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Nature-Based Solutions for Climate Resilience, Green Skills and Sustainable Communities

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28 May 2026 | 09:30 – 14:00 | Tech-Park Kaunas
Baršausko str. 59,
Conference Hall 3, Kaunas, Lithuania

RENATURE Multiplier Event 2026

TECH-PARK KAUNAS

This project has been funded with support from European Commission.
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Development of bio-based and biodegradable polymer composites using locally sourced agro-waste and application of these composites for the production of packaging

Prof. dr. Visvaldas Varžinskas,

Head of Research Center for Advanced Packaging Materials and Technologies at KTU

Research was conducted as part of the execution of Project "Mission-driven Implementation of Science and Innovation Programmes" (No. 02-002-P-0001), funded by the Economic Revitalization and Resilience Enhancement Plan "New Generation Lithuania."

KTU Centre of Packaging Innovations and Research

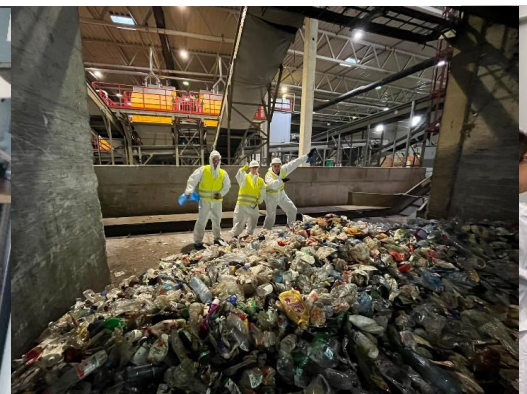
- The only one specialized centre for packing research in Lithuania, which offer a complex package of scientific research and services: including all life-cycle of packings: from selection of environmentally friendly raw materials (materials), package design, preparation for press and press processes, engineering of packing processes, to management of safe packages which became waste and recycling solutions.
  Our R&D areas are:

  * Packaging materials;
  * Packaging processes;
  * Packaging legislation or certification;
  * Packaging testing.

- 3 Professors,
- 5 associate professors,
- 3 senior researchers (PhD),
- 3 PhD students
- 2 administrative staff

Recently issues related to legal regulation, sustainable development and environmental impact of packages or packing become more and more significant for the centre's activities.






InTechCentras
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RecyClass RECYCLABILITY

RecyClass RECYCLING PROCESS

RecyClass 100% RECYCLED PLASTIC

From advanced labs…

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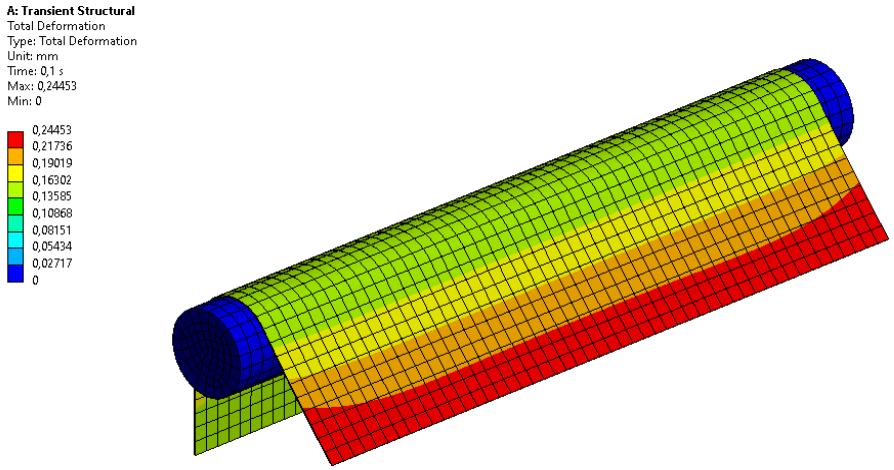

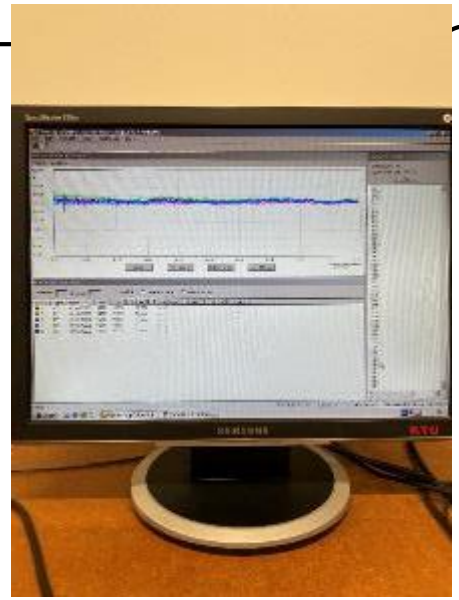

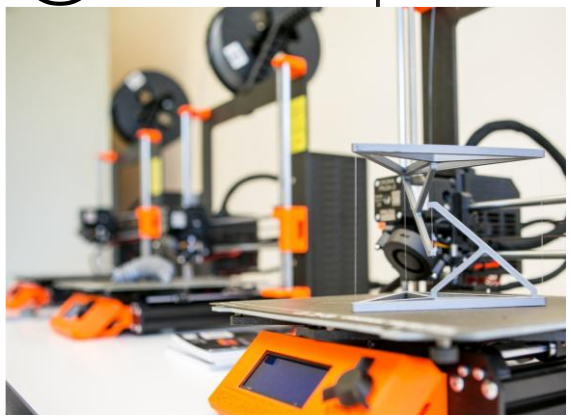

Up to morphological research...

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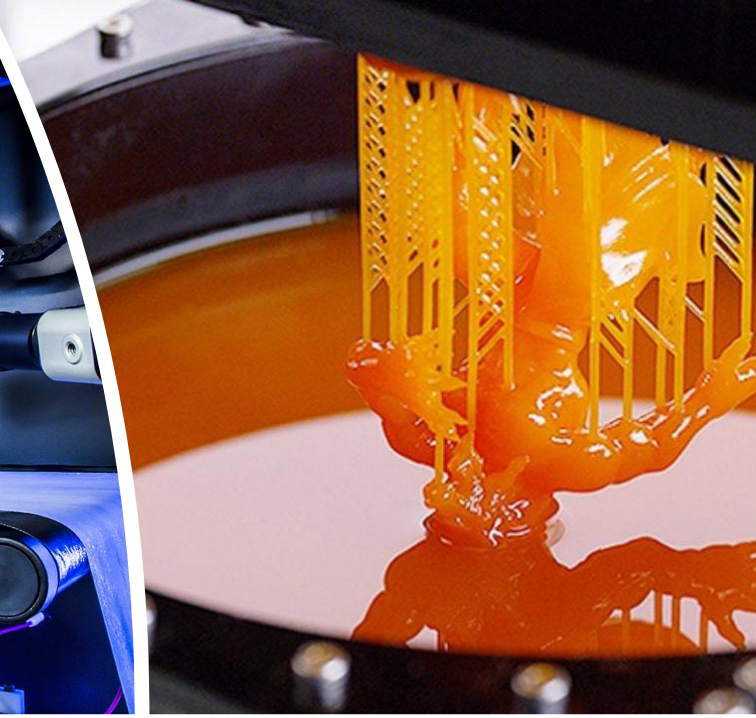
R&D project topics and research groups



