



PlastLIFE public morning coffee – Plastic-replacing materials

Natural Resources Institute Finland
9.10.2026



LIFE21-IPE-FI-PlastLIFE

PlastLIFE-hanke saa EU:n LIFE-ohjelmasta rahoitusta, jolla hankkeen materiaalit on tuotettu. Materiaalien sisältö edustaa ainoastaan hankkeen omia näkemyksiä, joista CINEA/Euroopan komissio ei ole vastuussa.



| plastlife.fi | [#plastlife](https://twitter.com/plastlife) |

Valorising residual biomass into plastic-replacing packaging solutions

Dr Risto Korpinen



LIFE21-IPE-FI-PlastLIFE

PlastLIFE-hanke saa EU:n LIFE-ohjelmasta rahoitusta, jolla hankkeen materiaalit on tuotettu. Materiaalien sisältö edustaa ainoastaan hankkeen omia näkemyksiä, joista CINEA/Euroopan komissio ei ole vastuussa.



| plastlife.fi | [#plastlife](https://twitter.com/plastlife) |

Plastic packaging waste in Finland

≈160,000 tonnes per year plastic packaging waste generated

- This includes about 95,000 tonnes of consumer packaging.



Picture: Fortum and Mika Surakka. Source: Ollakka, M. (2023)

Muovipakkausten kemiallinen kierrätys alkaa teollisessa mittakaavassa, *Kemia-lehti*, 10.10.2023.

Sources: SYKE — <https://kiertotalousratkaisuja.syke.fi/muovin-polttoa-jatteena-rajoitettava-muovinkierrätyksen-tehostamiseksi/>
Verkkouutiset — <https://www.verkkouutiset.fi/a/suomi-maksaa-eulle-90-miljoonaa-euroa-kierrattamattomasta-muovista/>

29% recycled in 2023



29% recycled

71% not recycled

≈46,000 tonnes recycled annually

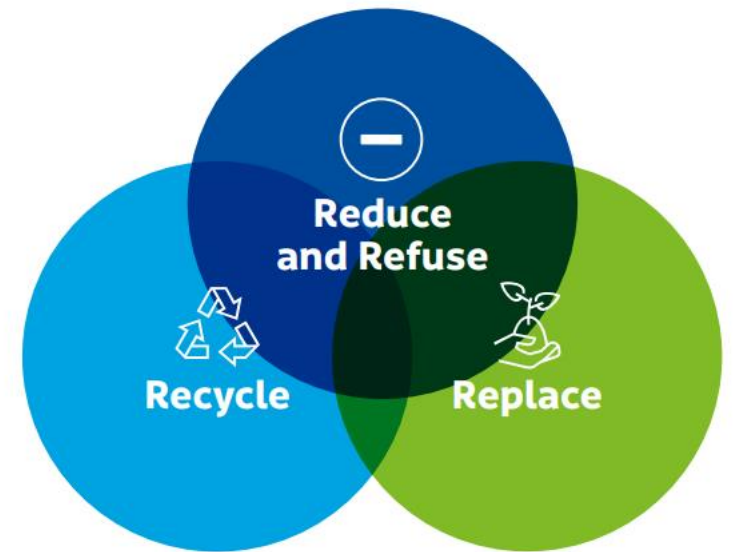
- Estimated by applying the 2023 recycling rate to the annual waste volume



| plastlife.fi | #plastlife |

Finnish plastics roadmap 2.0

1. **Reducing litter and other environmental damage caused by plastics.**
2. **Avoiding unnecessary consumption and promoting re-use.**
3. Increasing the recycling of plastics and the recyclability of plastic products.
4. **Replacing virgin plastics made from fossil raw materials**
 - with recycled plastic or
 - **with sustainably produced renewable materials.**



Four different strategies to produce alternative bio-based packaging materials to replace plastics



Fibre-based packaging material containing side streams from horticulture – T6.3.1



Thermomechanical processing and extrusion molding technology for packaging – T6.3.2



Mycelia-based composites – T6.3.3



Translucent film material from fish and plant side streams – T6.3.4

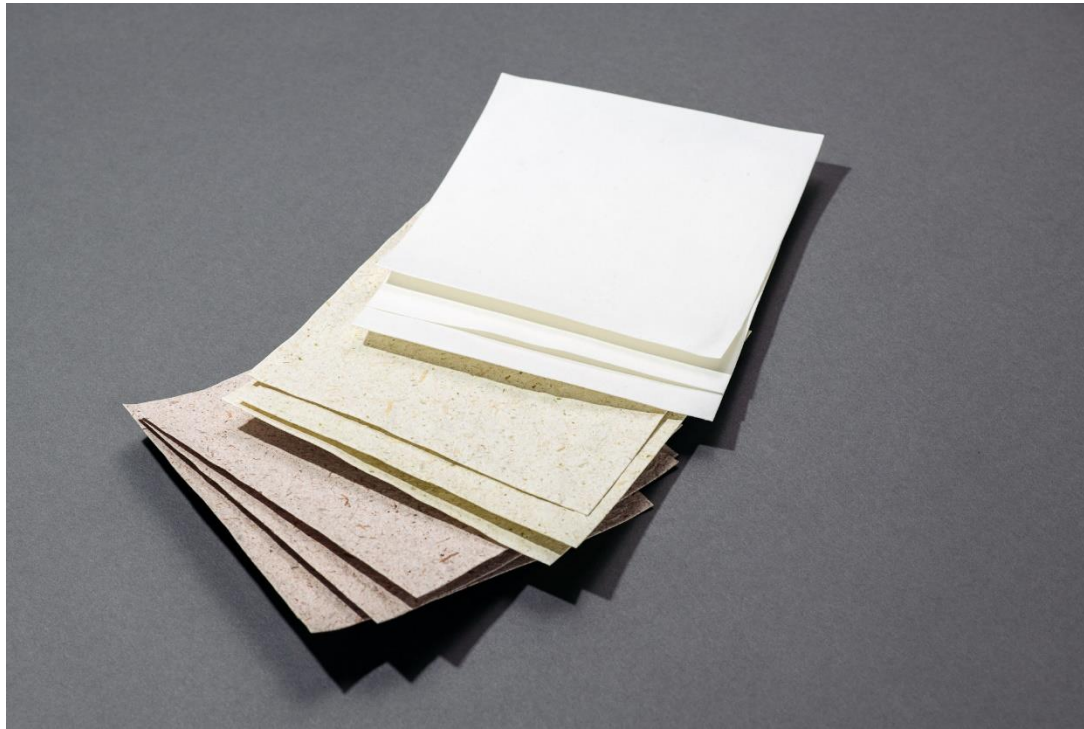
Horticultural side streams offer a new fibre source

- Greenhouse stems and leaves are about 25% of crop mass
- ~9,130 tonnes of fresh stalks in Finland in 2025.
- Today: mainly composted or incinerated.
- Opportunity: replace virgin fibres in attractive packaging.



