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Multi-blade shaft milling for preserving the native structure of milled products

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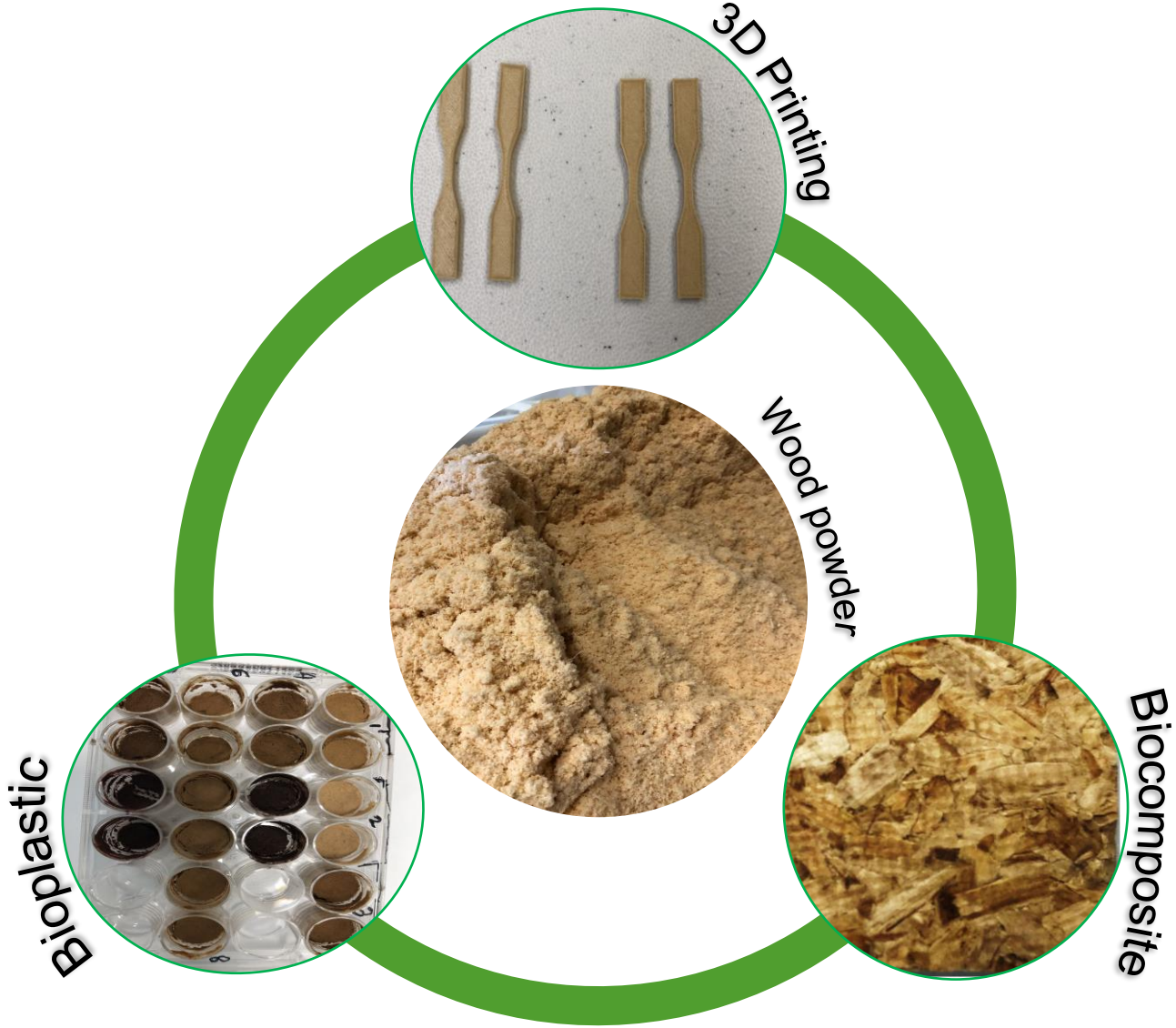
Presentation outline