- **Development of bio-based and biodegradable polymer composites using locally sourced (Baltic Sea region) agro-waste and application of these composites for the production of reusable plastic packaging.**

- Application of bio-based materials (PLA, PHA, chitosan, collagen, keratin) for the formation of nano-coatings (using electrospinning technology) and the study of the barrier properties of such coatings and the application of the technology to the packaging industry.

- Development of bio-based and biodegradable UV-sensitive resins for application in SLA 3D printing technologies and application of the developed materials to manufacturing technology solutions for the application of advanced biocomposite packaging materials.

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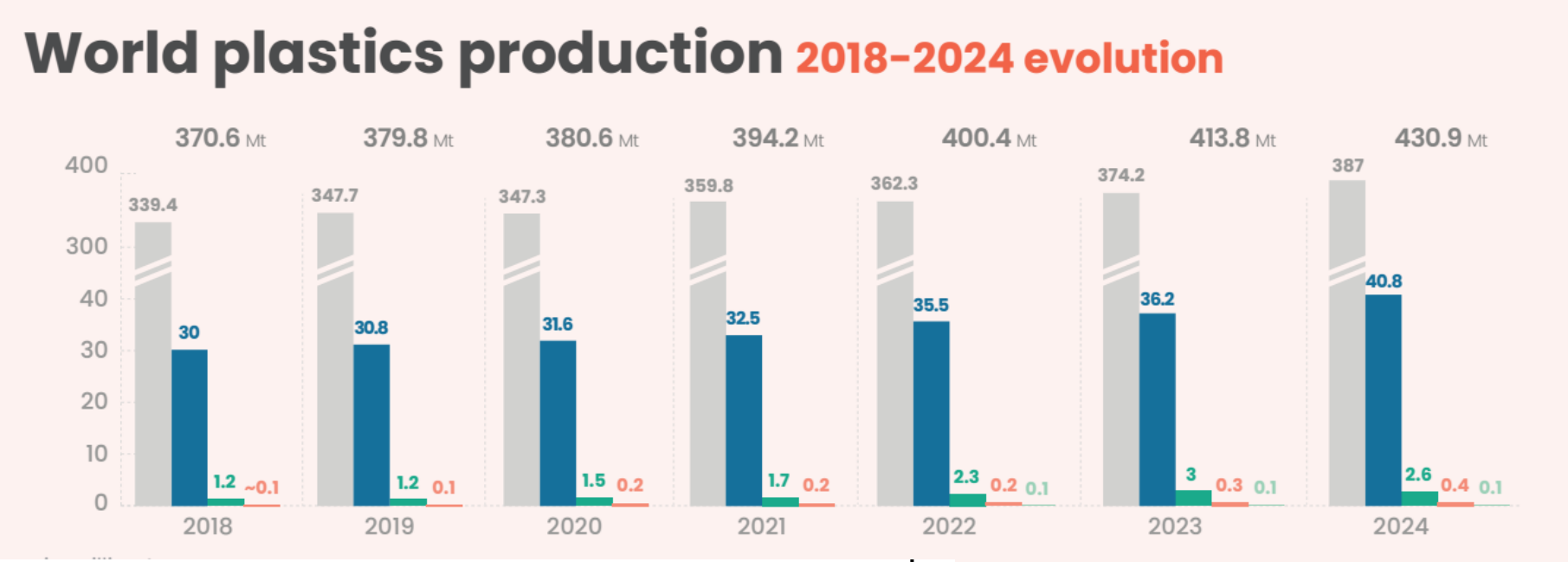
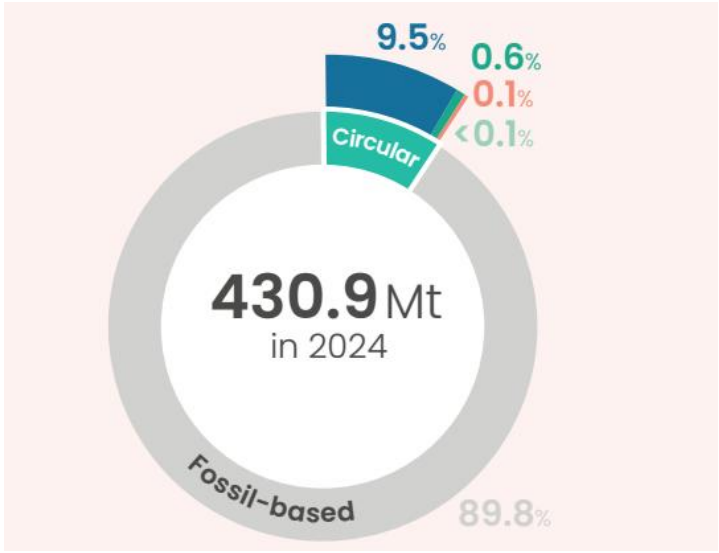
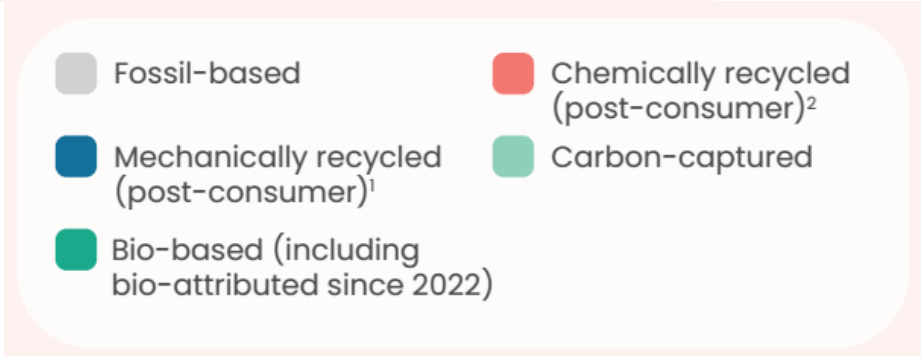
Plastic production in the world:







