Valorisation of bio-based resources for innovative materials, products and applications

FH Salzburg

Transilvania University of Brasov

FH-Prof. Dr. Thomas Schnabel

Salzburg University of Applied Sciences
Department of Forest Products Technology & Timber Constructions

introduction

- Salzburg University of Applied Sciences (43 bachelor- und master programmes)
- two study degree programmes related to wood technology & timber constructions with 260 students
- Head of R&D department of wood and biogenic technologies with 10 staff members
  - 14 national and international projects in 2020
  - 22 scientific articles (web of science) in 2020
  - 6 scientific articles (other databases) in 2020
  - 8 books and contributions in books in 2020
  - 4 contributions on conferences in 2020

FH Salzburg Campus Kuchl

research context on my habilitation

- research results were obtained from 12 international and national projects with 29 international and 19 national project partners
- results were presented in
  - 21 scientific papers (web of science)
  - 19 scientific papers (other databases)
  - 2 books
  - 22 international conferences papers/presentations
  - member of scientific boards
- knowledge was transferred in
  - 7 lectures (e.g. bio-based materials, wood modification)
  - various student projects for bachelor and master thesis
  - 2 PhD students (ongoing process)

FH Salzburg Campus Kuchl_Wildbild

content

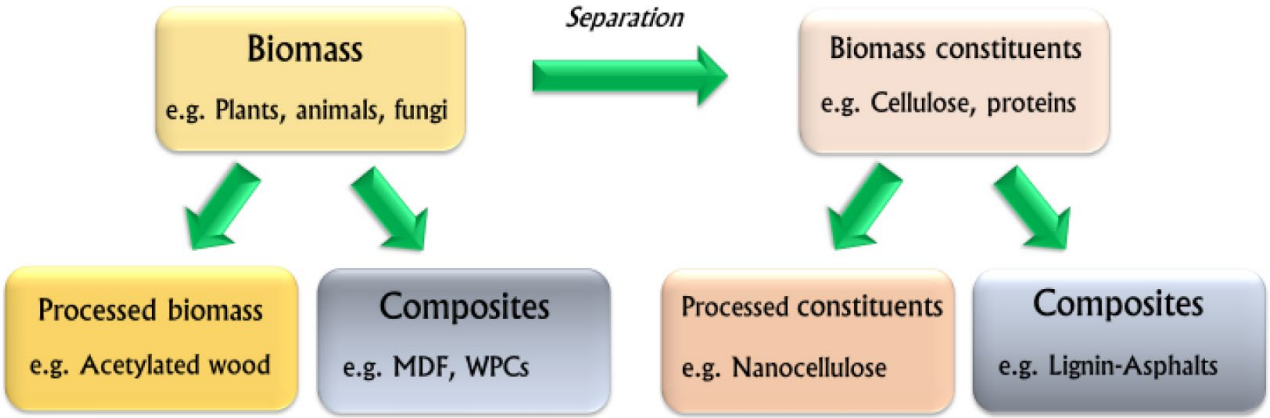
- current situation
- introduction of bio-economy
- topic of straw-based materials
- research on wood-leather fibreboards
- focus on tree extractives
- future research and academic activities
- summary

current situation – changing world

- consumption of resources increases continuously
- bio-based raw materials are increasingly investigated for new products and applications
- linear economy is transformed to circular economy
- innovative business models are needed
- development of new value chains is fostered

bio-based polymer from plants for the new products

- no competition to food
- plant derivates (e.g. oils, glucose)
- carbon-neutral, and high-performing materials
- carbon atoms in solid materials



Overview of research topics in the field of bio-based polymers (Tondi and Schnabel 2020)

bio-economy

- interconnection between different industry sectors
- reduction of waste
- by-products versus innovative products
- cascading and recycling