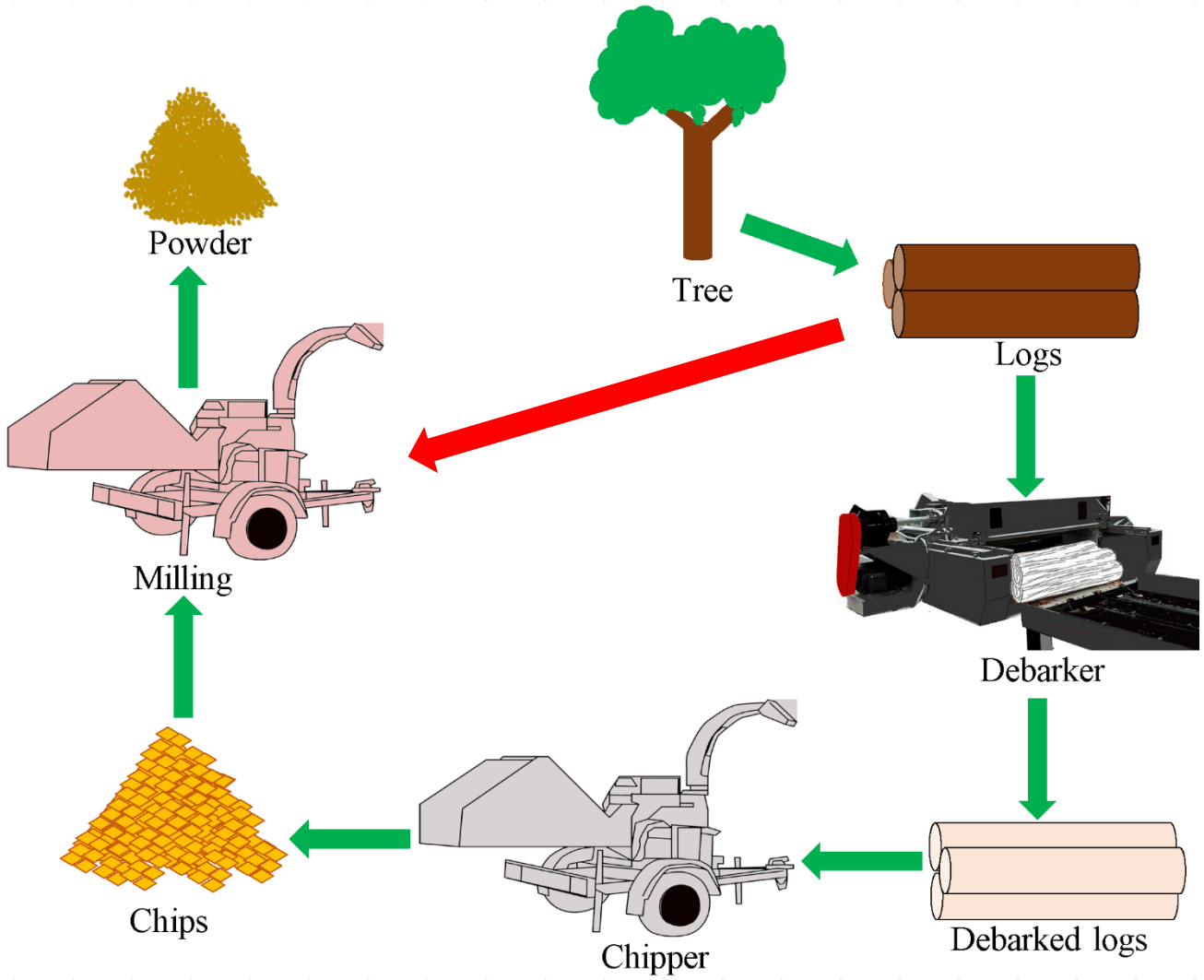
- Background
- Objectives
- Materials and methods
- Results
- Conclusions