PLASTICS EUROPE
Enabling a sustainable future

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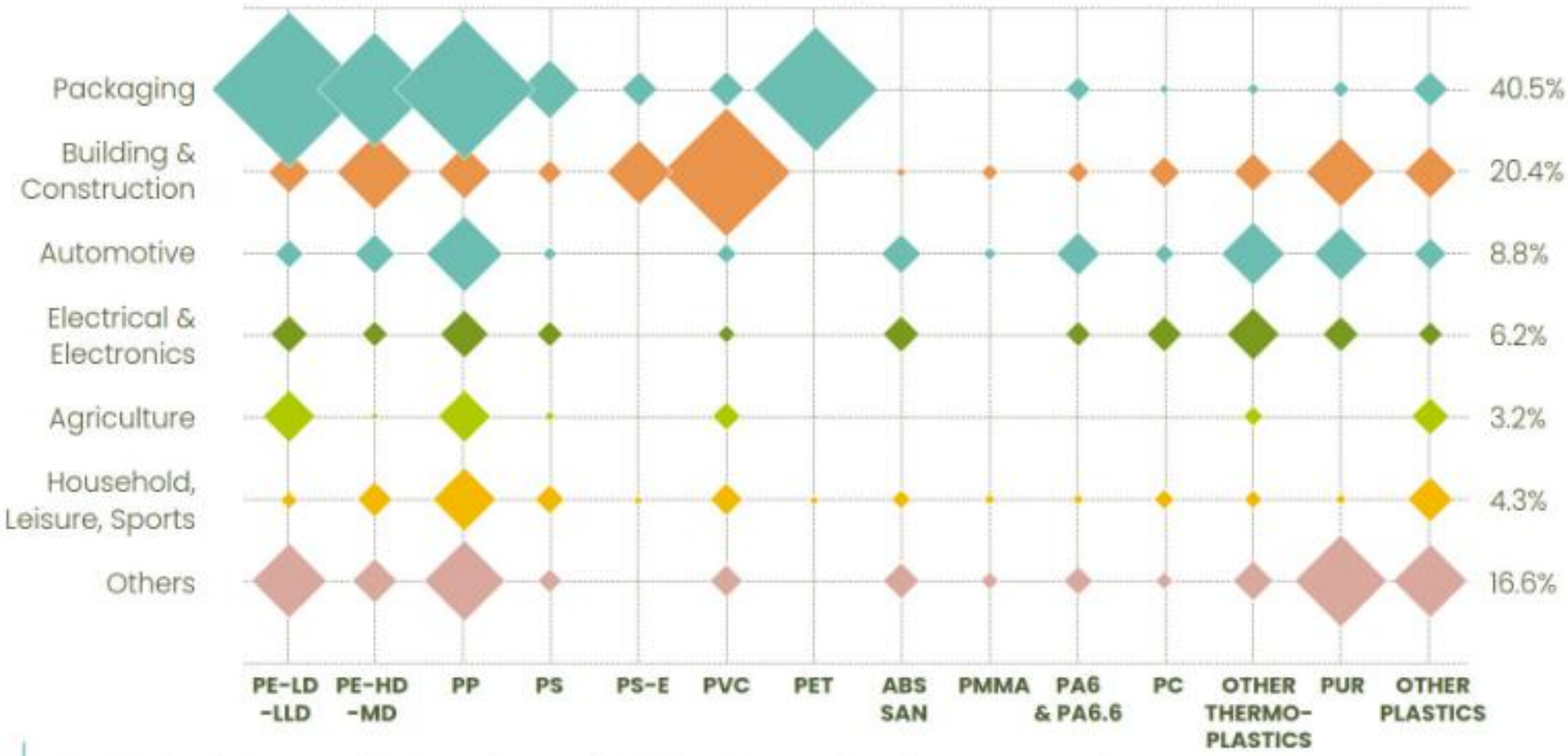
By sector and polymers (2020)

Demand for plastics from EU-27+3 manufacturers: 49.1 Mt



SOURCE: Plastics Europe Market Research Group (PEMRG) and Conversio Market & Strategy GmbH.
Demand estimations do not include recycled plastics.
Numbers behind this graph are available upon request.

