Food Packaging from Nature: Cellulosic Films for the 21st Century
A.L.L. Gresty1, E. Newcombe1, M. Cockroft1, P. J. Hine2, M. E. Ries1, Y. Benitez-Alfonzo1
1School of Physics and Astronomy, University of Leeds, Leeds, UK; 2Futamura Group, Wigton, UK

What’s the problem?
Reckless overuse of plastics is at the forefront for climate activists. The packaging industry produces 141 million tonnes of plastic packaging annually and contributes up to 36% of total plastic pollution [1].

What’s the solution?
• Cellulose is a long chain glucose polymer that is the main chemical constituent of most plants, making it Earth’s most abundant biopolymer.
• Cellulose can be extracted from plants and converted to films with high strength using a technique known as ‘The Viscose Process’.
• A resurgence of cellulose films has been seen in the food packaging industry.
• They offer a biodegradable and renewable alternative to synthetic films.
• Using different plants to produce these films gives rise to different mechanical properties, with this non-uniformity causing uncertainty in quality control of films.

The Big Question
Why do different plant species cause non-uniformity in the mechanical performance of films?

What can I do?
Range of physical techniques to assess what microscopic features of the films are affecting their macroscopic mechanical properties

1 Mechanical Properties
• Confirm customer complaints. Strength and stiffness greater in Eucalyptus film in machine (MD) and transverse (TD) direction.

2 Molecular Movement
Movement of the cellulose molecule in each film shows similar behaviour.
• Molecular movement is not impacting the mechanical properties of the films.

What does this mean?
• It is clear that plant choice is impacting the mechanical properties of these films.
• The water content, composition and orientation are all a result of the original plant species, working together to alter the mechanical performance of the films.
• These results have changed Futamura’s production process as they have stopped using Hemlock in films and now incorporate eucalyptus in all films.

What’s the impact?
• Plant choice is deliberated extensively by industry; with sustainability and cost being important factors.
• Futamura aim to understand the links between plant selection and film final properties in order to optimally tune their films.
• This understanding will enable the use of waste materials across all cellulose-based products, improving their ‘green’ credentials even further.

Take home message
Understanding the relationships between plant properties and production is vital in the drive for unlimited utilisation of plants for endless applications in the material industry to accelerate the switch to renewable and biodegradable materials.

Table: Plant Composition: Cellulose, hemicellulose and lignin content [3]

<table>
<thead>
<tr>
<th>Plant</th>
<th>Cellulose %</th>
<th>Hemicellulose %</th>
<th>Lignin %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>49</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Hemlock</td>
<td>42</td>
<td>9</td>
<td>29</td>
</tr>
</tbody>
</table>

Graphs:
- Young’s Modulus vs. Strength
- Temperature vs. Moisture Content
- Water Content vs. Moisture Content
- Orientation
- Composition

References