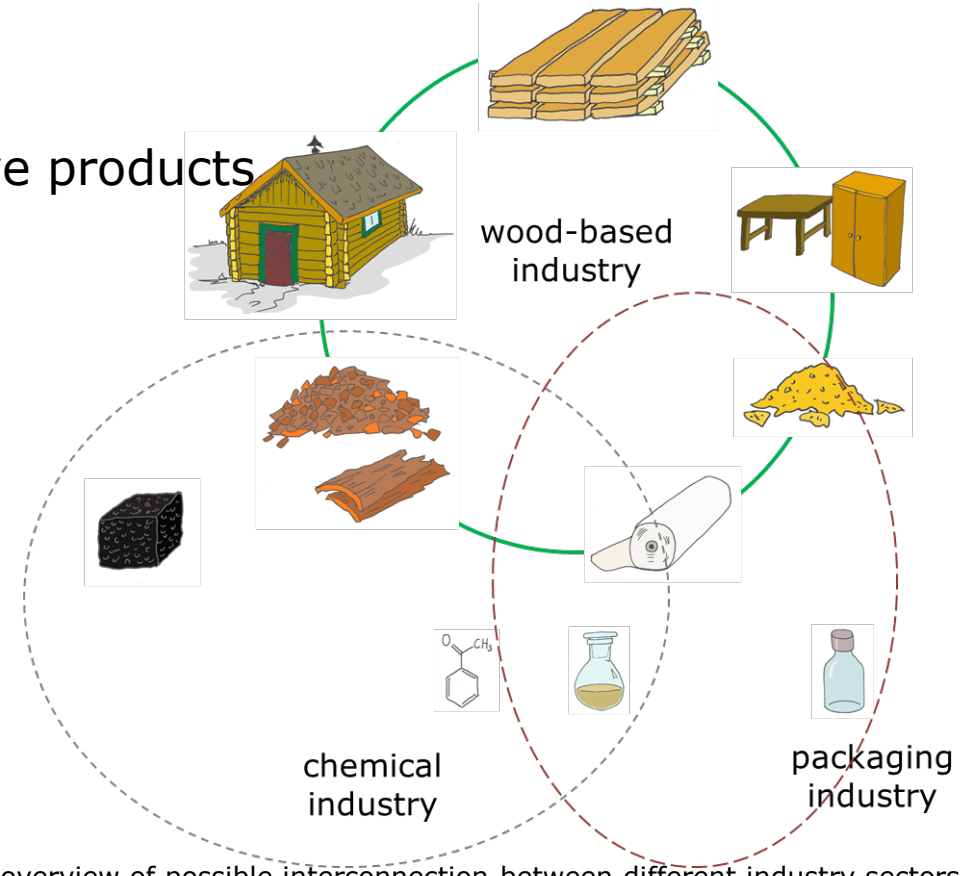
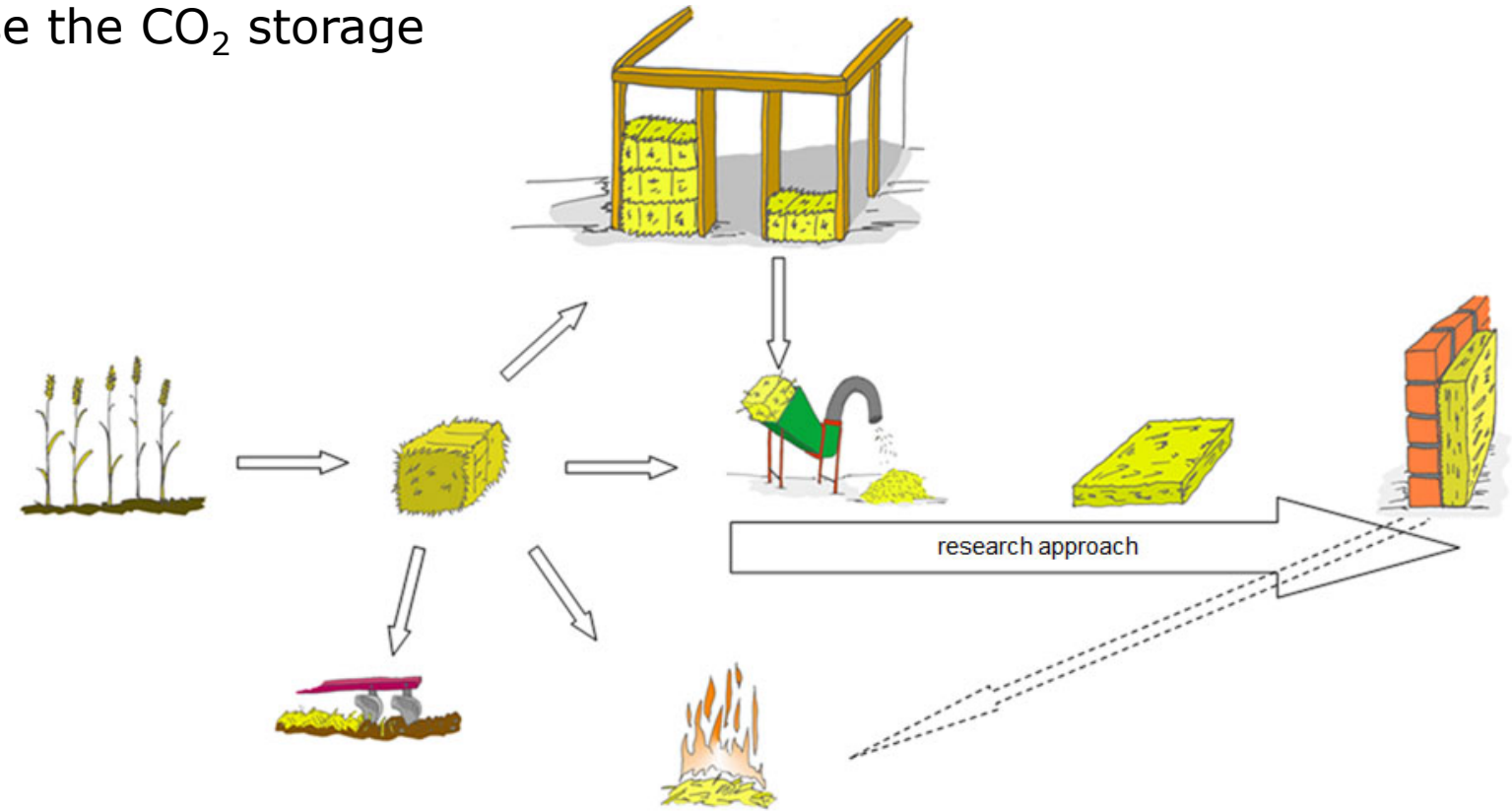