Trends in plastic production in the world and in the EU

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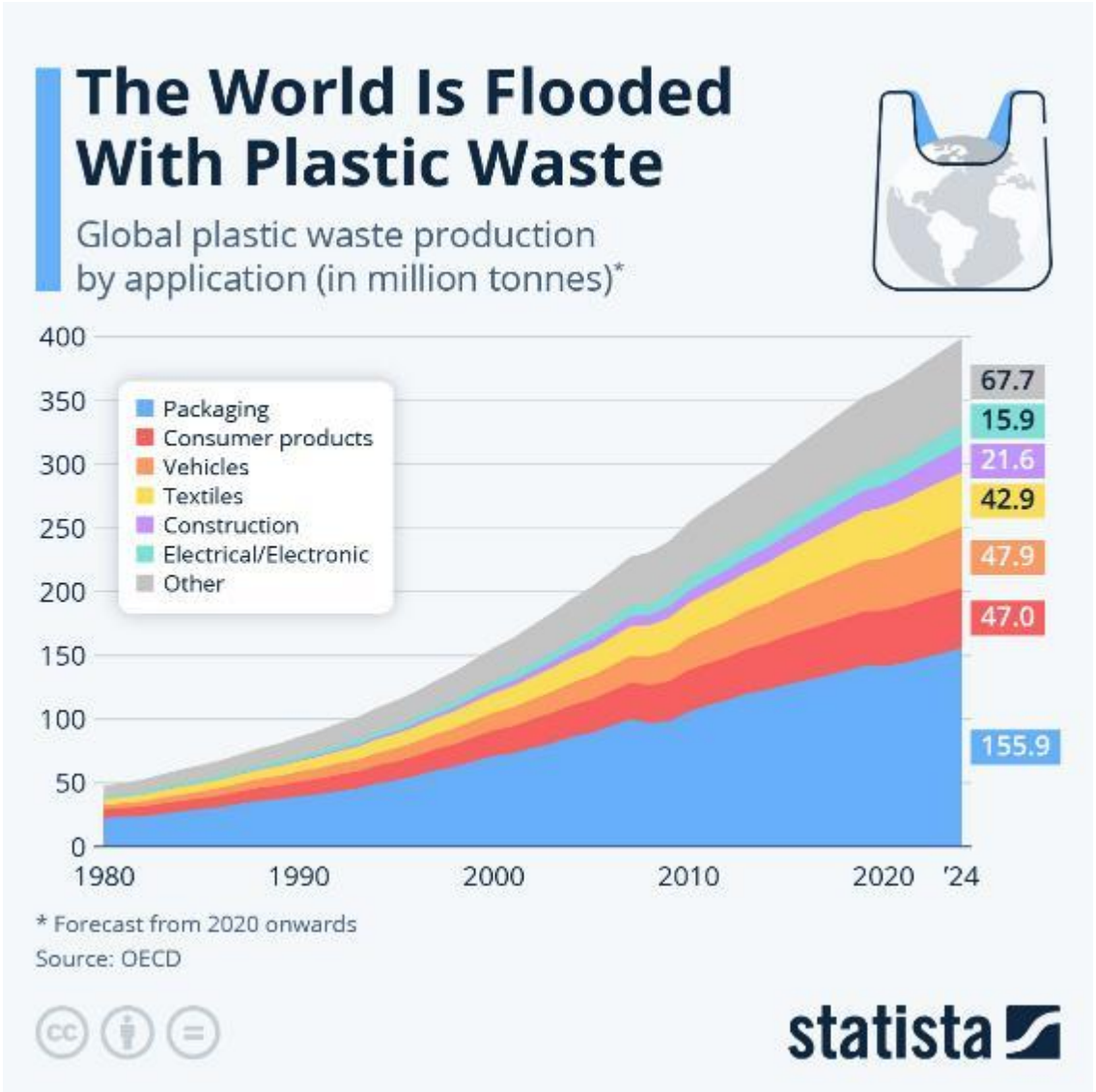
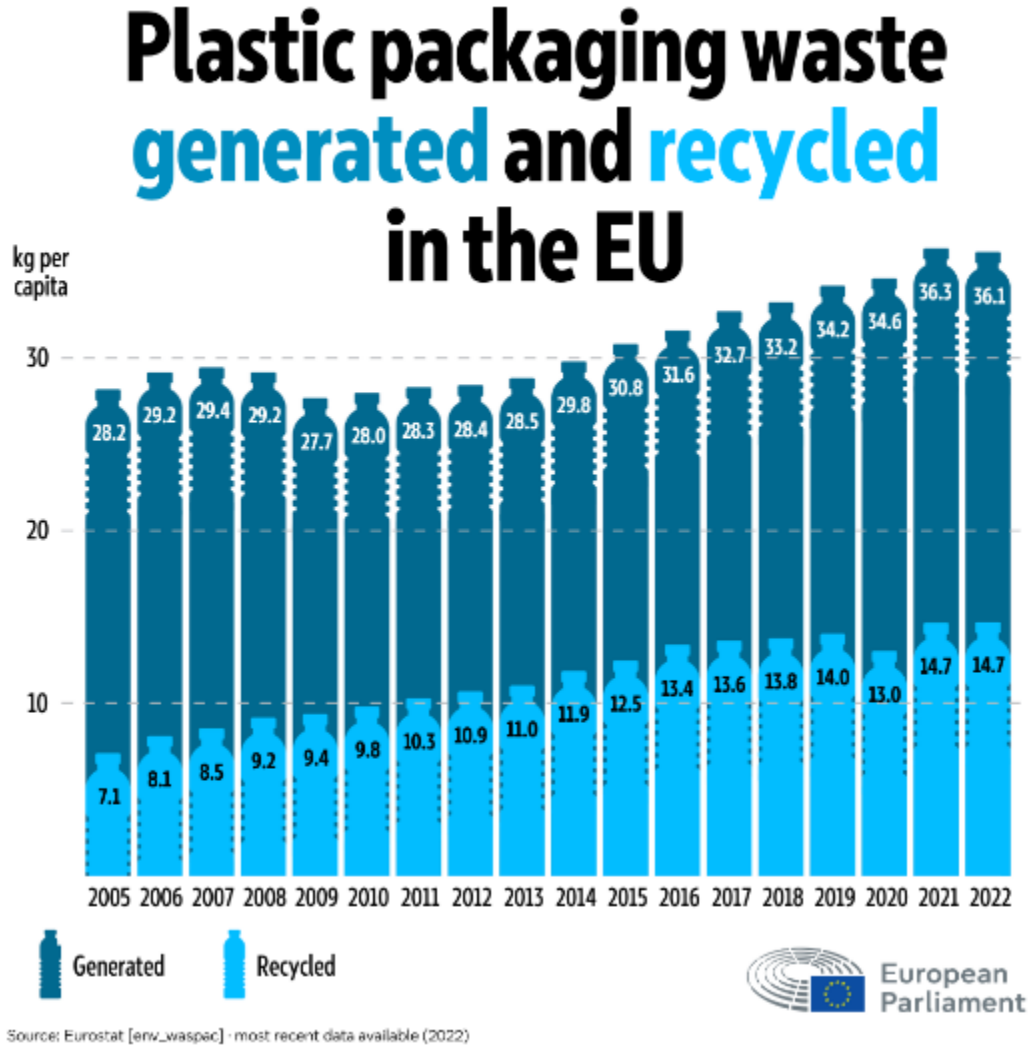