Picture Arvobio project

From plant residues to ready paperboard sheets



Picture Jarkko Mikkonen

- Stems were softened and separated into fibres.
- The fibres replaced 20% of virgin kraft pulp.
- Sheets were formed, pressed and dried; selected samples were calendered.
- Mechanical testing results prompted the production of pilot-scale paperboard.



Horticultural side streams for biobased paperboard

- Pilot trials produced fully biobased, biodegradable paperboard with greenhouse side-stream fibres.
- Composition: 16.7% tomato or cucumber stem fibre and 83.3% bleached kraft pulp.
- Side-stream fibres added a distinctive look without reducing overall mechanical performance.
- Tomato fibre can reinforce board; cucumber fibre needs optimisation for strength-critical uses.
- Annual supply could yield about 7,000 tonnes of tomato-fibre and 4,500 tonnes of cucumber-fibre board for packaging and niche products.
- The approach reduces virgin fibre use and supports cascade use of horticultural biomass.

Tomato fibre containing board



Cucumber fibre containing board



Pictures Risto Korpinen

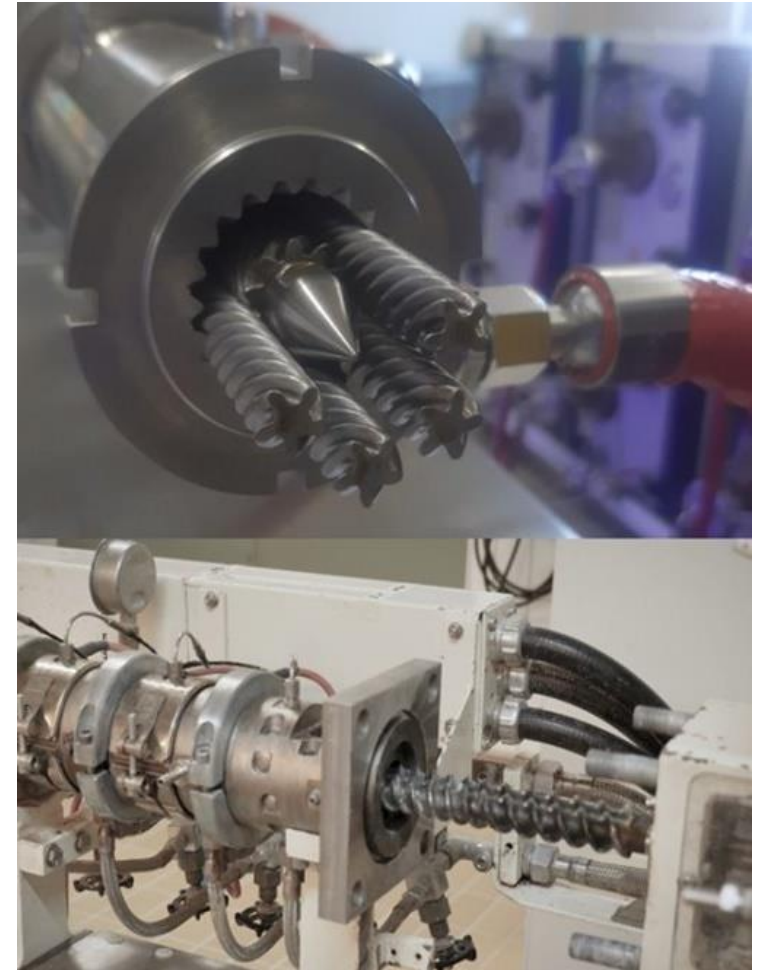


Extrusion-based product development

Continuous process — raw materials are mixed and kneaded under controlled heat and shear, then pushed through a die into a set shape.

Flexible feedstocks — multi- and twin-screw extruders handle diverse raw materials and side streams. Planetary roller systems mix heat-sensitive, fibre-rich compounds gently and evenly.

Packaging formats — films and sheets for wraps, bags and pouches; thermoformable sheet for trays, cups and lids; and extruded tubes or profiles.



Pictures Taru Kariniemi and Veli Hietaniemi

Mycelium-based material development

Mycelium forms a natural network that binds lignocellulosic fibres.



Pictures: Henri Vanhanen

Laboratory cultivation enables:

- Mycelium-based composites
- Pure mycelium materials



Mycelium-based material showcase

Fungal strain and lignocellulosic fibers are selected and fermented in **Luke**

Design and molding using 3D printed equipment was done at the **University of Lapland**

Package for glass bottle



Panel for insulation



Pictures: Matias Säkkinen

Aim:
Replacement of
styrofoam



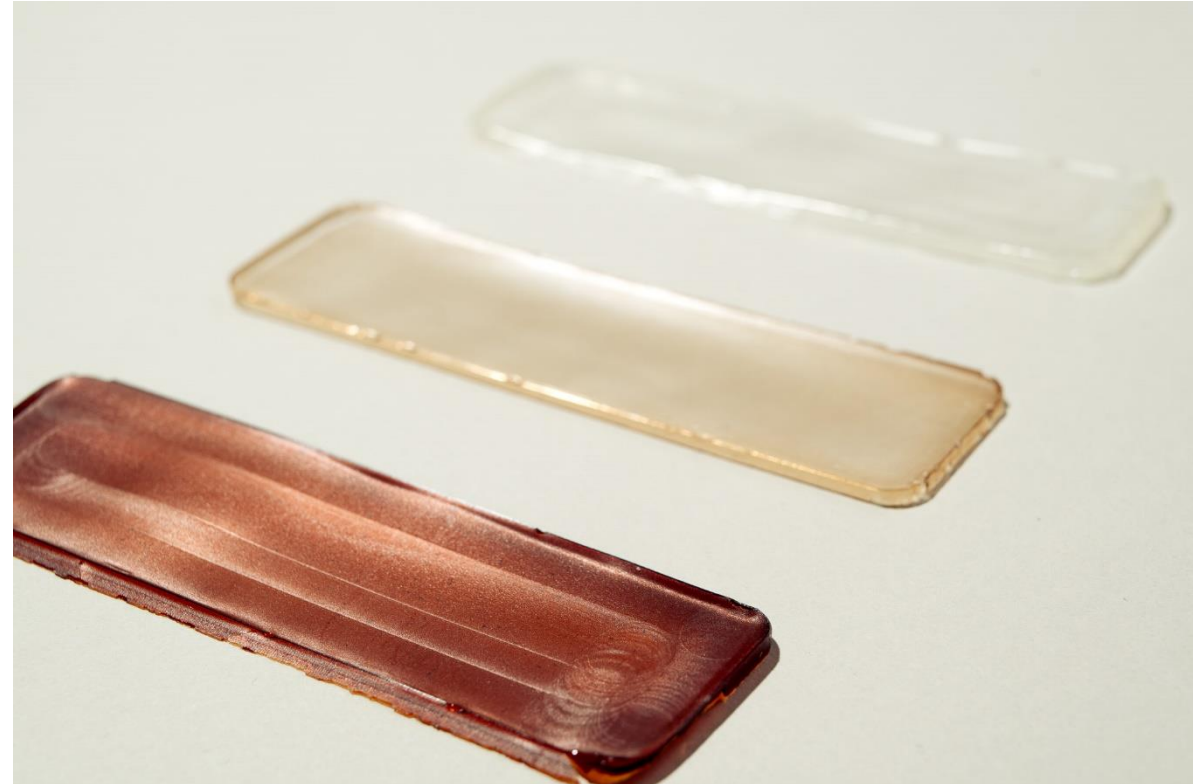
Fish side-stream based translucent material to replace plastic films



Translucent film-like materials from fish and plant side-streams have been developed.

