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.

Food history items
When was chemical sprayed?
When was the seed scattered?
When was it harvested?
Who is farm producer? etc.

information-added agro-product

Internal quality is one of the information
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

512 × 480 pixels

Image Processing Board

Display

VGA

Camera

AC100V

DC12V

250mm

X-Ray Generator

Control Unit

Sample

Fluorescence board

Output Voltage and current: 60keV, 3mA
Materials

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

512 pixels

480 pixels

200 pixels
Experimental result (sprit-pit of peach)

(a) Appearance

(b) Cut sample (Sprit-pit)

(c) Side view

(d) Top view
Gray level distribution with a split-pit of peach.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sprit-pit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top view</td>
<td>8.0</td>
<td>57.1</td>
<td>21.3</td>
<td>24.8</td>
</tr>
<tr>
<td>Side view</td>
<td>6.4</td>
<td>49.1</td>
<td>19.1</td>
<td>13.4</td>
</tr>
<tr>
<td><strong>Normal-pit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top view</td>
<td>7.0</td>
<td>37.5</td>
<td>19.2</td>
<td>10.3</td>
</tr>
<tr>
<td>Side view</td>
<td>5.3</td>
<td>33.0</td>
<td>17.3</td>
<td>9.9</td>
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</tbody>
</table>
Gray level distribution with a rotten core of pear.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotten core</td>
<td>9.5</td>
<td>44.5</td>
<td>23.6</td>
<td>28.7</td>
</tr>
<tr>
<td>Crack</td>
<td>12</td>
<td>39.9</td>
<td>25.5</td>
<td>13.0</td>
</tr>
<tr>
<td>Normal</td>
<td>9.0</td>
<td>43.7</td>
<td>21.5</td>
<td>14.2</td>
</tr>
</tbody>
</table>
Line sensor system

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

Rotten core

Holder
Transmittance images when X-ray power changed

(a) 70keV
(b) 80keV
(c) 90keV
(d) 100keV
(e) 1mA
(f) 2mA
(g) 3mA

70keV, 3mA is suitable for apple
Disease of flesh

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: 512x512 pixel, 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

Hole
Water core of apple
CT numbers distribution

CT number=0

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.