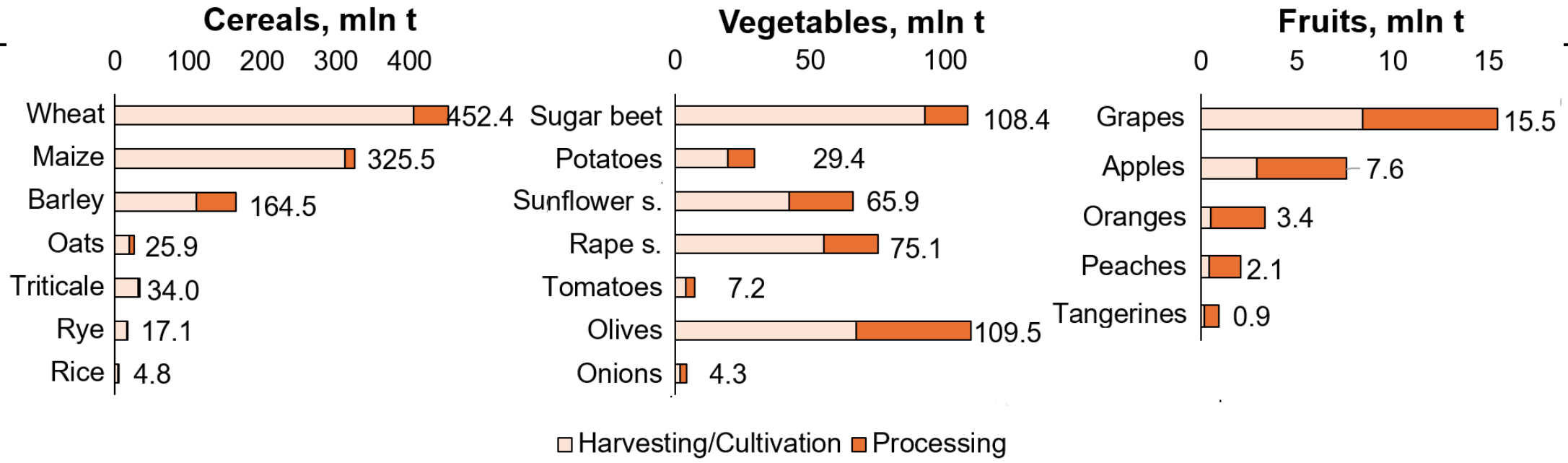


Agro-waste abundance

Agro-waste from the most common crops in Europe in 2022

No official statistic on agro-waste

2.6 billion tons per year of agricultural waste, co-products, and by-products in Europe (Bedoic et al., 2019)
700 million tonnes of agricultural waste annually in Europe (according AgroCycle EU-funded project)



Bedoić, R., Ćosić, B., Duić, N.: Technical potential and geographic distribution of agricultural residues, co-products and by-products in the European Union. Science of The Total Environment. 686, 568–579 (2019). https://doi.org/10.1016/J.SCITOTENV.2019.05.219

Main agro-waste fibers and typical combinations with biopolymers

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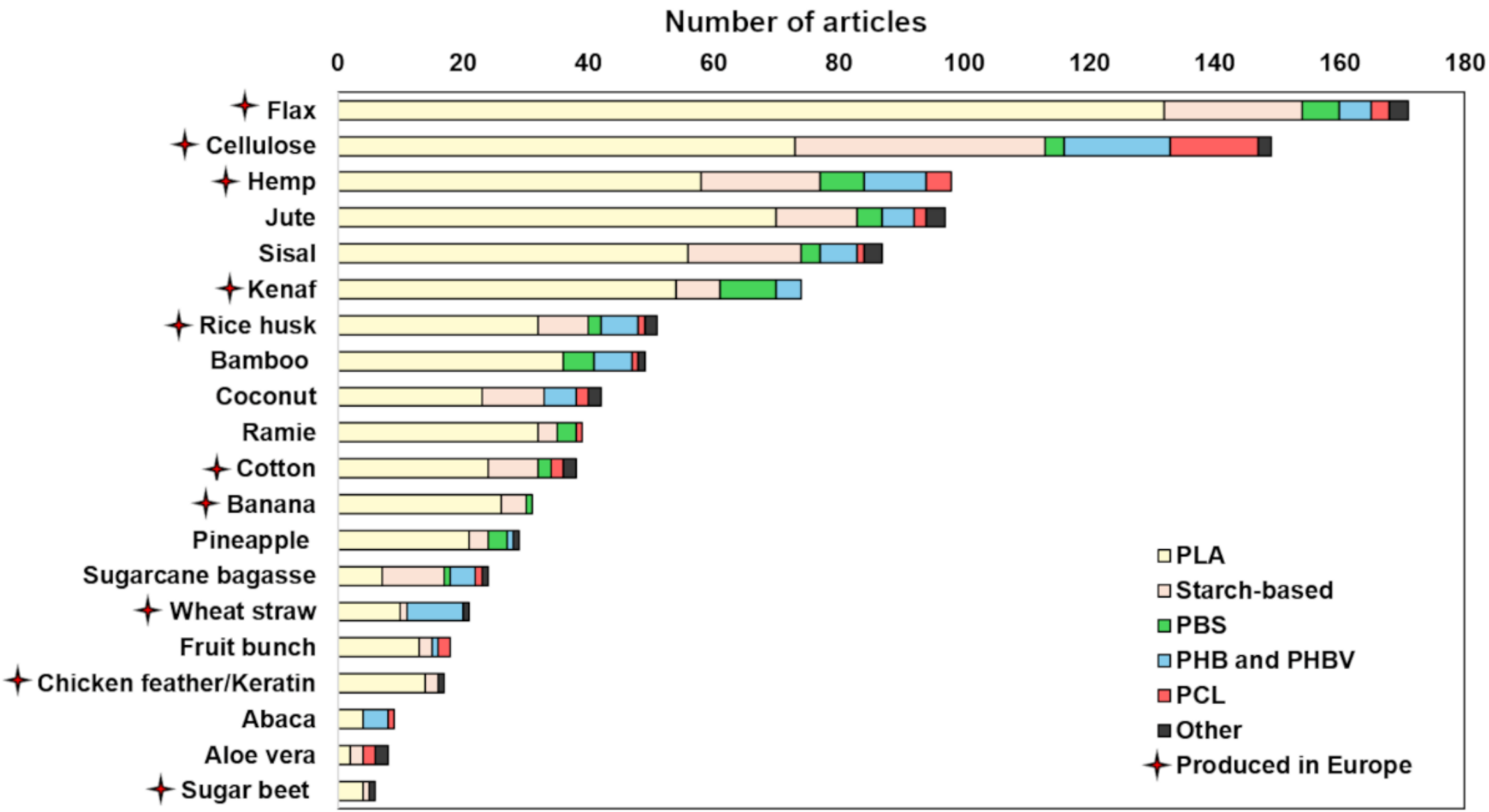