The films have been found to possess antimicrobial barrier properties and are an interesting option for food packaging

- Enhanced food safety
- Prolonged shelf-life



Picture: Jarkko Mikkonen



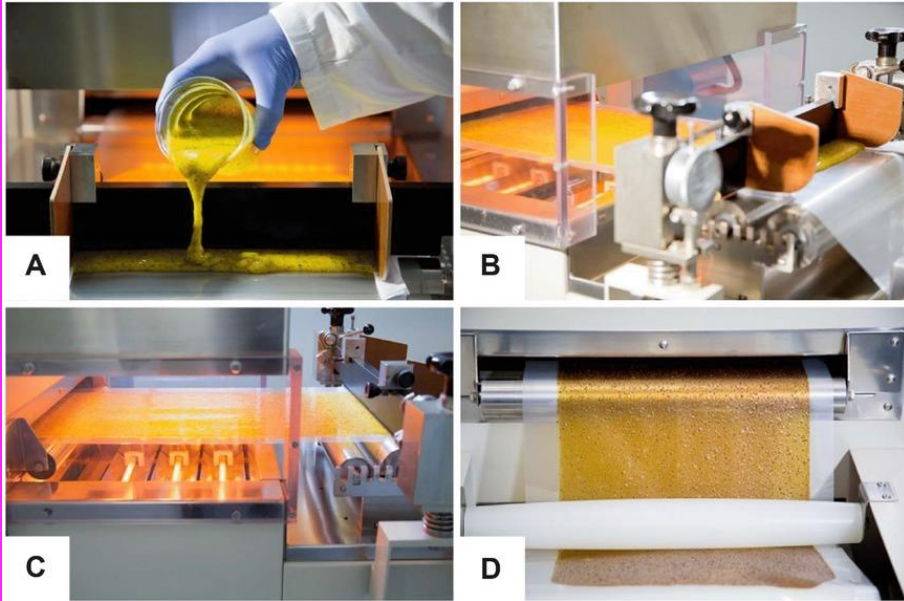
From fish side streams for active packaging

- Gelatin is a collagen-derived biopolymer.
- In addition to mammalian sources, it can be isolated from fish-processing side streams – skin, bones, fins and scales – both from marine and freshwater fish
- Gelatin yield from fish skins is about 10–14 %, i.e., it is possible to get about 36,700 kg of gelatin from 10 M kg of salmonid side streams.

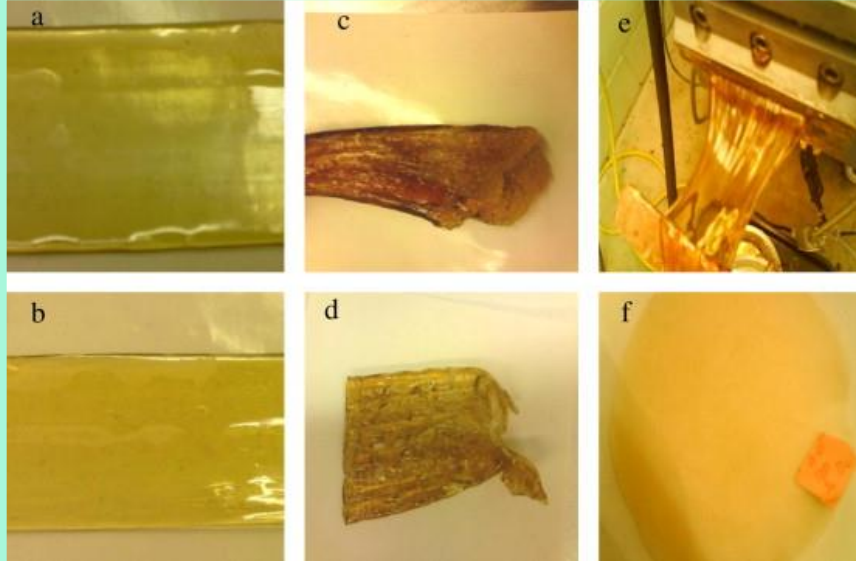


Picture: Jaakko Hiidenhovi

Ways of film manufacture



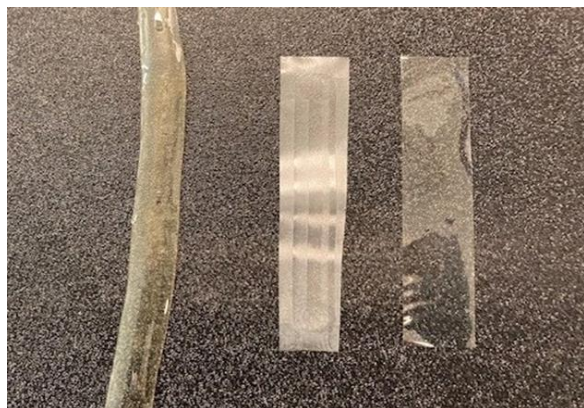
Casting ⁽¹⁾



Extrusion ⁽²⁾



Heatpress



Different manufacturing techniques
yield differing films

¹ Otoni et al 2017 ² Krisha et al 2012



| plastlife.fi | #plastlife |

Techno-economic evaluation and carbon footprint of selected packaging materials developed in PlastLIFE

Dr Ashraful Alam



LIFE21-IPE-FI-PlastLIFE

PlastLIFE-hanke saa EU:n LIFE-ohjelmasta rahoitusta, jolla hankkeen materiaalit on tuotettu. Materiaalien sisältö edustaa ainoastaan hankkeen omia näkemyksiä, joista CINEA/Euroopan komissio ei ole vastuussa.