Wood powder applications



- Value-added products
- Replacing fossil-based feedstock
- Bioeconomy

Conventional powder production



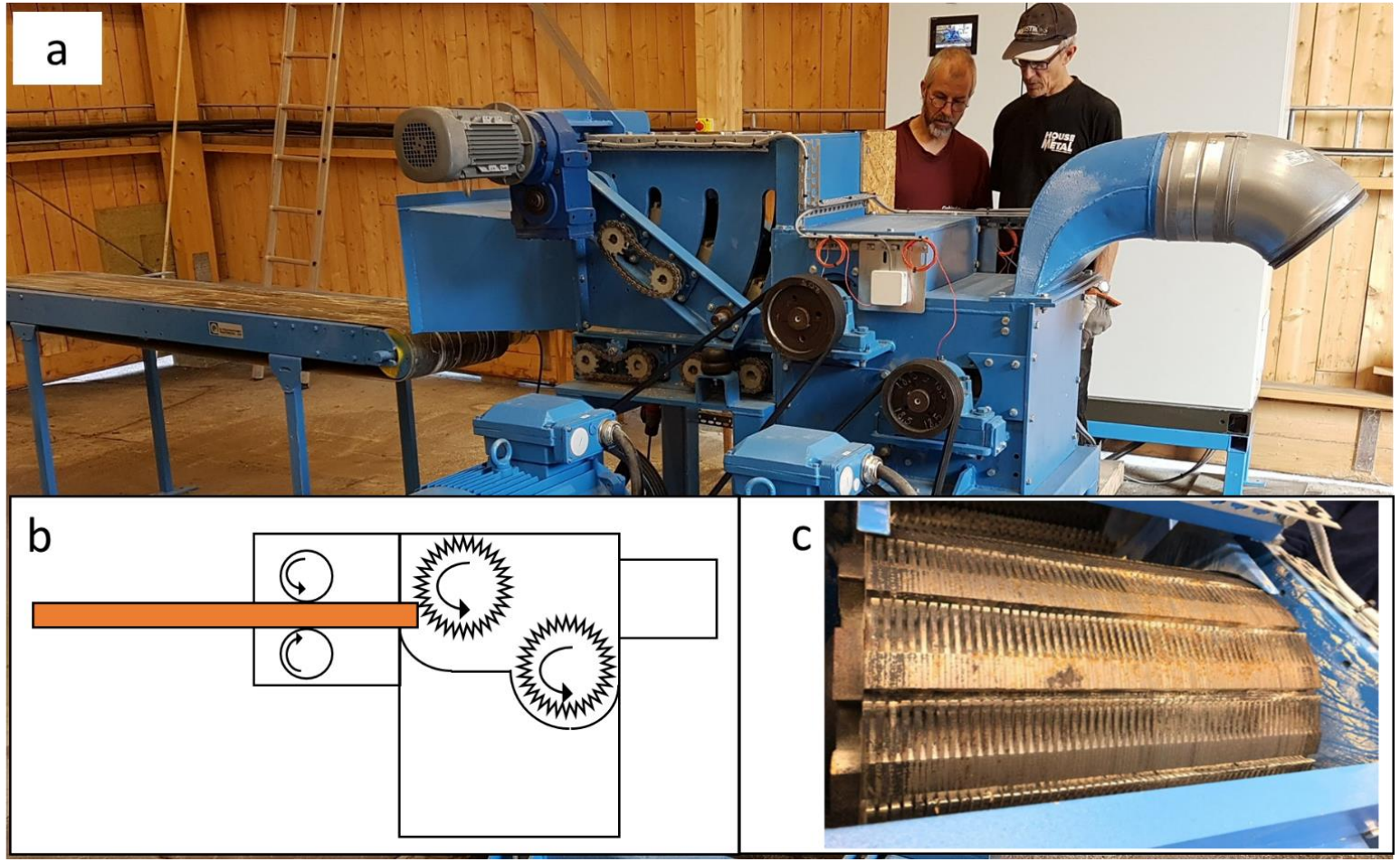
- Hammer mills common
- Relies on wood chips
- Pre-drying needed
- Impact and shear forces

Objectives

- To determine the specific surface area
- To analyse the influence of the mill on wood cellular structure
- To investigate extractives distribution

Materials and methods

Multi-blade shaft mill (MBSM)