The most common polymer matrix with LCA studies

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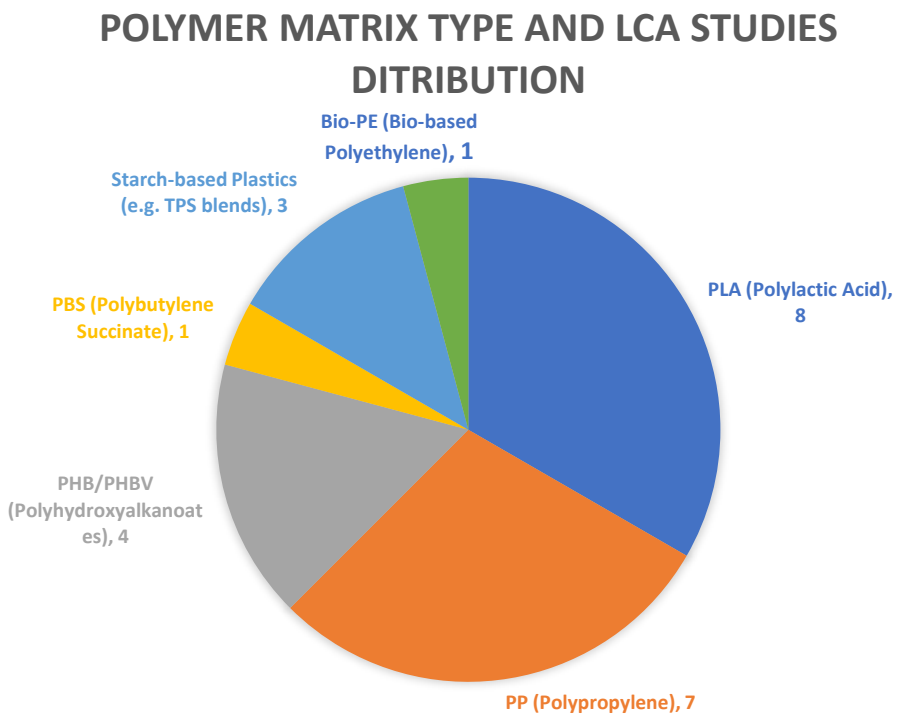
Polymer Matrix	Number of LCA Studies	LCA Boundary	Dominant Application
PLA (Polylactic Acid)	8	Both cradle-to-gate and cradle-to-grave (varies by study)	Packaging – e.g. used in films, trays, etc. (also some automotive uses)
PP (Polypropylene)	7	Both cradle-to-gate and cradle-to-grave (varies by study)	Automotive – common in car interior panels & parts (some packaging applications as well)
PHB/PHBV (Polyhydroxyalkanoates)	4	Both (many include full cradle-to-grave with end-of-life)	Packaging – often in disposable packaging materials (also studied in automotive and building contexts)
PBS (Polybutylene Succinate)	1	Primarily cradle-to-gate (production-focused LCA)	Packaging – used in biodegradable consumer products (e.g. bioplastic items)
Starch-based Plastics (e.g. TPS blends)	3	Both (several include cradle-to-grave to capture biodegradation at EOL)	Packaging – used in films, food containers, mulch films
Bio-PE (Bio-based Polyethylene)	1	Cradle-to-gate (focus on manufacturing phase)	Packaging – bio-based PE composites for packaging/containers



Cradle-to-Gate Dominance: Many bio-composite LCAs use cradle-to-gate boundaries, assessing impacts up to the factory "gate"

The most common biodegradable infills with LCA studies

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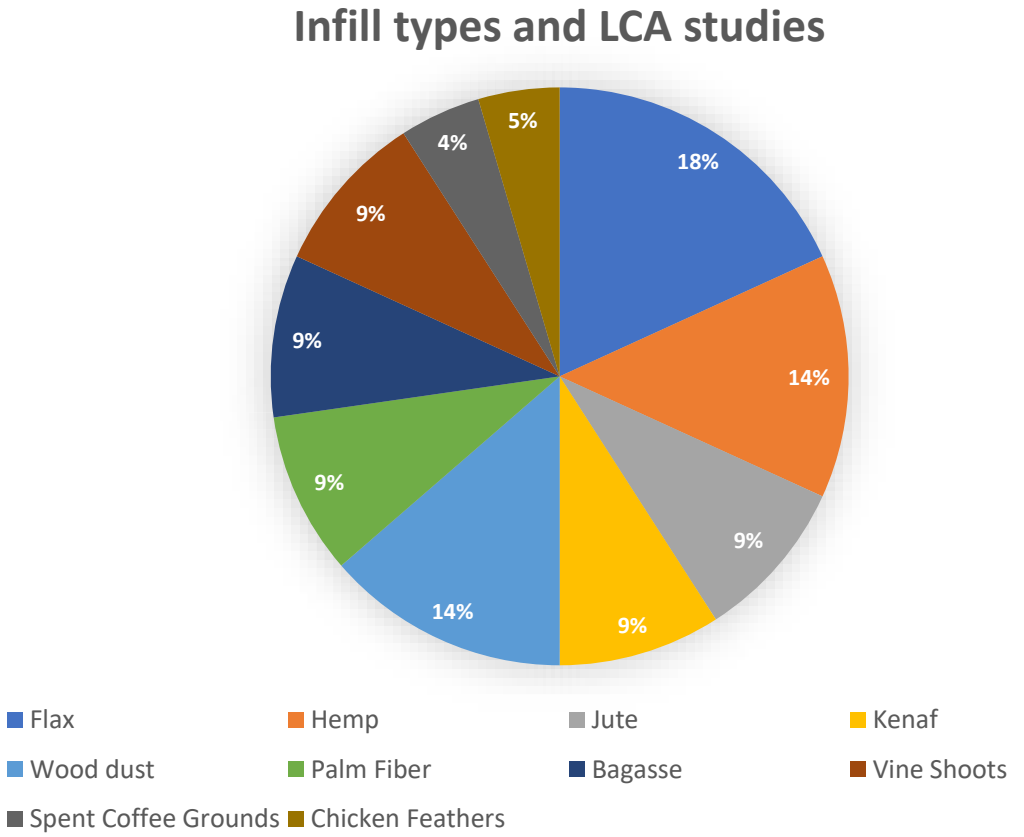
Infill Type	Number of Studies	LCA Boundary	Application
Flax	4	Both	Packaging, Automotive
Hemp	3	Cradle-to-Gate	Automotive
Jute	2	Cradle-to-Gate	Construction
Kenaf	2	Cradle-to-Grave	Automotive
Wood dust	3	Both	Packaging
Palm Fiber	2	Cradle-to-Grave	Packaging
Bagasse	2	Cradle-to-Gate	Packaging
Vine Shoots	2	Cradle-to-Gate	Packaging
Spent Coffee Grounds	1	Cradle-to-Gate	Packaging
Chicken Feathers	1	Cradle-to-Gate	Packaging



- Focus is shown to agricultural and industrial wastes as fillers
- Flax and hemp dominate as infills due to performance and availability

Agro-waste can be valorized for both biocomposite matrix and reinforcement (1-3 TRL)

