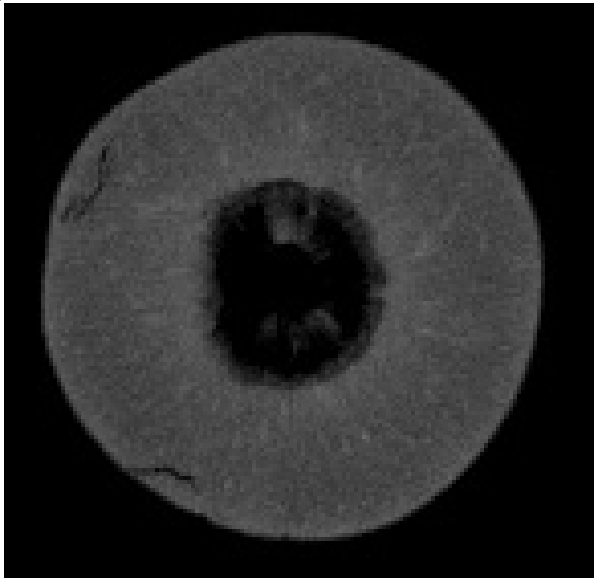
High water content

CT image of lignified sample



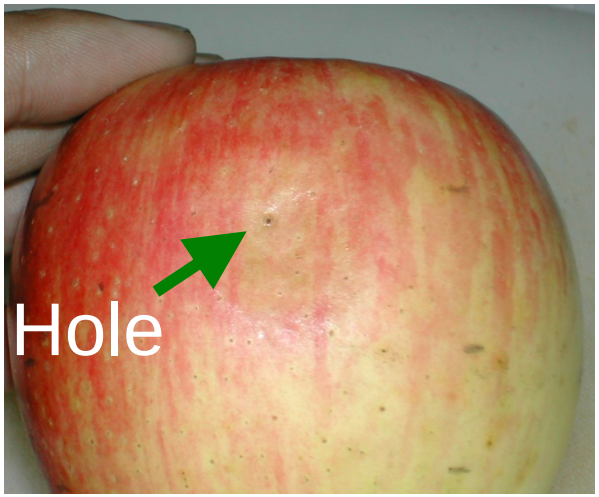
appearance

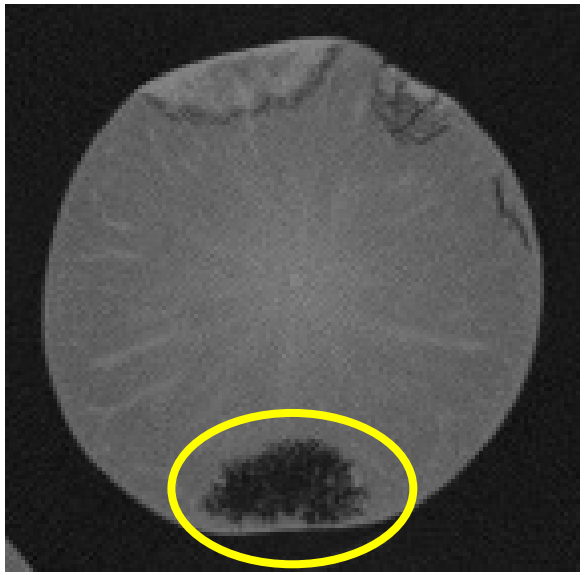
Same sample

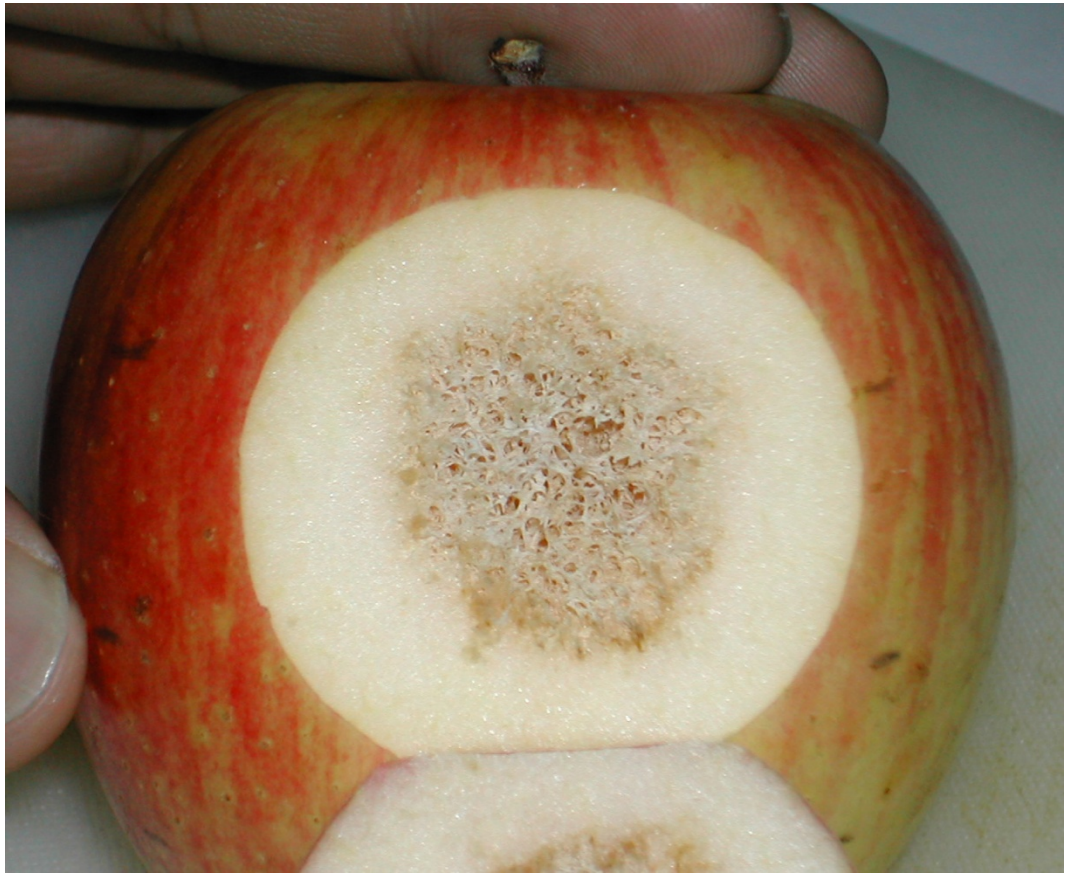


Rotten core sample

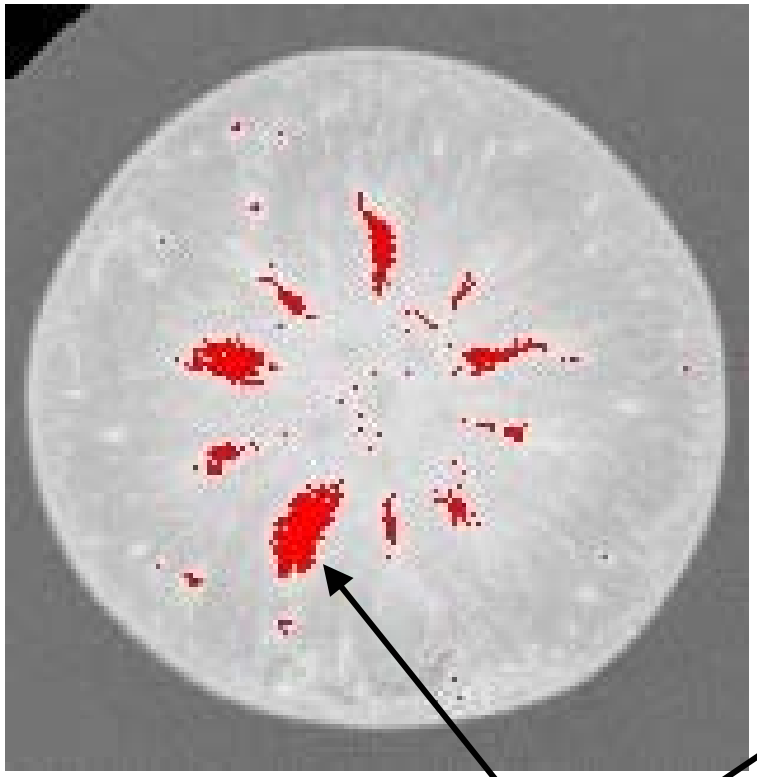
Defect by an injurious insect