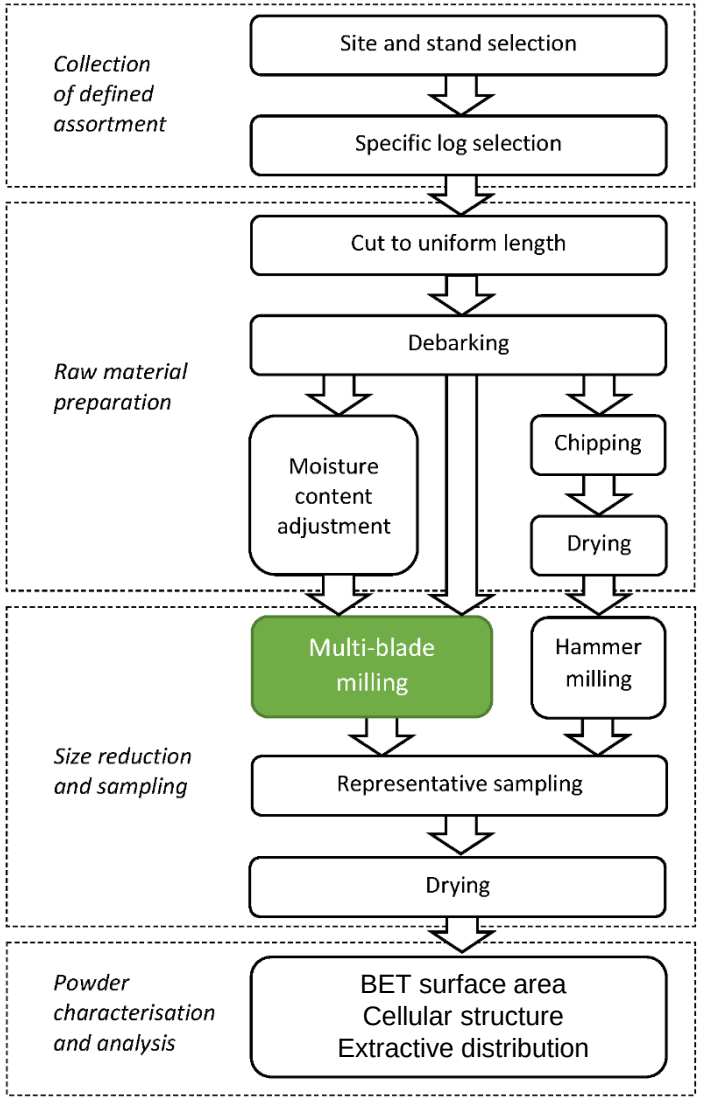


- Biomass Technology Center
- MBSM Prototype (a)
- Principle of operation (b)
- Multi-blade shaft (c)

Operational parameters

- Three factors
  - Wood moisture content (MC)
  - Feeding speed (FS)
  - Blade speed (BS)

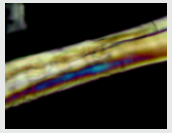
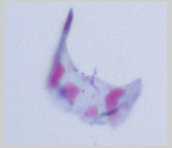
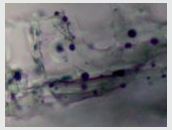
An overview of the experimental procedure



Sample preparation and analyses

- Systematically coning and quartering sampling
- Brunauer-Emmett-Teller (BET) surface area

Light microscopy (LM) - histochemical techniques

Stain	Detection	Example
Saffranin	Surface and fibre properties	
None	Micro-structural deformation by polarized light microscopy	
Nile Blue	Triglycerides as red/pink	
Sudan black B	All lipids as blue-black	
Osmium tetroxide	Unsaturated fats as black	