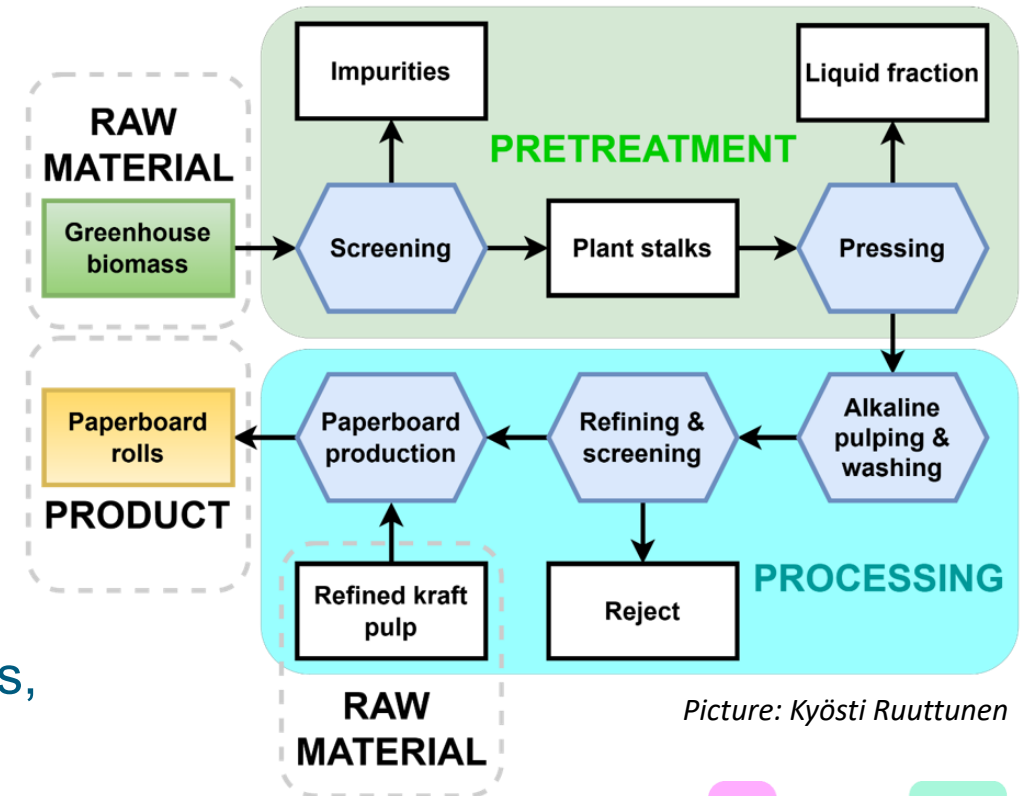
| plastlife.fi | [#plastlife](https://twitter.com/plastlife) |

Paperboard containing kraft and horticulture (tomato & cucumber) side streams

Comparison: 100% kraft pulp vs. 83.3% kraft pulp + 16.7% Horticulture side streams.

System boundary covers:

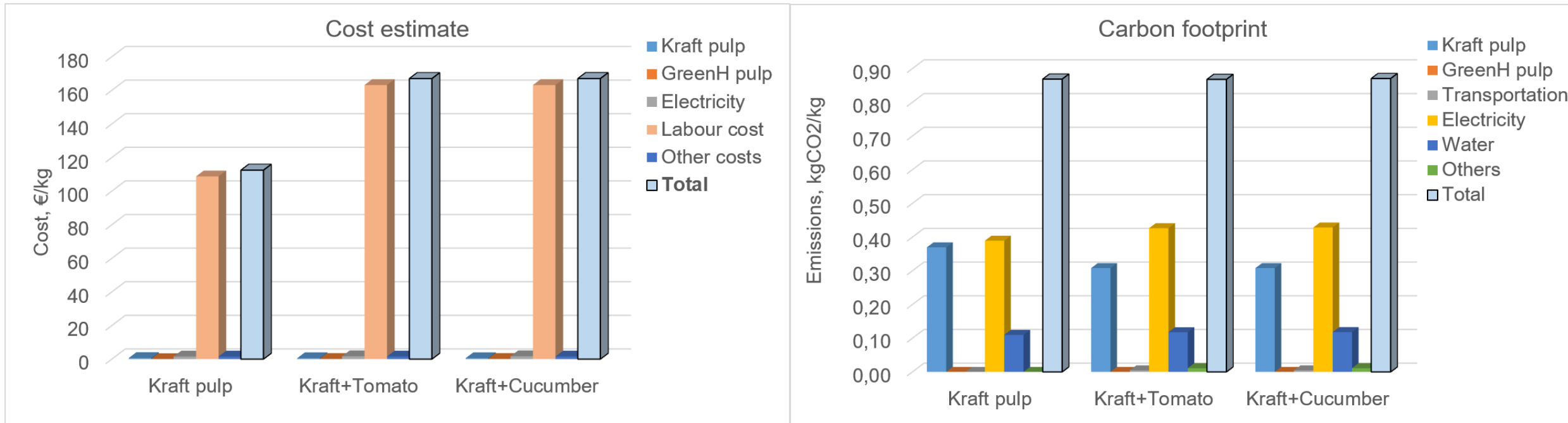
- Raw materials: kraft pulp production, side stream collection and raw material transport.
- Fibre preparation: biomass pretreatment and papermaking furnish.
- Paperboard production: material and energy inputs,
- Water use and wastewater treatment.



Picture: Kyösti Ruuttunen



Cost and carbon footprint of different packaging board (Lab scale)



Carbon footprint comparison with plastic

Weight-basis: 1 kg paperboard:

69% lower GHG emissions than **virgin plastic packaging**

33% lower GHG emissions than **recycled plastic packaging**

Function-basis: Packaging for 1 kg vegetables (= 990cm³ volume)

62% lower GHG emissions than **virgin plastic packaging**

20% lower GHG emissions than **recycled plastic packaging**

Weight-based



Function-based



Weight 15.91g

Weight 13.3g



Concluding remarks

- Fully **biobased, biodegradable** board from horticultural side streams is **technically feasible**.
 - Replacing 17–20 wt.% of wood fibre maintains **mechanical performance** and an attractive appearance.
- Estimated **industrial board price**: €1,220–1,360 per bone-dry tonne.
 - Plastic benchmark: €800–1,400/t (ING, accessed Sep 2026).
- **Potential GHG reduction**: up to 70% VS conventional plastic under the conditions assessed.
- Next steps: validate **industrial scenarios** with primary data and assess **fossil resource depletion** and **ecotoxicity** alongside carbon footprint.

Potential to replace fossil plastics depends on cost efficiency, impurity removal and industrial process optimization.