Chart of bio-economy concept, overview of possible interconnection between different industry sectors

idea behind straw-based materials

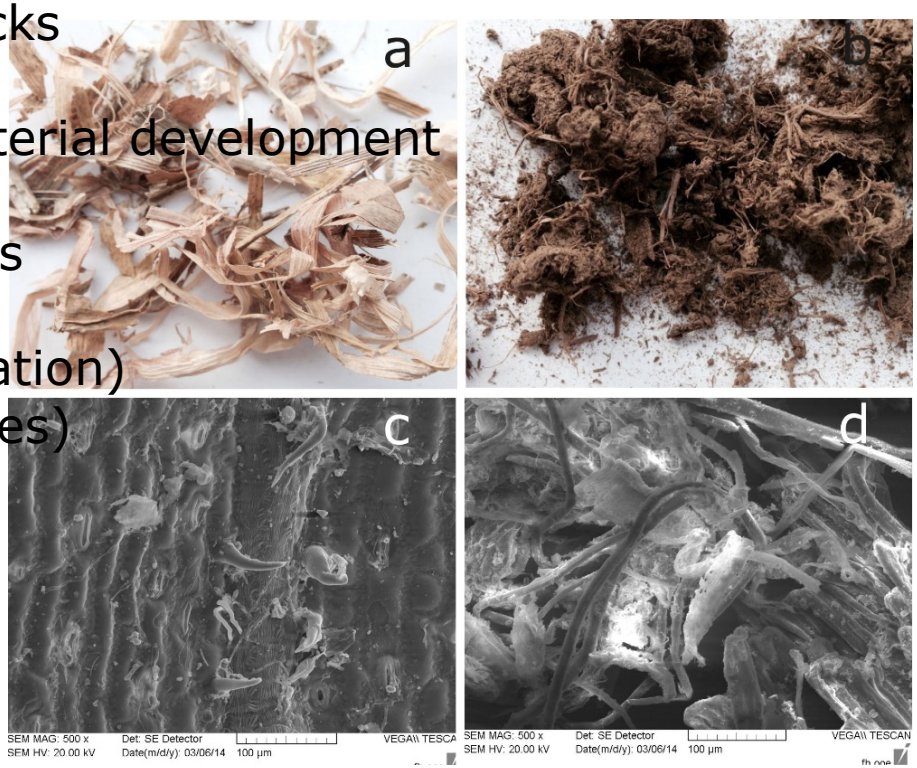
- development of bio-based products
- increase the CO_2 storage



Research approach for the development of new insulation materials from different plant materials (Schnabel et al. 2019)