- Worked at Wood Science Division, Uppsala

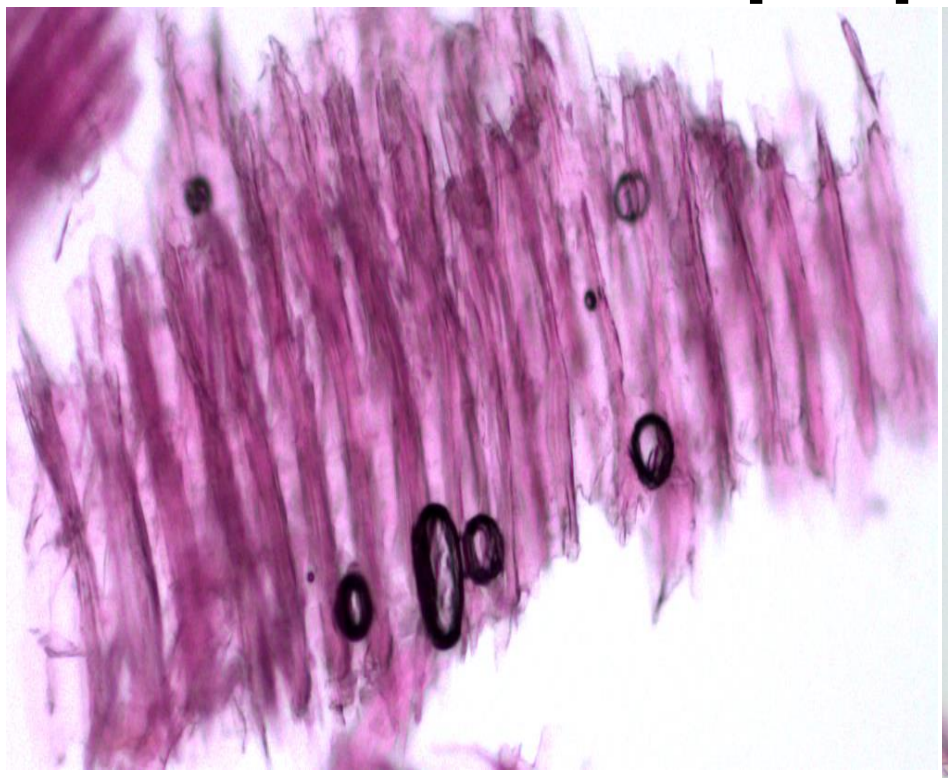
Results

BET Surface area and porosity

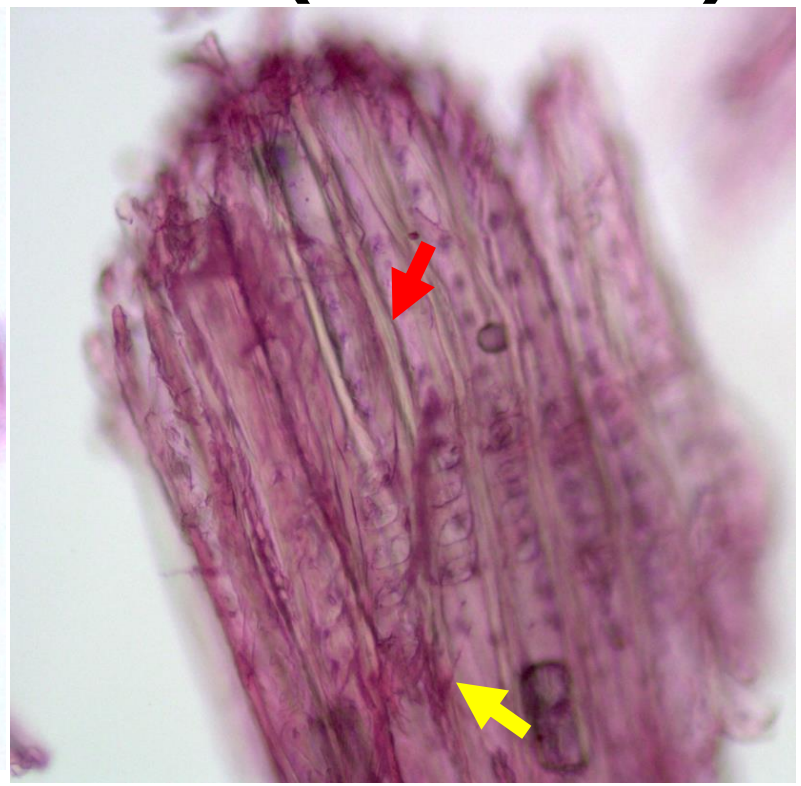
Sample description	BET specific surface area ($m^2\ g^{-1}$)	Pore volume ($cm^3\ g^{-1}$)	BET surface area generation ($m^2\ kWh^{-1}$)
MBSM, green wood	1.378	0.002759	6981
MBSM, dry wood	0.5573	0.001035	2826
Hammer mill	0.4291	0.001037	4990

- Green milling is most interesting

Surface and fibre properties (Saffranin)



MBSM



Hammer mill

- MBSM: smooth surface, less/no fiber defibration and fibrillation
- Hammer mill: fibre defibration (red arrow) and fibrillation (yellow arrow)