Environmental performance, biodegradation and stakeholder perspectives

Dr Jenni Tienaho



LIFE21-IPE-FI-PlastLIFE

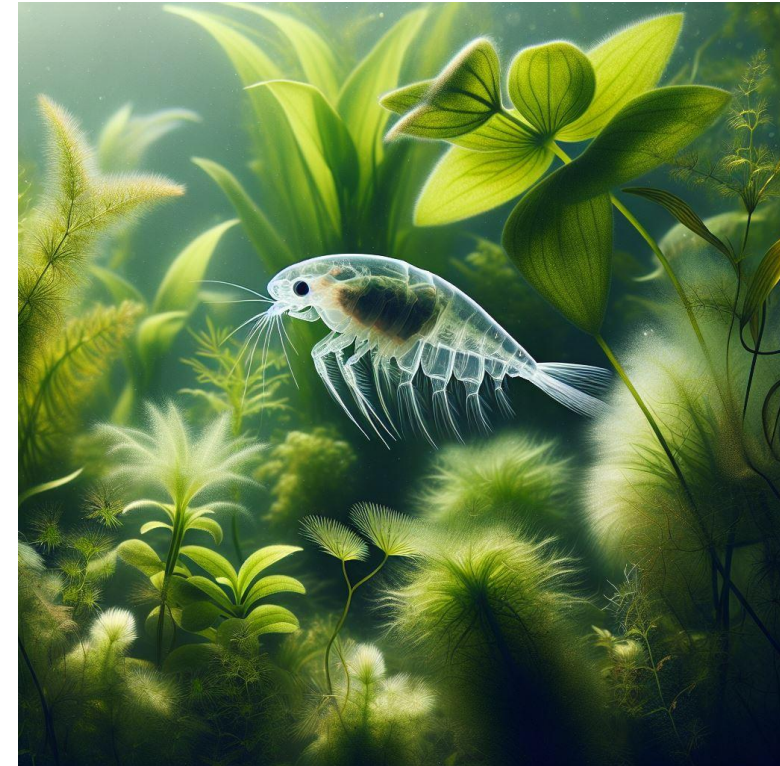
PlastLIFE-hanke saa EU:n LIFE-ohjelmasta rahoitusta, jolla hankkeen materiaalit on tuotettu. Materiaalien sisältö edustaa ainoastaan hankkeen omia näkemyksiä, joista CINEA/Euroopan komissio ei ole vastuussa.



| plastlife.fi | [#plastlife](https://twitter.com/plastlife) |

Environmental performance: material matters

- Materials were tested for their acute and chronic toxicity using water flea (*Daphnia magna*) at JYU/Sami Taipale's group
- Most of the materials did not cause clear adverse effects in water fleas.
 - Some materials affected reproduction and growth even at low concentrations
 - Two materials also increased mortality at high concentrations.
- More tests to confirm basis of effects are planned



AI generated image

Environmental safety of materials must be assessed on a case-by-case basis and biomaterial does not guarantee harmlessness.

More information on the results can be found in D6.6 report and Master's thesis by Emma Kemppainen

PlastLIFE D6.6. Report on the technical and mechanical properties of new plastic-replacing materials

Raportti uusien muovia korvaavien materiaalien teknisistä ja mekaanisista ominaisuuksista

Authors: Risto Korpinen, Jaakko Hiidenhovi, Marta Cortina Escibano, Henri Vanhanen, Martin Ramos Díaz, Sami Taipale, Kyösti Ruuttunen, Jenni Tienaho



Biodegradation of new materials as end-of-life use

- Aerobic and anaerobic biodegradation of the developed materials was tested by Measurlabs at accredited laboratories
 - How well the materials break down with and without oxygen
- Aerobic soil conditions according to ISO 17556 CO₂ Evolution Method
- Anaerobic conducted in accordance with ASTM D5511 under high-solids conditions

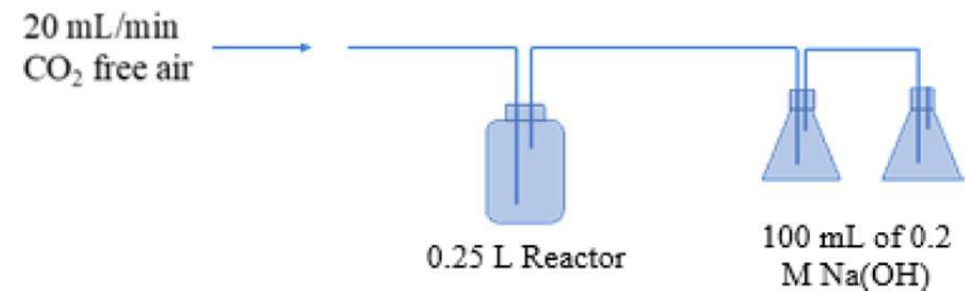


AI generated image

Aerobic soil conditions: strong performance for most materials

- Both fibre-reinforced paperboards showed high biodegradation after 90 days.
 - Cucumber-fibre paperboard had the highest measured result: 114%. (compared to reference)
 - Tomato-fibre paperboard reached 87%, similar to the cellulose reference at 86%.
- Mycelium materials A and C reached about 84–86%, while material D reached 78%.
 - Mycelium B degraded less effectively, reaching 54%.
- The fish-gelatine material degraded rapidly at first, but the final measured value was only 34%.

Sample	Biodegradation Average	60% threshold reached
Cellulose Microcrystalline (Reference)	$86.1 \pm 3.7\%$	Day 31
Paperboard + Tomato	$87.4 \pm 1.4\%$	Day 49.5
Paperboard + Cucumber	$114.3 \pm 7.5\%$	Day 34
Mycelia A	$86.3 \pm 14.6\%$	Day 38
Mycelia B	$54.2 \pm 14.7\%$	Not reached
Mycelia C	$83.6 \pm 14.3\%$	Day 28.5
Mycelia D	$77.9 \pm 6.7\%$	Day 62
Fish gelatine	$33.7 \pm 9.0\%$	Not reached



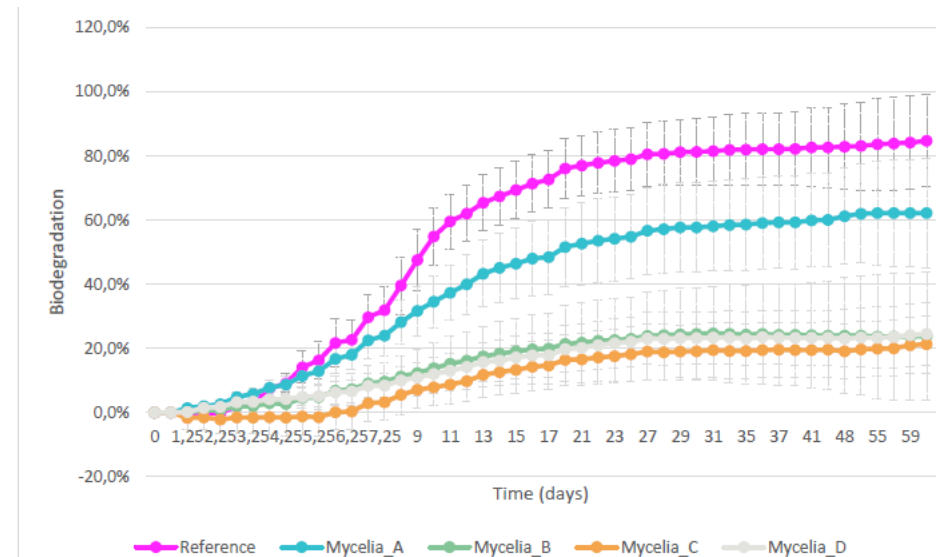
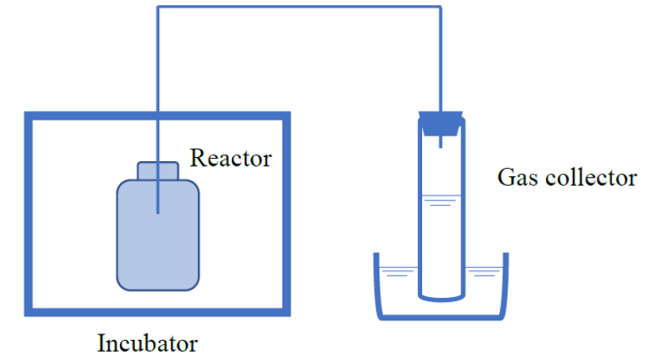
Anaerobic conditions: slower and less complete degradation

After 62 days, the cellulose reference reached about 85% biodegradation.