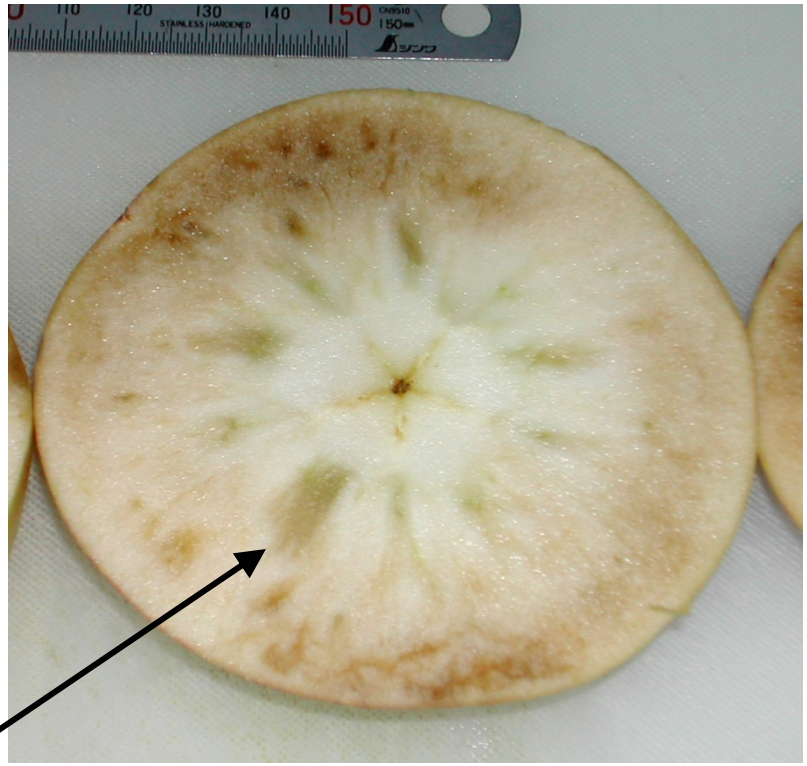






Water core of apple

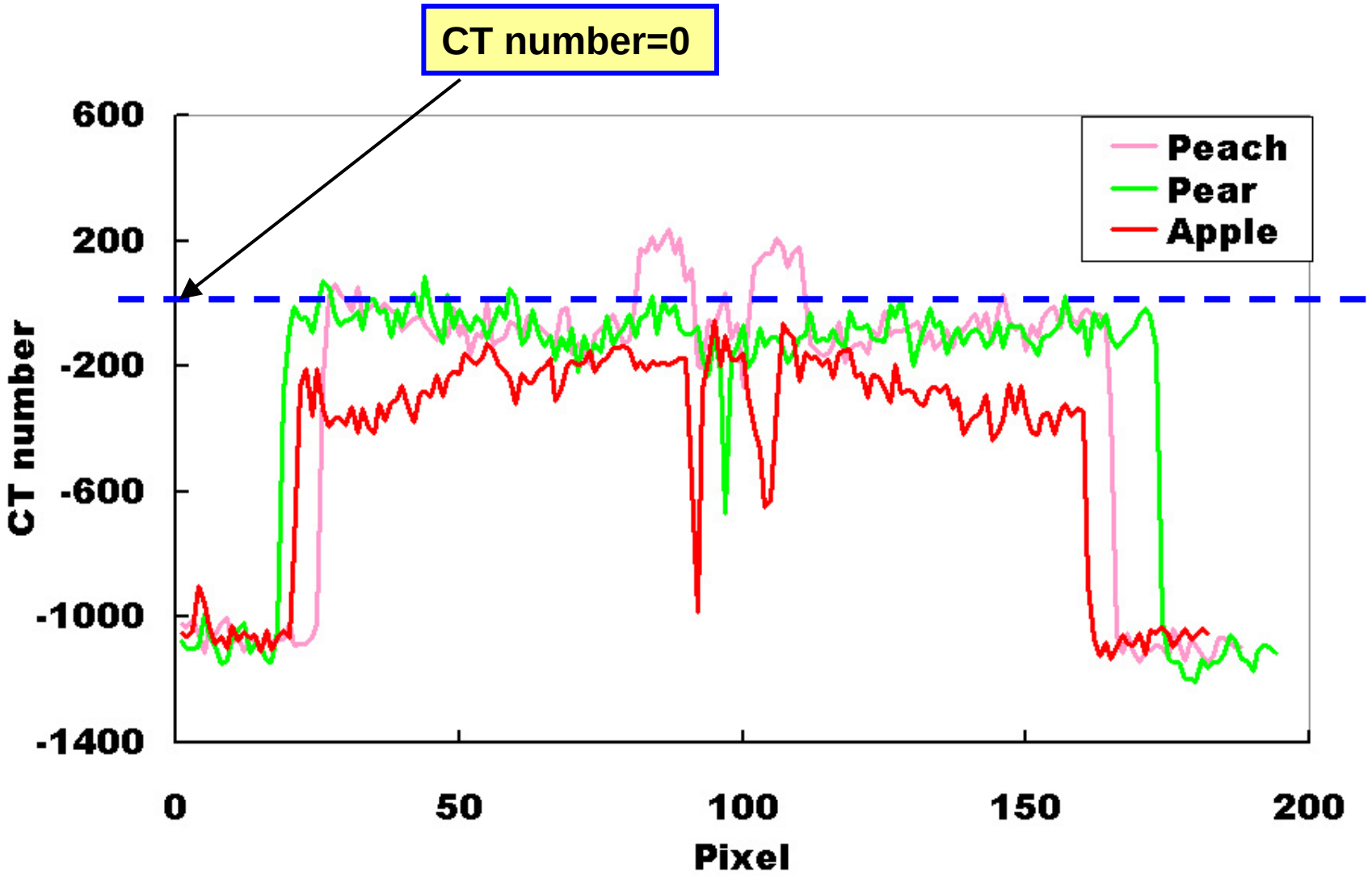




Water core

CT numbers distribution

High CT number means high water content.



Conclusion

X-ray was efficient as an internal fruit quality evaluation method.

Fluoroscope image of X-ray quickly gave information of inside split-pit of peach and of rotten core of pear. (But, slight water content change could not be detected.)

X-ray CT image gave water content distribution and internal structure of fruit. (But, long time is necessary to scan.)

Optimum agricultural product inspection system of combining these X-ray methods, UV, color and infrared TV cameras is desired.