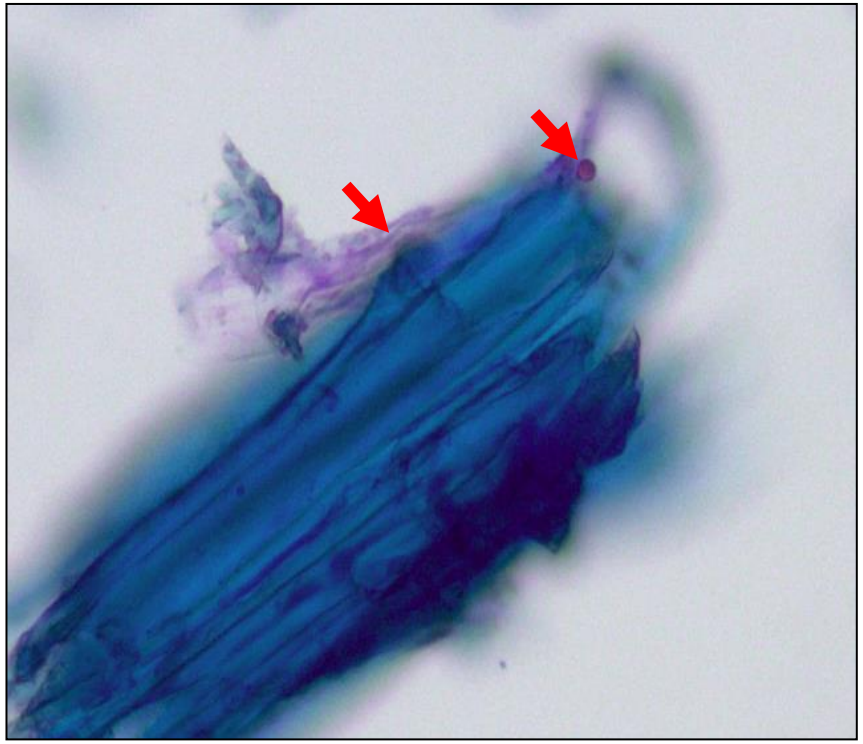
Micro-structural deformation (polarized LM)

MBSM

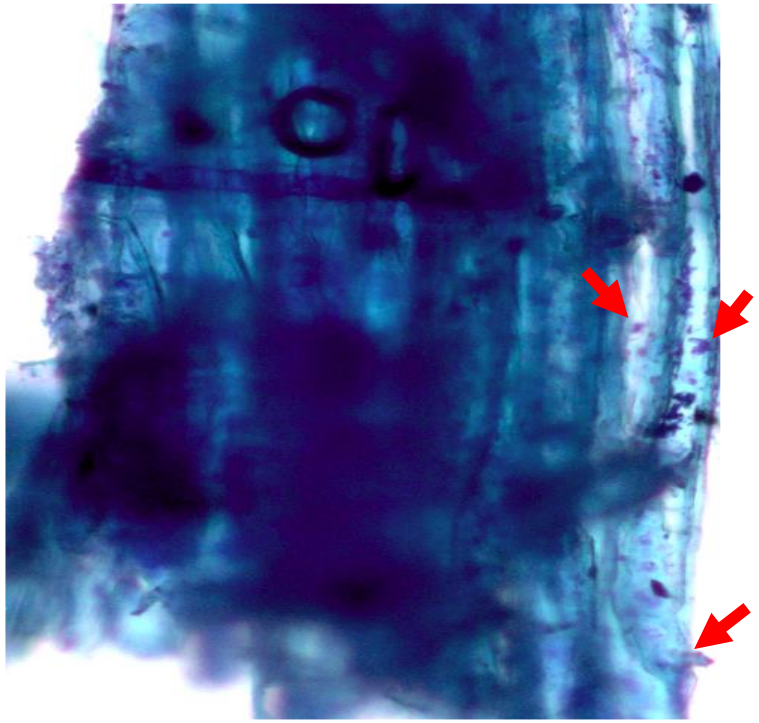
Hammer mill

- MBSM: continuous, sharp and much less disrupted brightness
- Hammer mill: disrupted brightness (red arrows) likely indicates deformation/damages to the crystal structure of their cellulose fibrils and clear buckling effect

Triglycerides (Nile blue)