Mycelium A performed best among the tested mycelium materials, reaching about 62%.

Mycelium B, C and D reached only about 21–24%.

For all samples, degradation was fastest during the first 10–20 days and then slowed towards a plateau.



Take home message

- The way a material is disposed of strongly affects how well it biodegrades.
- Most tested fibre- and mycelium-based materials broke down well in oxygen-rich soil.
- Degradation was much slower in oxygen-free, landfill-like conditions.



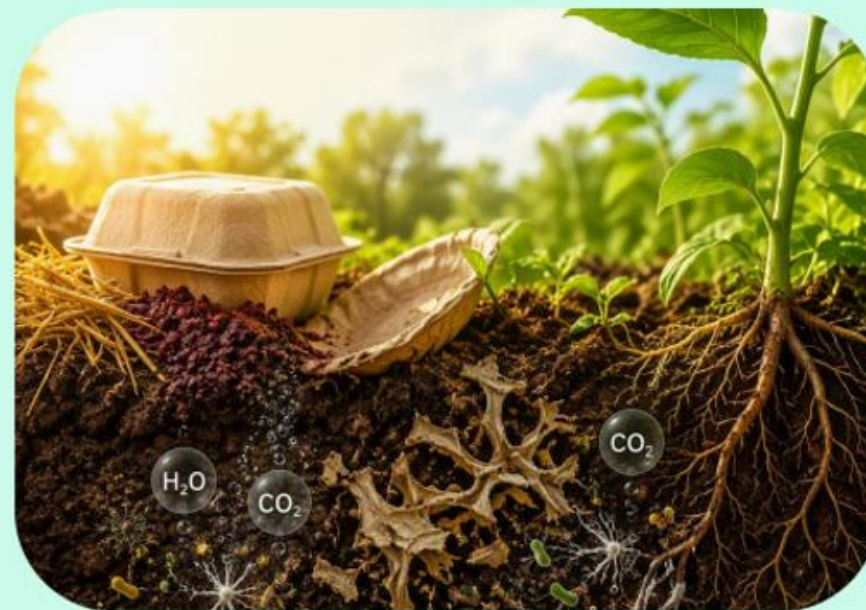
Stock image

More information on the results can be found in D6.8 report

D6.8 Biodegradability of the new materials tested as an end-of-life use

Uusien materiaalien biohajoavuus elinkaaren lopussa

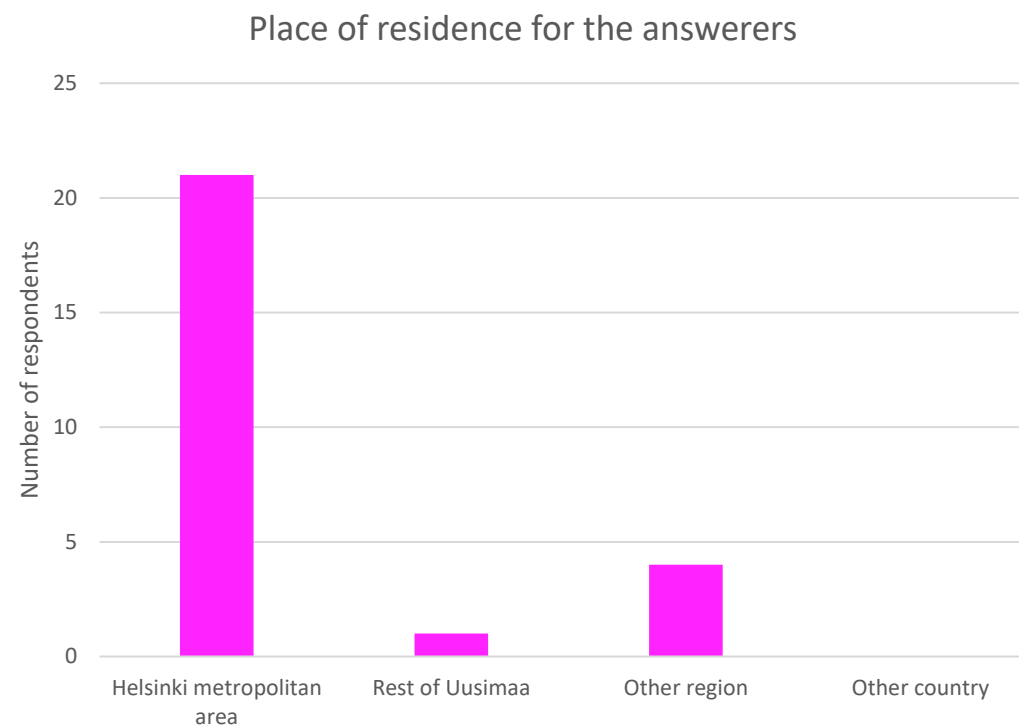
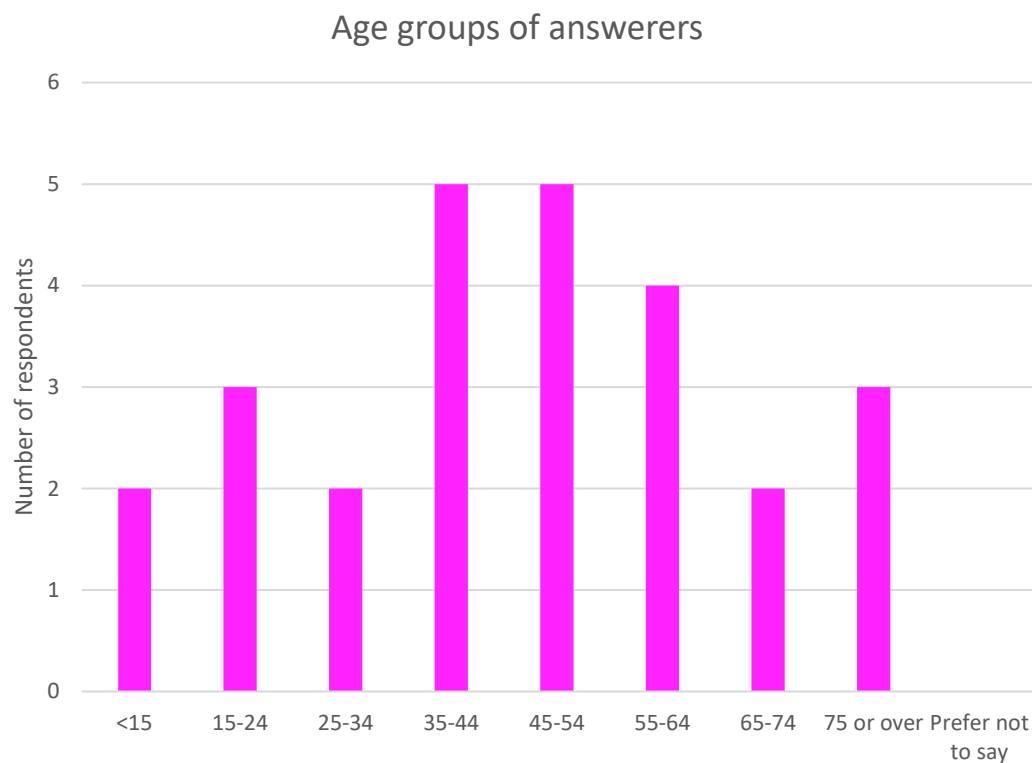
Authors: Jenni Tienaho, Risto Korpinen, Jaakko Hiidenhovi, Marta Cortina Escribano, Henri Vanhanen (Luke)