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BIOPOLYMER

- Starch
- PLA
- Cellulose
- PHAs
- Protein

+

REINFORCEMENT

Fibrous


Flax


Hemp


Wheat


Kenaf


Cotton


Rice husks


Sugar beet


Banana

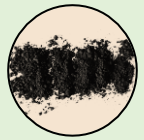

Chicken feather

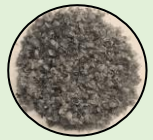
Particulate


Fruit peels


Nutshells


Powders


Agro-waste ashes


Coffee silverskin

Nano

- Nano-cellulose
- Nano-chitin
- Nano-starch
- Nano-lignin

→

BIOCOMPOSITES

Bio-based matrix – modified celullose or PLA (4-5 TRL)

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- Hemp husk

- Hemp shives

- Coffee silverskin

- Citrus peel

- Wheat bran

Agro – waste as fillers for biocomposites

Composition of Bioplastic Composites (36 different compositions)

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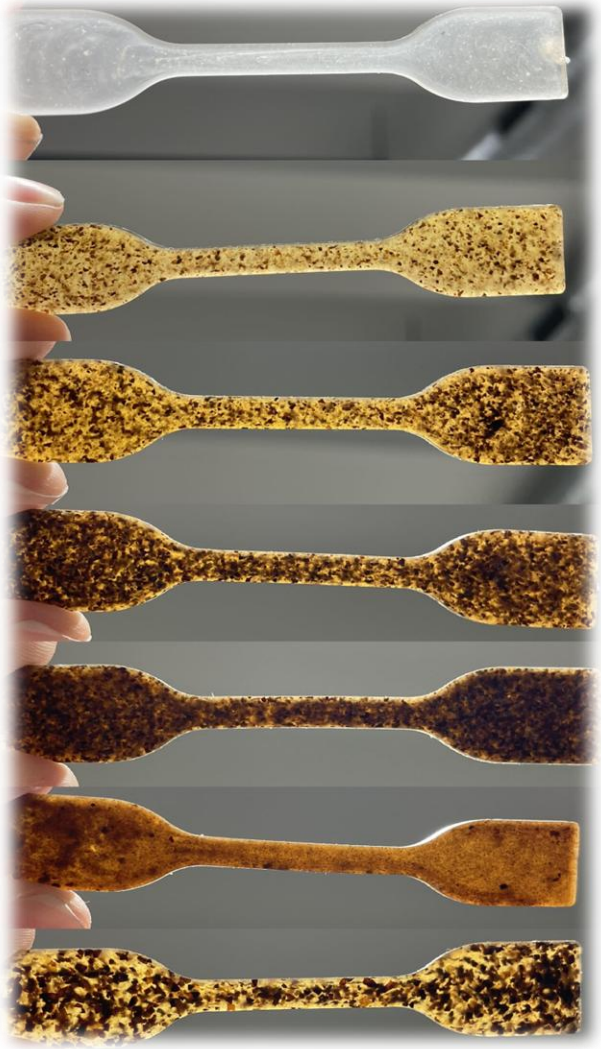
- **95-70%**

- plasticized celullose diacetate or PLA

- **5-30%**

- agro-waste filler (it could be also mechanically or chemically pretreated)



Mechanical properties of composites with fractionated coffee silverskin filler particles

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No	Particle size, µm	Amount of filler, wt%	Tensile strength at break, MPa	Elongation at break, %	Young's modulus, MPa
1	Without filler		43.9±4,1	9.7±0.8	1042±66
2	<315	5	37.1±4.6	8.6±2.1	1109±155
3		10	30.6±3.6	8.9±1.1	1003±89
4		**20**	**31.4±4.1**	**6.4±0.6**	**1401±99**
5	315-400	5	31.6±3.6	9.8±0.9	967±71
6		10	30.6±2.2	7.9±0.7	1062±128
7		**20**	**29.1±2.4**	**4.7±0.7**	**1321±123**
8	400-630	5	33.8±2.3	9.7±0.8	1023±106
9		10	30.5±4.6	6.6±0.9	992±96
10		**20**	**30.4±5.6**	**4.3±0.7**	**1322±120**

Effect of chemical pretreatment of hemp husk with NaOH on mechanical properties of composites

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No	Particle size*, μm	Amount of NaOH, %	Tensile strength at break, MPa	Elongation at break, %	Young's modulus, MPa
1	Without filler		43.9±4.1	9.7±0.80	1042±66
2	160-630	0	26.19 ± 1.91	3.66 ± 0.24	1114 ± 112
3		4	25.85 ± 2.02	3.57 ± 0.82	1172 ± 127
4		8	28.26 ± 2.70	3.56 ± 0.26	1266 ± 49
5		**12**	**29.03 ± 2.68**	**3.55 ± 0.53**	**1329 ± 51**
6		16	27.85 ± 2.54	3.55 ± 0.53	1384 ± 106