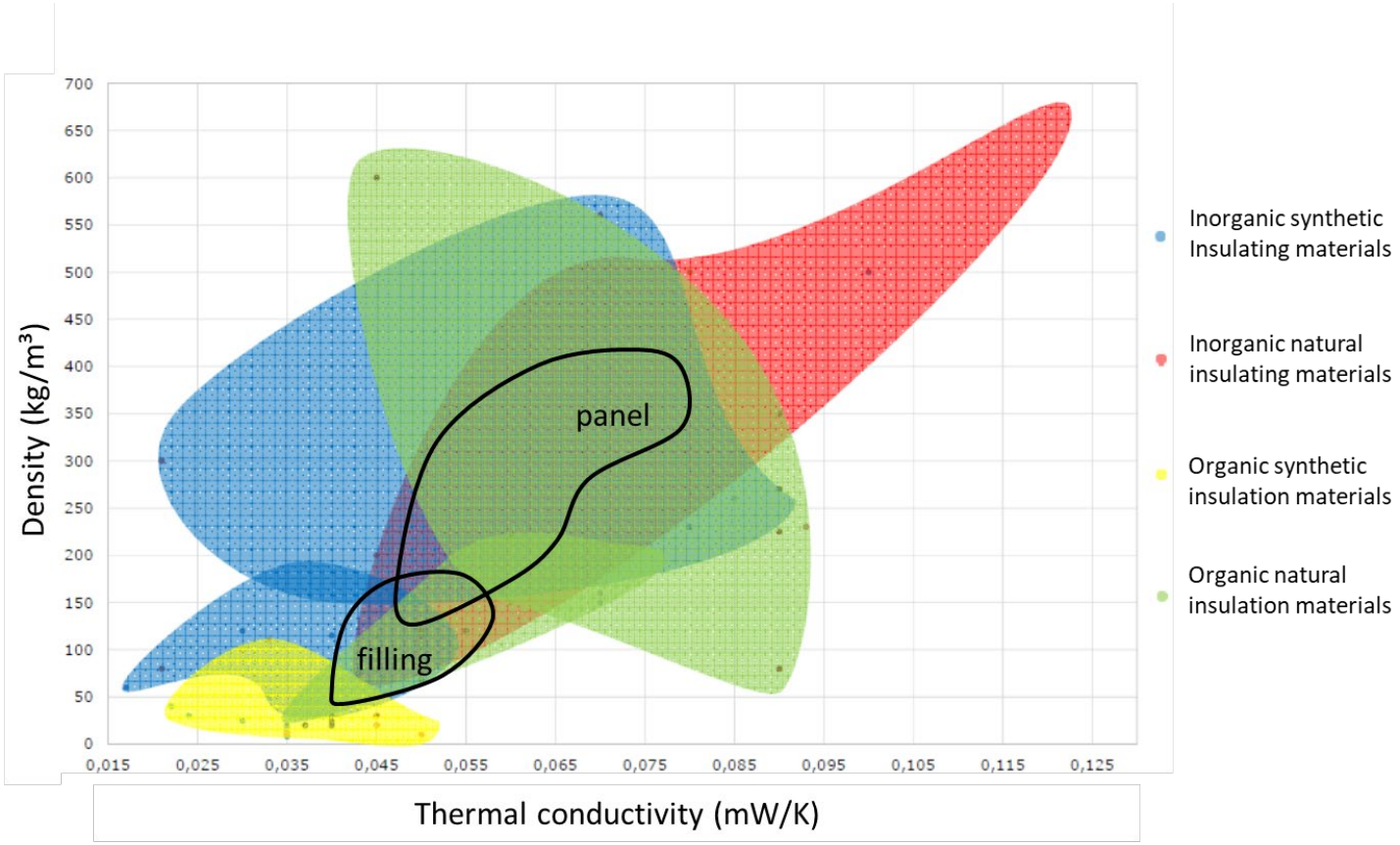
straw-based materials

- materials from various plant species
- cutin layer (waxes) has drawbacks
- different pre-treatments for material development
- investigation for two applications
  - bulk material (blow-in insulation)
  - panel production (3 adhesives)



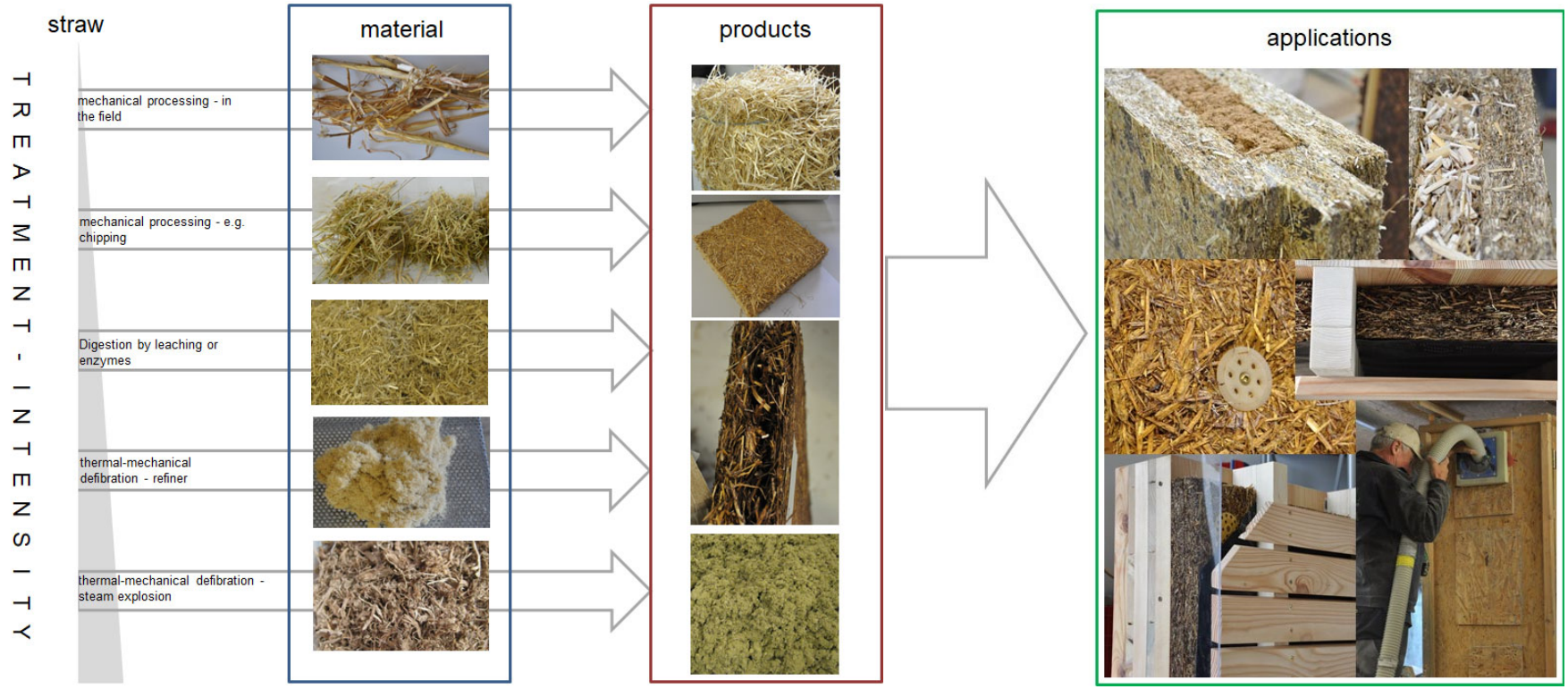
Raw materials of maize with different treatments: a) chopped and b) steam pressurised at macro level, respectively as well as c) chopped and d) steam exploded material at the micro level (Schnabel et al. 2019c)