Stakeholder perspectives: Public showcase at Rautatientori 16th June

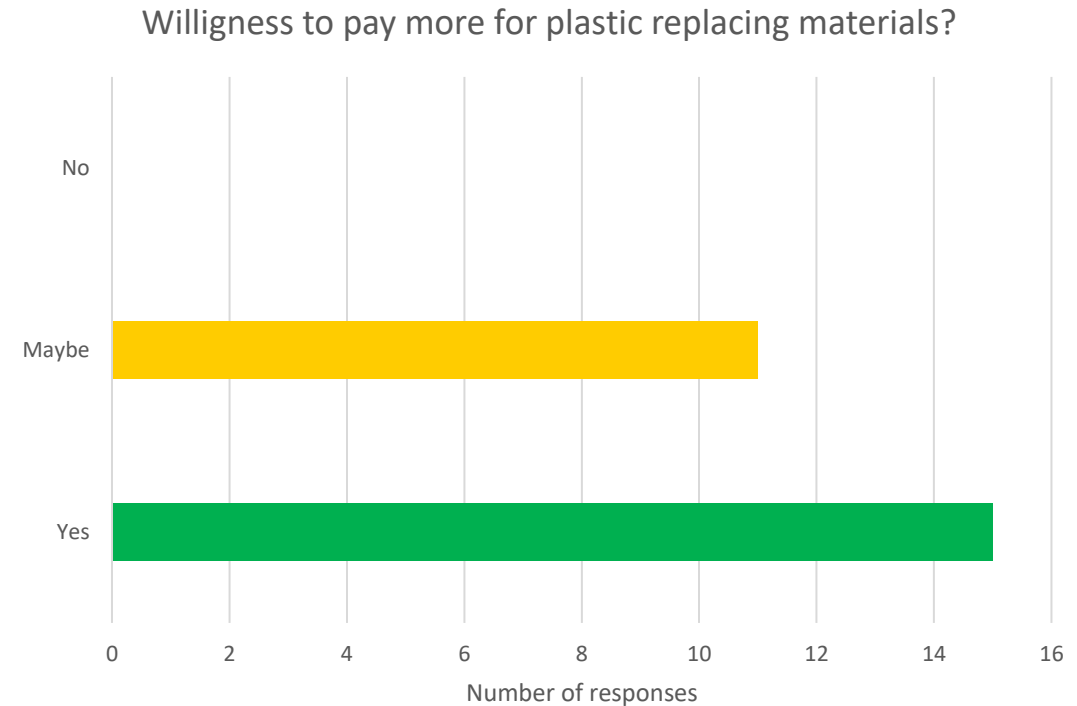
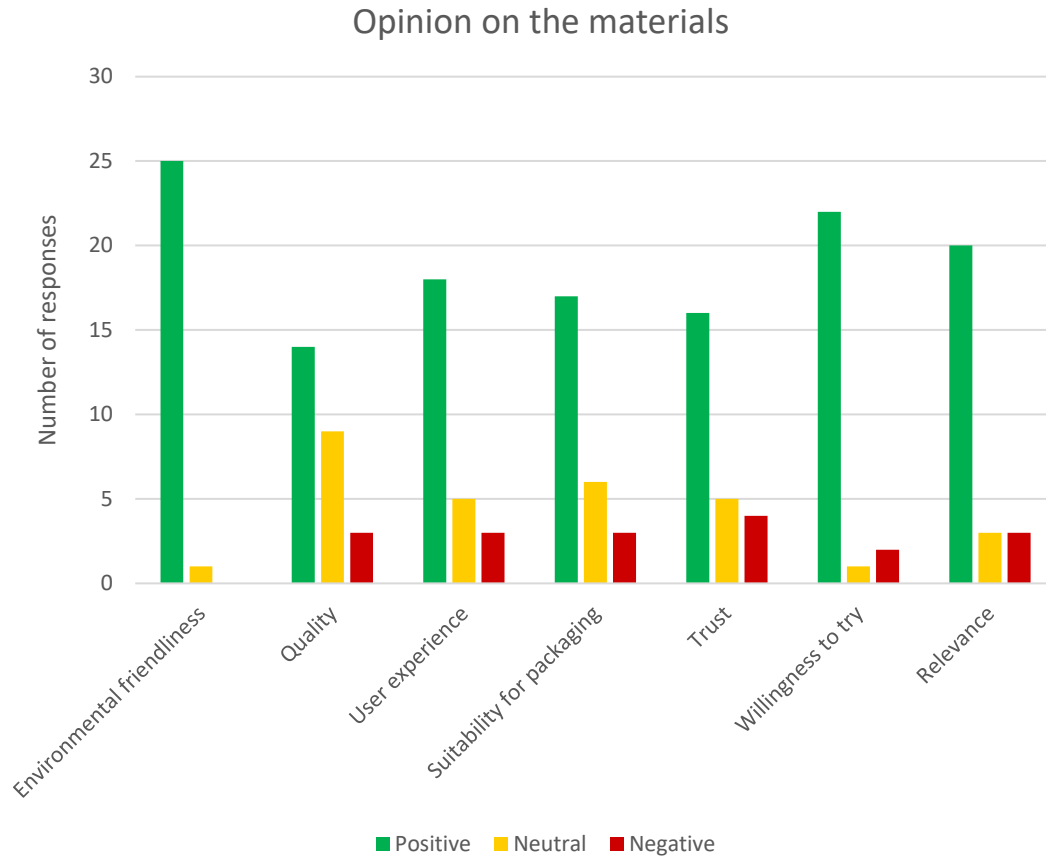


