CITES Tree Species Programme

Project: CITES S608:
“Big-leaf Mahogany Provenance and Timber Identification by NIRS Technology”

Kuala Lumpur, October 05, 2022.
1. INTRODUCTION: NIR wood identification

- Minimum sample preparation.
- Fast data acquisition (~15 sec).
- Availability of Handheld equipment (U$ 2000 to 30,000).

- NIR spectra contain chemical specific information:
  - Species identification
  - Origin/provenance

Lignin  Extractives  Cellulose

- Requires a representative number of samples of each interest species.
- Requires Chemometrics (e.g.: PLS-DA, SIMCA).
- Requires a relative control of the moisture content of the sample.
2. CONTEXT: NIR identification with different moisture contents

Laboratory conditions:

- Discrimination threshold
- Estimated class number
- Number of the sample

Field conditions:

- Moisture and temperature variation
- Small number of outliers
- Mahogany
- Other species

Discrimination errors

Sample/Scores Plot of XCALsel,c & TEST:

- Hotelling T^2 (99.97%)
- Q Residuals (0.03%)

Laboratory conditions:

- High number of outliers

Field conditions:

- Moisture and temperature variation

Sample/Scores Plot of XCALsel,c & TEST:

- Hotelling T^2 (99.97%)
3. Current design for in situ drying and NIR analysis

EXPERIMENTAL PROCEDURE:
1) Sanding the sample
2) Drying for 8 min.
3) Cooling the sample by applying a high volatile fluid.
4) Obtaining the spectra
4.1 Results: Two missions at the JB Madeiras sawmill (Brasília/DF, Brazil) to test the new drying method.

Three species were tested: *Erisma uncinatum* (cedrinho); *Micropholis melinoniana* (curupixá) and *Cedrela odorata* (cedar).

- **Average moisture content before drying** = 15 %
- **Average moisture content after drying** = 11 %

<table>
<thead>
<tr>
<th>Species</th>
<th>Nº of samples</th>
<th>Nº of spectra</th>
<th>False positive rate</th>
<th>False negative rate</th>
<th>Efficiency Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar</td>
<td>22</td>
<td>66</td>
<td>0.0 %</td>
<td>2.5 %</td>
<td>98.7 %</td>
</tr>
<tr>
<td>Cedrinho</td>
<td>13</td>
<td>39</td>
<td>4.1 %</td>
<td>15.8 %</td>
<td>89.9 %</td>
</tr>
<tr>
<td>Curupixá</td>
<td>18</td>
<td>54</td>
<td>3.4 %</td>
<td>0.0 %</td>
<td>98.3 %</td>
</tr>
</tbody>
</table>

- After drying, the results presented better precision and a lower rate of errors.
NIR spectra were obtained on C. odorata boards recently sawn and after the drying method.

**PCA results:**

- First PC is directly related to the moisture content in the samples;
- After the drying process, the samples are closer to the training samples.
4.2 Results: mission at the Madeflona concessionaire, in Flona Jamari (Itapuã do Oeste – Rondônia state, Brazil)

**Discrimination results:**

All samples before drying were outliers in the discrimination model.

<table>
<thead>
<tr>
<th></th>
<th>Cedar model</th>
<th>Mahogany model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TP</strong> (true positive)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>FN</strong> (false negative)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>FNR</strong> (false negative rate)</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>ER</strong> (efficiency rate)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td><strong>TN</strong> (true negative)</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td><strong>FP</strong> (false positive)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>FPR</strong> (false positive rate)</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>ER</strong></td>
<td>95%</td>
<td></td>
</tr>
</tbody>
</table>

*TP: true positive  
FN: false negative  
FNR: false negative rate  
ER: efficiency rate  
TN: true negative  
FP: false positive  
FPR: false positive rate
4.3 Cedar cargo tracking:

Aproximatelly 20 m³ of Cedar

Cargo origin:
Madeflona concessionaire, in Flona Jamari (Itapuã do Oeste – Rondônia state, Brazil)

Destination:
Ubatuba city, São Paulo State, Brazil

Distance: ~3100 km

Time between the measuring procedures: 22 days
4.3 Cedar cargo tracking: experimental procedure

- **MEASUREMENTS AT THE ORIGIN AND FINAL DESTINATION:**
  - Origin: 252 spectra (126 before drying and 126 after drying).
  - Final destination: 126 spectra.

- Measurement performed at the ends of the boards.
## 4.3 Results: Application of the Cedar cargo model for different samples:

### Summary of results for cargo tracking:

<table>
<thead>
<tr>
<th>Samples</th>
<th>Number of samples (spectra)</th>
<th>Probability of belonging to the target cargo</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training samples</td>
<td>56 (168)</td>
<td>100 %</td>
<td>Belong to the cargo</td>
</tr>
<tr>
<td>Validation samples</td>
<td>28 (84)</td>
<td>95.2 %</td>
<td>Belong to the cargo</td>
</tr>
<tr>
<td>Samples measured at final destination</td>
<td>42 (126)</td>
<td>81.0%</td>
<td>Belong to the cargo</td>
</tr>
<tr>
<td>Cedar (JB Madeiras)</td>
<td>12 (24)</td>
<td>20.8 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Cedar (LPF)</td>
<td>37 (111)</td>
<td>31.1 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Cedrinho (JB Madeiras)</td>
<td>10 (20)</td>
<td>25.0 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Cedrinho (LPF)</td>
<td>63 (189)</td>
<td>2.4 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Mahogany (Agrocortex)</td>
<td>24 (75)</td>
<td>32 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Mahogany (LPF)</td>
<td>48 (228)</td>
<td>20.8 %</td>
<td>Not compatible</td>
</tr>
<tr>
<td>Curupixá (LPF)</td>
<td>40 (120)</td>
<td>33.8 %</td>
<td>Not compatible</td>
</tr>
</tbody>
</table>
5. Conclusions:

- The proposed drying procedure is efficient and improved the results in field conditions.
- Measurements/drying are more effective at the ends of the boards.
- The time for analysis increased to ~30min.
- Preliminary results indicate that the cargo tracking is possible.
- New experiments are being conducted to establish the acceptance probabilities and limitations.
Thank you for your attention!

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