thermal conductivity values of the straw-based materials



Overview of raw densities and thermal conductivities of insulation materials on the market compared to the results of the study by Nagl (2015) (Schnabel et al. 2020)

overview of possible applications of the straw-based materials



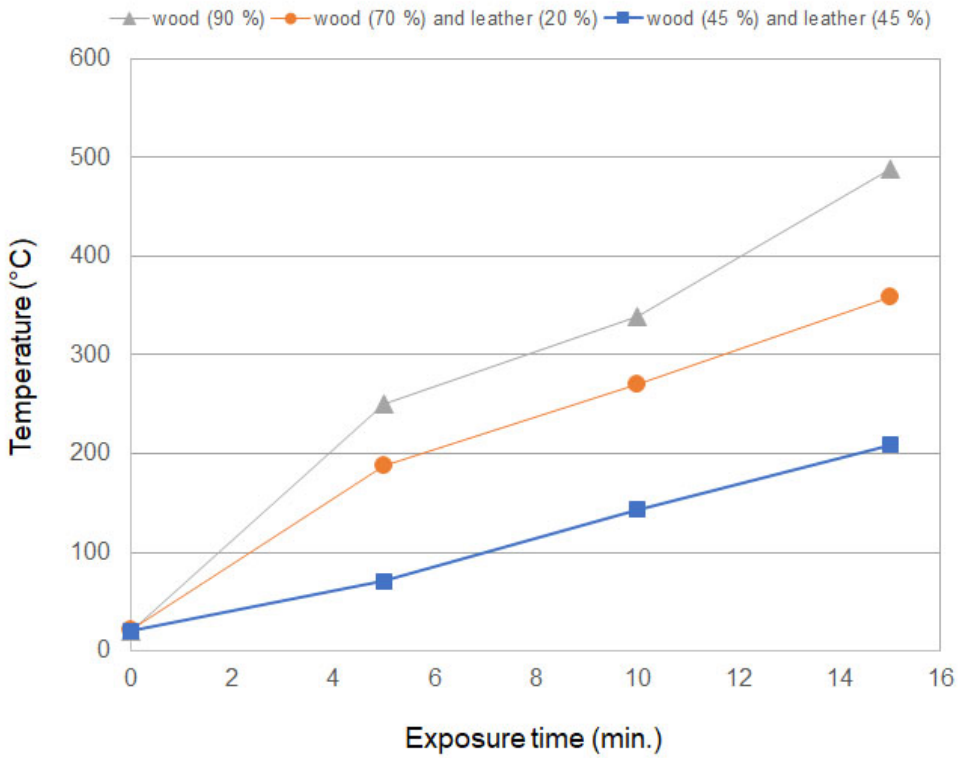
Overview of the feedstock and their possible products as well as possible applications (Schnabel et al. 2019)

leather shavings as new raw material fire resistance fibreboard

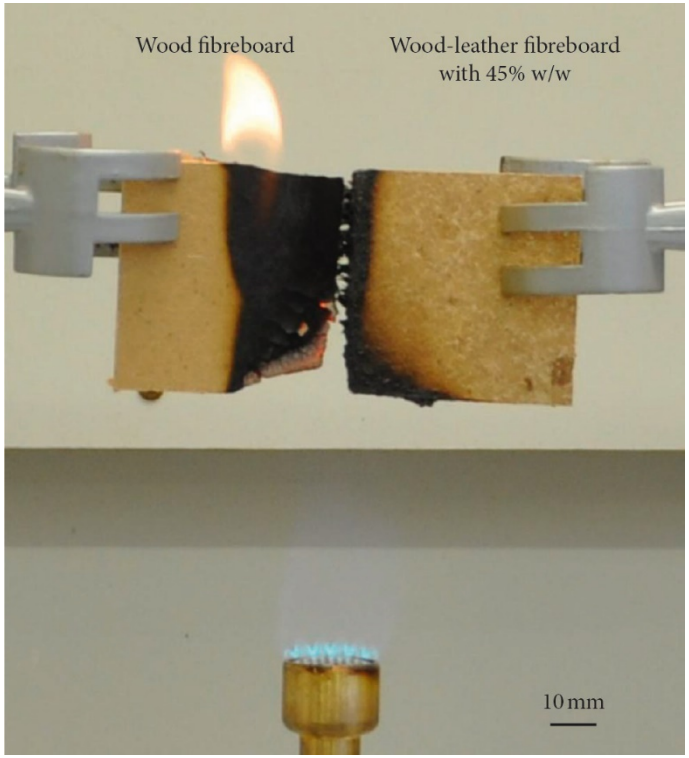
- by-products from the tanning industry
- difficultly landfilling or combustion (e.g. 200,000 tons per year)
- comparable to wood properties regarding the moisture absorption