Results – about respondents



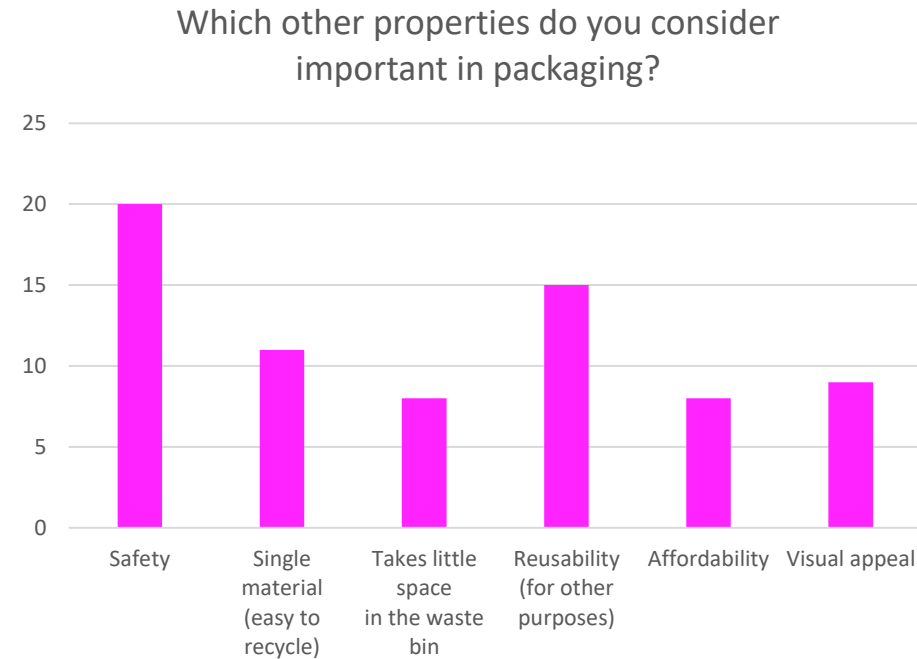
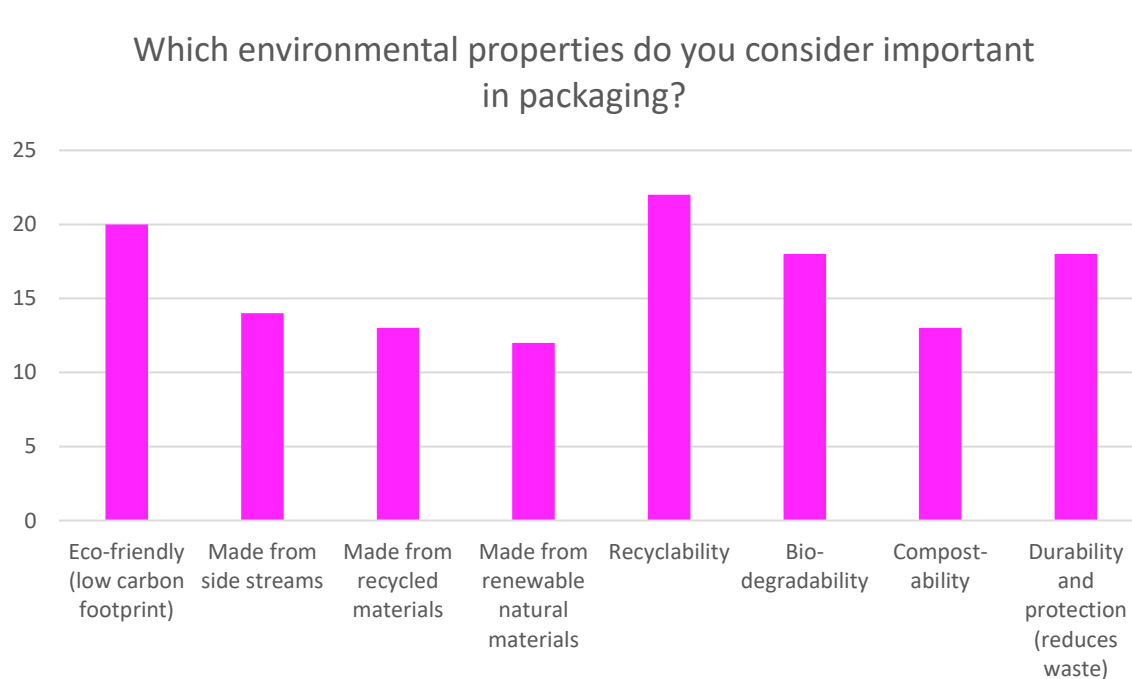
N=26

Results – Positive about the materials



N=26

Results - Recyclability and safety stood out in this survey



Overall opinions were very positive – even surprisingly positive – but for future, even more emphasis should be addressed to the questionnaire so that there will be no room for misinterpretations.

N=26, not a very large number of participants so results should be interpreted with caution.

Lessons learned

- Question **wording can strongly influence** survey results, and our questionnaire may not have been clear enough.
 - Some respondents gave **very negative ratings alongside highly positive comments**, suggesting possible misunderstandings.
- Many respondents were also unfamiliar with the term “side stream”= material left over from another production process
- **The importance of clear questions and plain-language explanations of technical terms.**



Picture: Jenni Tienaho

Further plans for the stakeholder engagement

Expert interviews / questionnaires to review the view of material developers, packaging field experts, etc., on the overall requirements for plastic replacing materials, and potential of the developed options.

These will be accessible in the final report to be delivered during Spring 2027.



Picture: Stock image

Persons involved in T6.3 –Thank you all!



Fibre-based packaging: Risto Korpinen, Pekka Saranpää, Kalle Kaipainen, Kyösti Ruuttunen, Jaakko Hiidenhovi, Eila Järvenpää, Tuija Peltomäki, Anna Happonen, Maryam Ghalibaf



Extrusion-molding and processing: Martin Ramos Diaz, Jarkko Hellström, Tuija Peltomäki, Taru Kariniemi, Veli Hietaniemi



Mycelia-based composites: Marta Cortina Escribano, Henri Vanhanen, Tuija Peltomäki, Taru Kariniemi



Fish side stream films: Jaakko Hiidenhovi, Jenni Tienaho, Ulla Jauhiainen, Auli Lehtonen, Tuija Peltomäki, Riitta Henriksson, Taru Kariniemi, Abishiree Mari Shiva



TEA: Kyösti Ruuttunen, Marjatta Vahvaselkä, Kimmo Rasa

LCA: Ashraful Alam and Luke team from T6.4



The background of the entire image is a close-up, high-resolution photograph of a large pile of plastic debris. The debris consists of numerous small, irregular fragments of plastic in various colors, including blue, black, white, grey, orange, and purple. The fragments are scattered across a light-colored surface, with some pieces appearing as small pellets and others as larger, jagged shards. The lighting is bright, highlighting the textures and colors of the plastic waste.

**Thank you for
your attention!**

PLASTLIFE

| plastlife.fi | [#plastlife](https://twitter.com/plastlife) |