* Amount of filler 20 %

3D printing (FDM – *Fused Deposition Modeling)*

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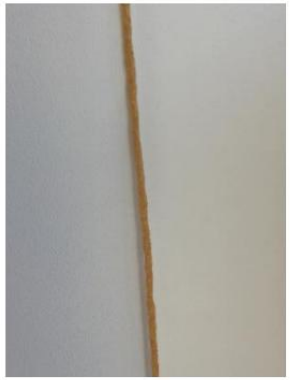
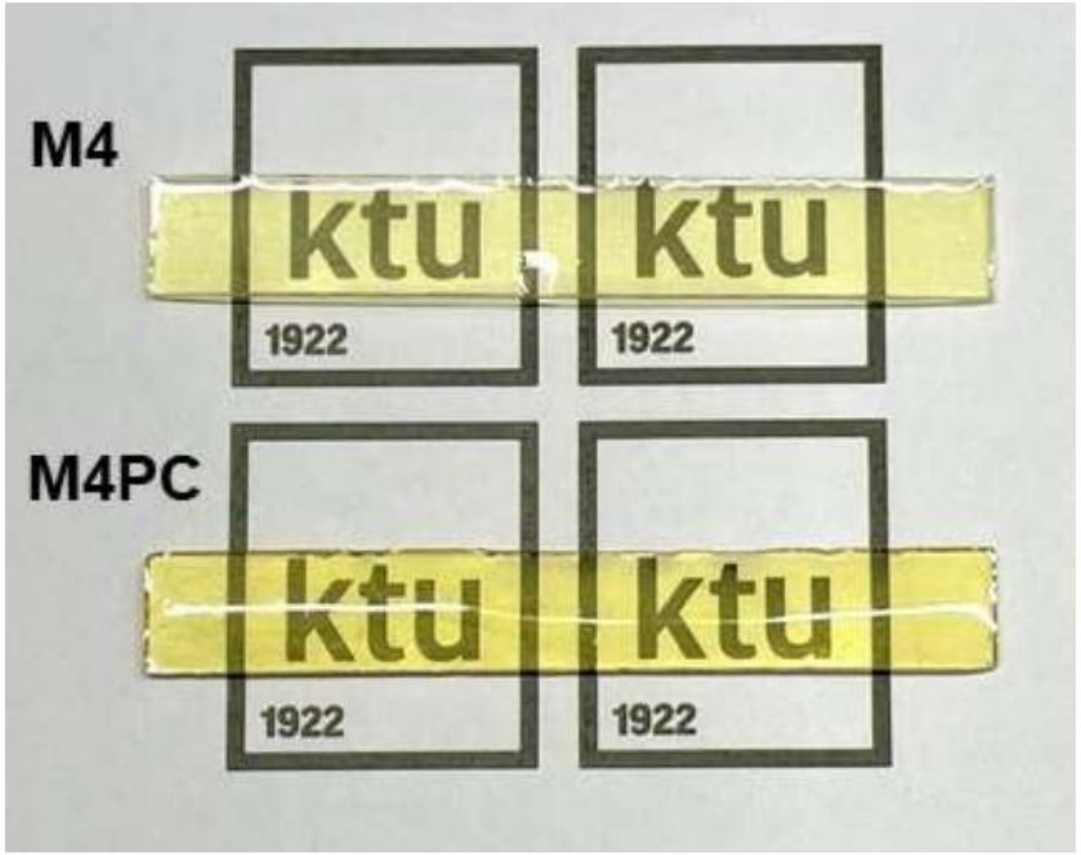
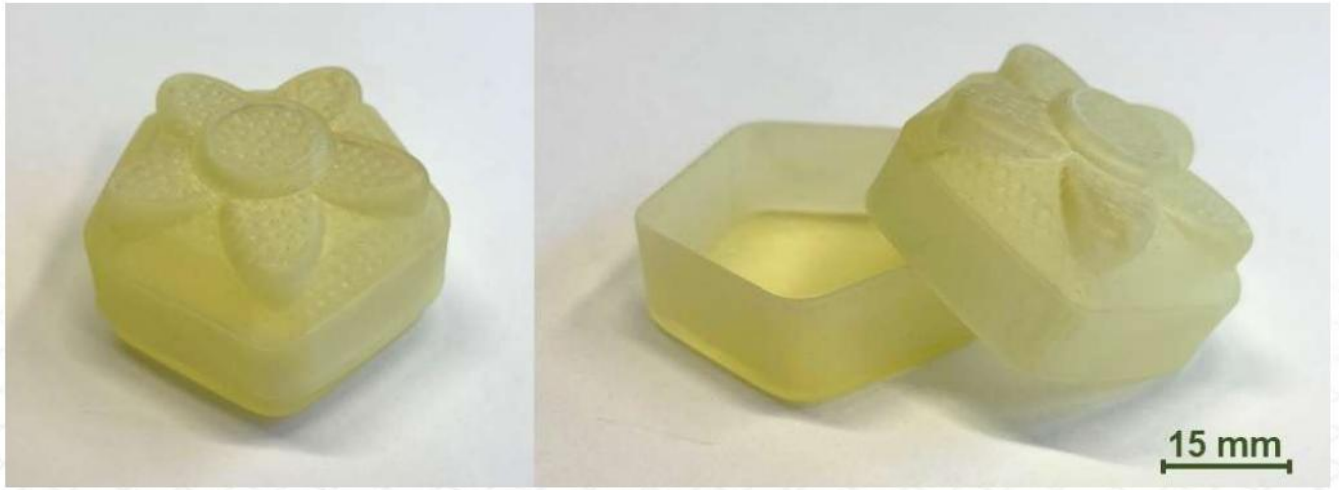


3D printing (MSLA / LCD – Masked Stereolithography) ktu





A box printed using an LCD 3D printer from a resin prepared on the basis of glycerol 1,3-diglycerolate diacrylate.

UV light-sensitive bio-based resins composed of **naturally derived monomers**: glycerol 1,3-diglycerolate diacrylate (GDGDA), tetrahydrofurfuryl methacrylate (THFMA), and phloroglucinol tris-epoxide (PHTE), using additional substances: sulfonium salt CPI-410S, diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide, and 2,5-bis(5-tert-butyl-benzoxazol-2-yl)thiophene.

Production and thermal processing of biocomposites (5-7 TRL)

Twin-screw extrusion

Injection molding

Compression molding

Thermoformed composite of hemp fibre (whole fraction) in a biodegradable polymer matrix.

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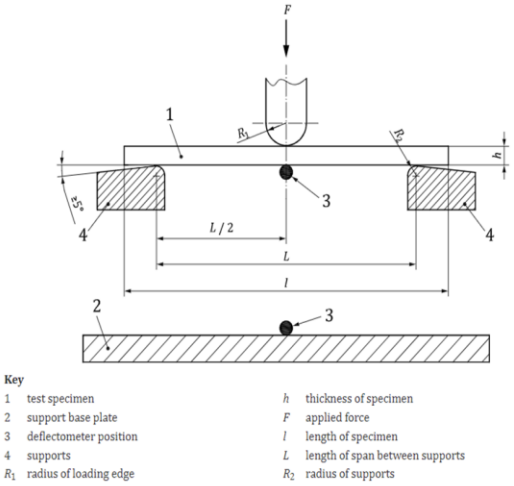

Key

1	test specimen	h	thickness of specimen
2	support base plate	F	applied force
3	deflectometer position	l	length of specimen
4	supports	L	length of span between supports
R_1	radius of loading edge	R_2	radius of supports

"Studies on the physico-mechanical properties of materials (resistance to applied forces) with a view to specifying newly developed materials (Determination of flexural properties ISO 178)"

The calculations lead to an average bending strength in the composite material at which the material structure cracks. The composite panel has a force of **17,3 MPa**, . With the bending strength value of the composite, it is possible to compare other materials on the market:

- Standard particleboard: the minimum bending strength values for standard particleboard used for interior applications are usually around **15-18 MPa**.
- High density particleboard: higher grades for more demanding applications may have bending strength of **18-20 MPa** or more.
- Standard MDF: Typically, the minimum stress is about **20-25 MPa**.

THANK YOU!

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IF YOU HAVE ANY QUESTIONS OR ARE INTERESTED IN OPPORTUNITIES FOR COOPERATION:

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