Leather (wet blue (chrome) and wet white (tannin)) and wood resources of the composite materials (Solt et al. 2015)

extraordinary properties of leather-wood fibreboard



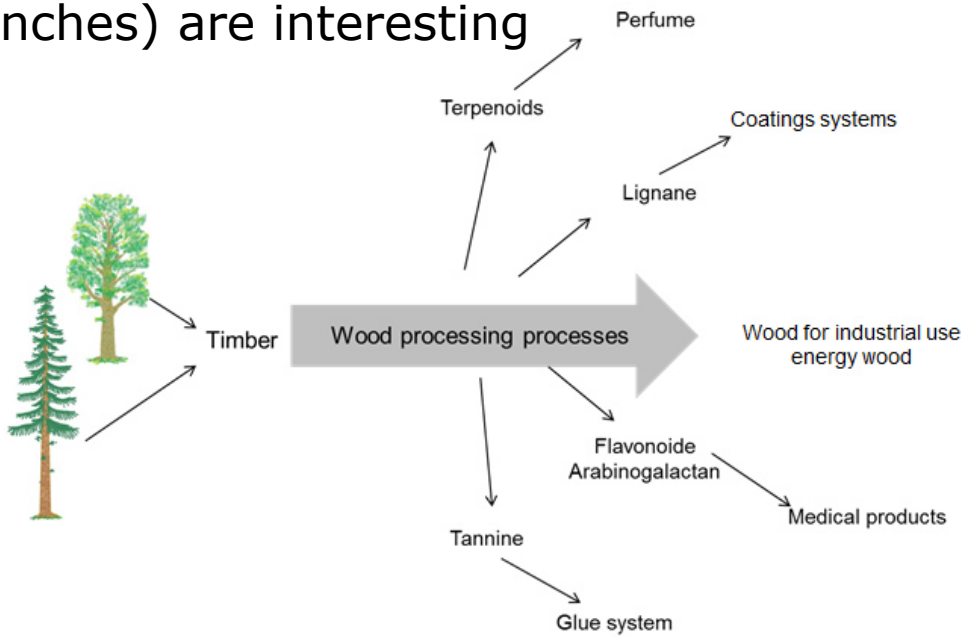
Temperature curve of different wood-leather fibreboards at 1 mm under the surface, which exposure with 50 kW/m IR lamps (Schnabel 2015)



Combustion test of wood (left) and wood-leather (right) fireboard by using a Bunsen burner (Schnabel et al. 2019b)

plant extractives – various applications

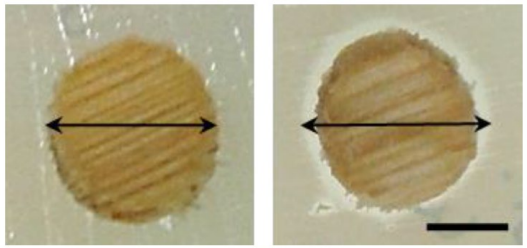
- great potential for products in other sectors
- extracts are used for cosmetics, food supplements and animal feed
- bark and knotwood (branches) are interesting



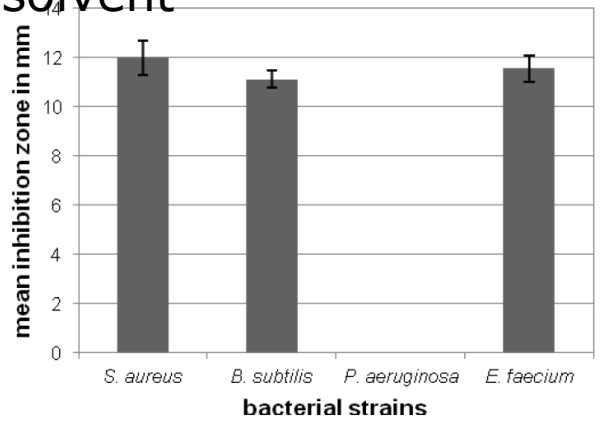
Holistic approach of the biomass usage (Schnabel 2016)

antimicrobial effects of wood and wood extractives

- wood has passive and active effects
- differences between the used solvent
- polyphenolic compounds

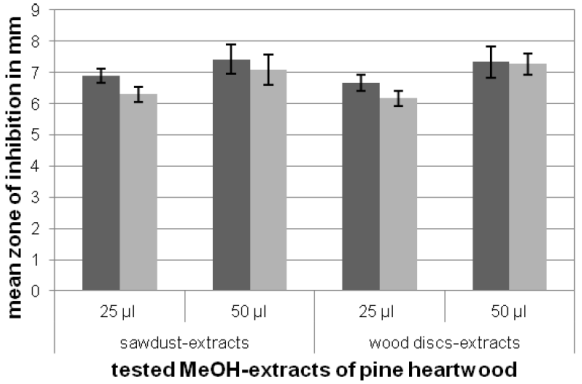


Representative photographic results of the effects of pine sapwood (left image) and pine heartwood (right image) on the growth of S. aureus. Arrows indicate the measured diameter for indicating the inhibition zone (Laireiter et al. 2014)



