Non-destructive techniques in seed quality determination

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Outline

• Seed anatomy and the importance of seed quality (germination and seed health)

• Non-destructive technologies used to assess various aspects of seed quality

• Results from PhD project
Seed anatomy

Spinach seed. A: Seed with pericarp, B: True seed, brown testa, C: Perisperm, D: Embryo, E: Micropylar endosperm
Germination

Any initial variation in plant size will increase as the crop matures, the larger plants in the population will continue to secure proportionally more of the resources available.

Komatzuna - Mizuna - Pak Choi - Chinese Spinach Cabbage
Seed health

Identification

• Outside or inside the seed coat
• Microscopy, PCR, ELISA
• Colour, size and shape of the fungal structures
Technologies in seed science and testing

- RGB imaging
- Hyperspectral and **multispectral imaging**
- X-ray imaging
- Magnetic resonance imaging
- (Infrared spectroscopy)
- **Near infrared spectroscopy**
- Chlorophyll fluorescence
- **Oxygen measurement (respiration)**
- Ethanol measurement (fermentation)
Multispectral imaging

- 19 light emitting diodes
  - wavelengths ranging from 395 to 970 nm
- High-resolution camera
  - 1280 x 960 pixel images

Infected spinach seeds

VIS  NIR
Spectral signature of mean data
Segmentation of uninfected seeds from infected seeds

Raw picture  CDA and threshold setting  Binary morphology

Test of 100 naturally infected seeds
84% uninfected detected by VideometerLab
71% uninfected observed by microscope
Multispectral imaging and germination

- Average of 300 seeds
- Pre-study of 25 seeds
FT-NIR spectroscopy

NIR spectrum ranging from 833 to 1667 nm
30 seeds within 12 min
Explorative evaluation

Outlier detection (PCA plot and Hotelling’s T-square versus residual variance plots for PC1)
Mean spectra

- Naked aged
- Coated aged
- Naked normal
- Coated normal

Absorption [log (1/\%)]

Wavelength (nm)

900 1000 1100 1200 1300 1400 1500 1600
Classification (ECVA = supervised model)

<table>
<thead>
<tr>
<th>Spinach seed germinated at 15°C</th>
<th>Germination %</th>
<th>Calibration set germ/non germ</th>
<th>Validation set germ/non germ</th>
<th>#PCs</th>
<th>Correctly classified seeds (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal, without pericarp</td>
<td>99</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Normal, with pericarp</td>
<td>97</td>
<td>175/2</td>
<td>108/2</td>
<td>9</td>
<td>93.6</td>
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<tr>
<td>Aged, without pericarp</td>
<td>86</td>
<td>150/12</td>
<td>127/8</td>
<td>10</td>
<td>91.1</td>
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<tr>
<td>Aged, with pericarp</td>
<td>87</td>
<td>150/15</td>
<td>108/9</td>
<td>8</td>
<td>98.3</td>
</tr>
</tbody>
</table>
Scatter plot

Spinach

Pak choi
Assignments of NIR spectra

**NEAR INFRARED SPECTROSCOPY IN FOOD ANALYSIS**

Table 2.4—continued

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Bond vibration</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1037</td>
<td>$2 \times C-H$ str. + $2 \times C-H$ def. $+(CH_3)_n$</td>
<td>oil</td>
</tr>
<tr>
<td>1053</td>
<td>$2 \times C-H$ str. + $2 \times C-H$ def. $+(CH_3)_n$</td>
<td>CH$_2$</td>
</tr>
<tr>
<td>1060</td>
<td>N-H str. second overtone</td>
<td>RNH$_2$</td>
</tr>
<tr>
<td>1080</td>
<td>$2 \times C-H$ str. + $2 \times C-C$ str.</td>
<td>benzene</td>
</tr>
<tr>
<td>1097</td>
<td>$2 \times C-H$ str. + $2 \times C-C$ str.</td>
<td>cyclopropane</td>
</tr>
<tr>
<td>1143</td>
<td>C-H str. second overtone</td>
<td>aromatic</td>
</tr>
<tr>
<td>1152</td>
<td>C-H str. second overtone</td>
<td>CH$_3$</td>
</tr>
<tr>
<td>1170</td>
<td>C-H str. second overtone</td>
<td>HC=CH</td>
</tr>
<tr>
<td>1195</td>
<td>C-H str. second overtone</td>
<td>CH$_3$</td>
</tr>
<tr>
<td>1215</td>
<td>C-H str. second overtone</td>
<td>CH$_2$</td>
</tr>
<tr>
<td>1225</td>
<td>C-H str. second overtone</td>
<td>CH$_3$</td>
</tr>
<tr>
<td>1360</td>
<td>$2 \times C-H$ str. + C-H def.</td>
<td>CH$_3$</td>
</tr>
<tr>
<td>1395</td>
<td>$2 \times C-H$ str. + C-H def.</td>
<td>CH$_3$</td>
</tr>
</tbody>
</table>

(Osborne et al., 1993)
Conclusions

• Non-destructive technologies tested in my Ph.D project have proved to be valuable tools in correlation of colour and biochemical information to seed germination and health of spinach seeds

• Control of Verticillium in seed production fields is important and multispectral imaging can be employed as a fast seed testing method

• Both methods are user friendly, rapid and efficient for testing the seeds
Thank you
Papers included in Ph.D thesis


Papers not included in Ph.D thesis