Zones of inhibition caused by exposing the four bacterial strains to pine heartwood (Laireiter et al. 2014)

pine heartwood



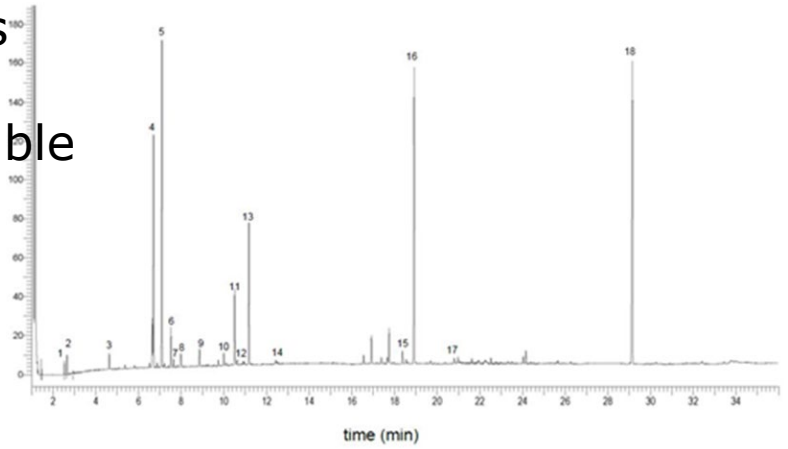
Results for the analysis of inhibitory zones of two bacterial strains with MeOH-extracts of pine heartwood at different concentrations (Laireiter et al. 2014)

E. faecium

B. subtilis

condensate from wood processing

- water from drying or steaming process
- different extractive contents are available
- various compounds were found



GC chromatogram of a condensate obtained from the steam treatment process of larch and spruce (Wagner et al. 2018)

Preparation of different condensate samples for further analysing

wood species	solid content (mg/ml)	total phenolic content (µg/ml) GAE
spruce	0.15	35.87
fir	0.763	126.02
larch	6.05	1000.00

Total extractive and total phenolic content of different condensate samples (Wagner et al. 2018)

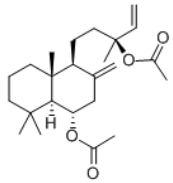
knotwood – differences of extracts

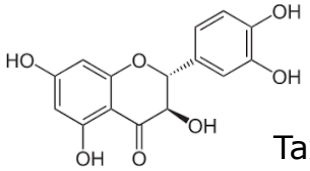
A huge amount of possible recourses of wood chips from saw mill industry

One example of a larch wood chip with a sound knot and the intact connection between knot and steam wood, and a larch wood chip with a dead knot and the inclusion of bark as well as oxidized resin (Wagner et al. 2020)

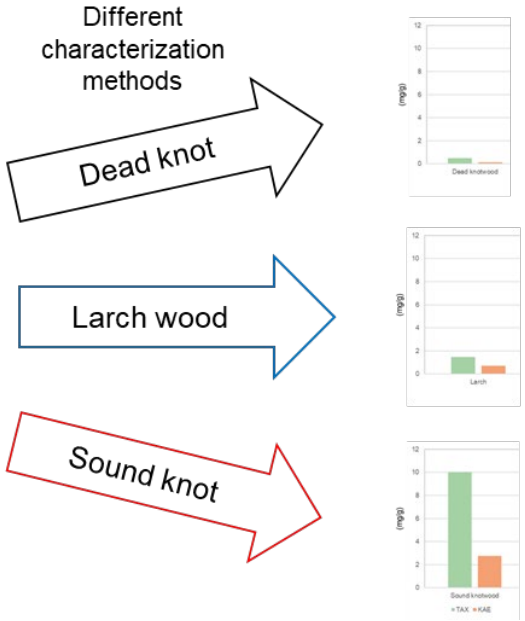
Larch wood chips

Larixol





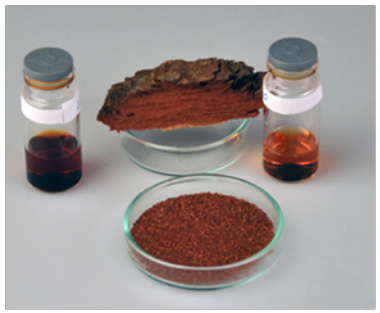
Taxifolin



Sound knotwood can provide a greater extraction yield than dead knotwood, and larch wood (Wagner et al. 2020)

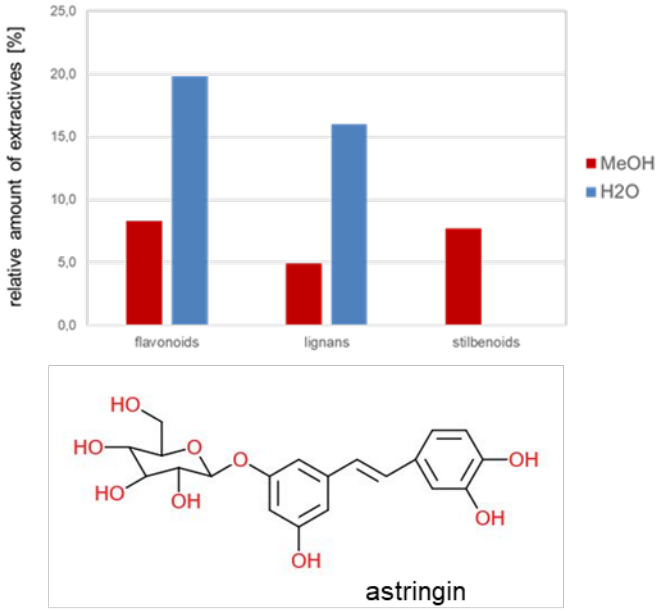
bark extractives – potential resources

larch bark extractives with water and methanol



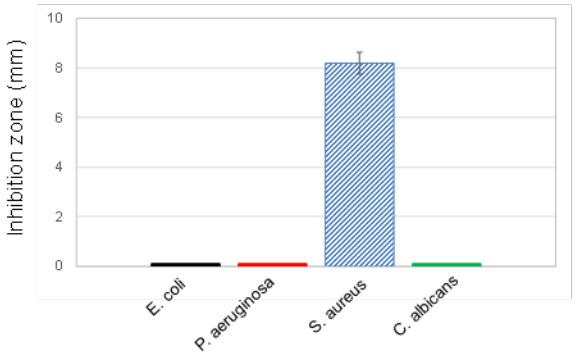
water and methanol extracts were investigated

main difference of polyphenols



results from the CG-MS analysis of the water and methanol larch bark extracts

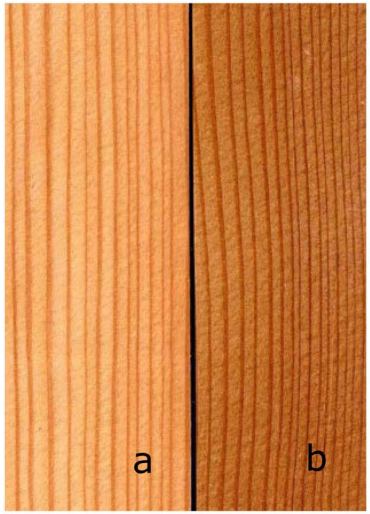
antimicrobial effects of MeOH extract



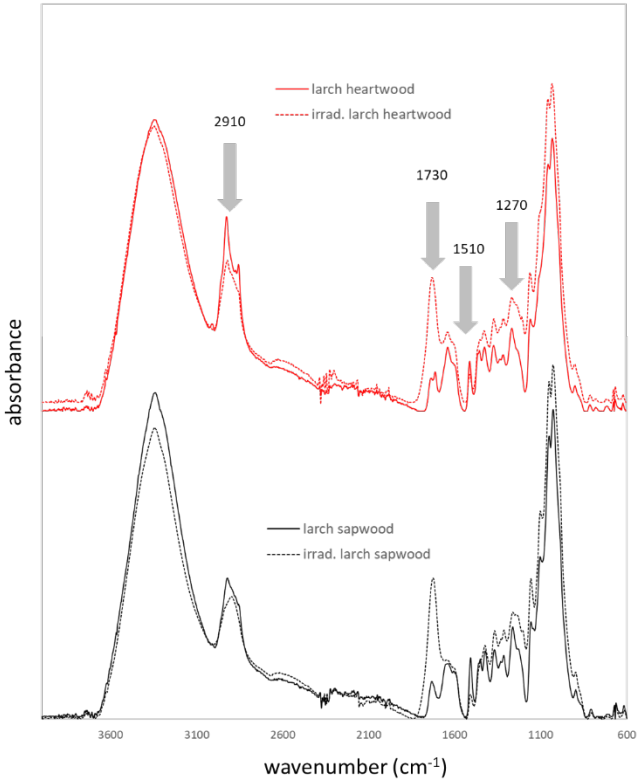
inhibition zones caused by exposure of four selected test microorganisms to larch bark methanol extracts

(Wagner et al. 2019)

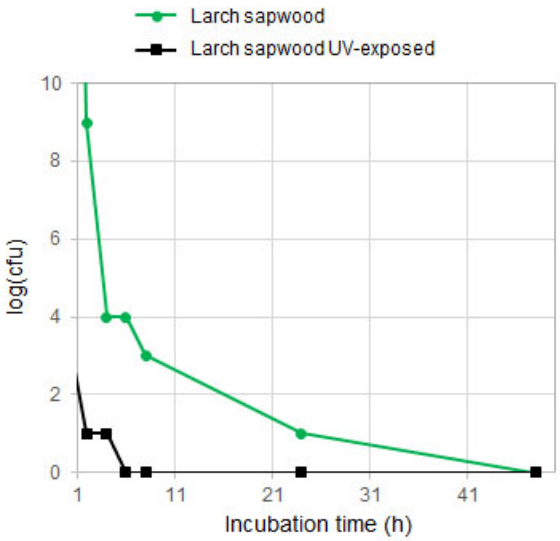
aging of wood materials



Larch heartwood samples before and after the light irradiation



FT-IR spectra of unirradiated and 20 h UV-light irradiated of larch sapwood and heartwood (Wagner et al. 2021)



CFUs development of K. pneumoniae without and after the ageing process (Wagner et al. 2021)

future research and academic activities

- transformation of the by-products to high value-added products
- fostering the circular and bio-economy concepts
- transformation of research results to industry
- involvement of the students in these activities
- modulations of e-learning concepts for distance learning
- increasing the network between research, business and academia

summary

- bio-based materials and products have interesting properties
- new applications of bio-based products were investigated
- possible transformations of the by-products to high value-added products were shown
- implementations of circular and bio-economy concepts were analysed
- new thinking for material, products and processes is needed

Transilvania University of Brasov
FACULTY OF WOOD ENGINEERING

FH Salzburg
Holztechnologie & Holzbau

Thank you for your attention!

Transilvania University of Brasov

FH Salzburg