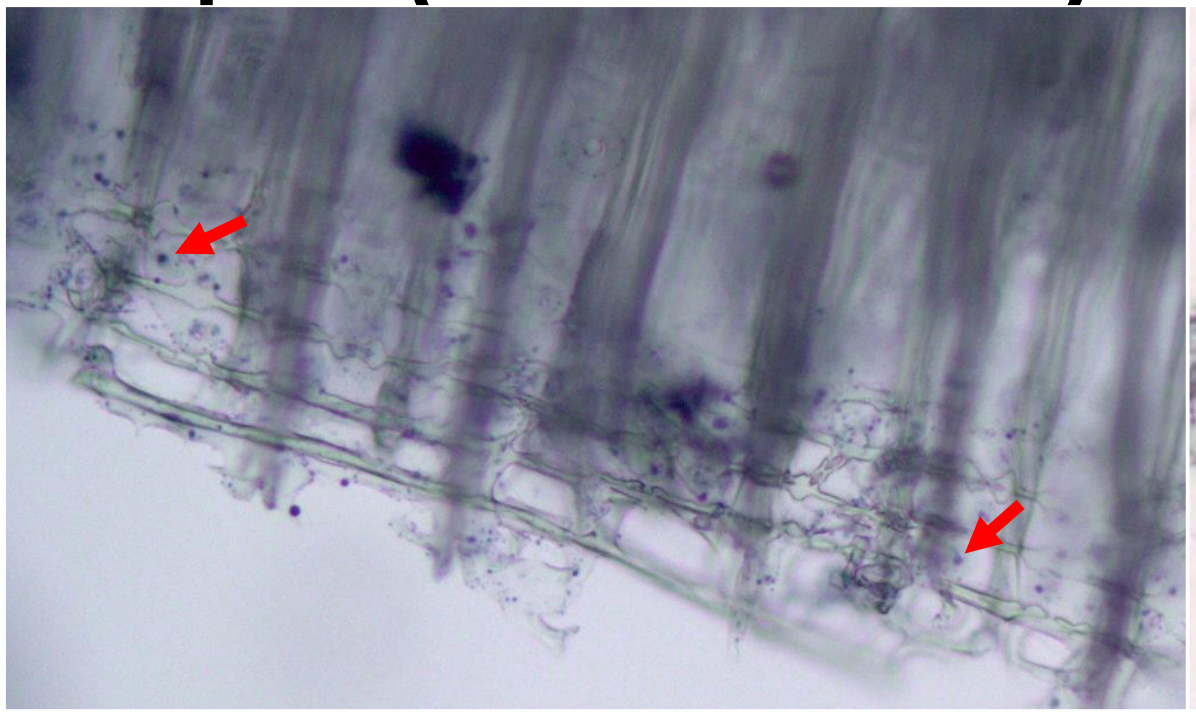
MBSM



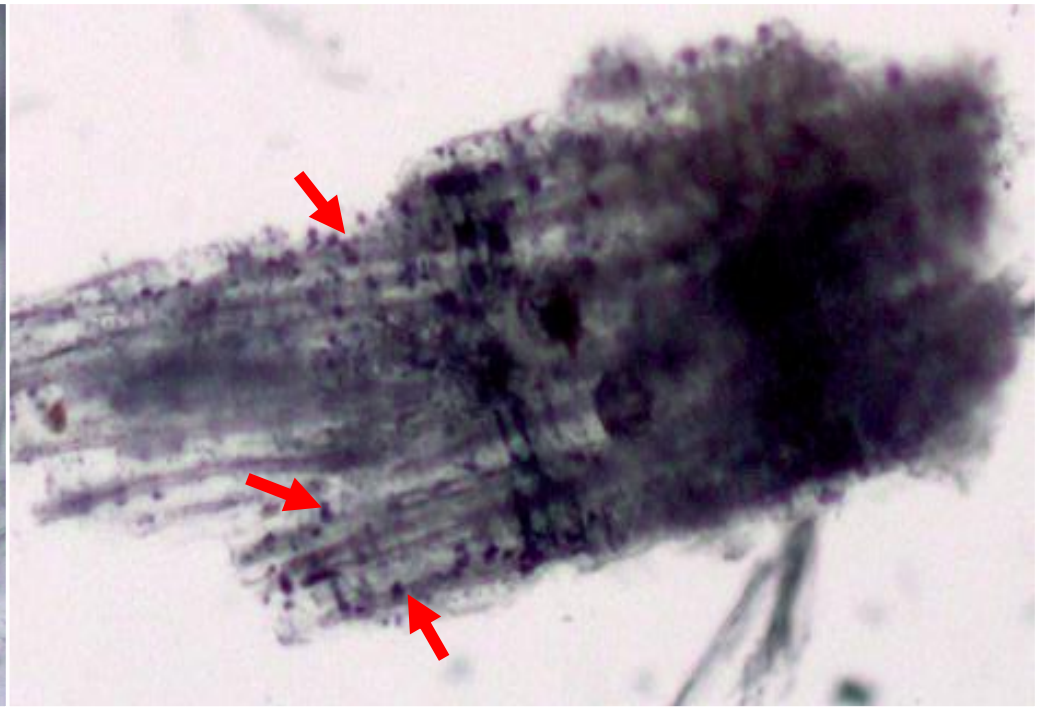
Hammer mill

- MBSM: micro-distribution/redistribution of triglycerides in cell wall material (red arrows)
- Hammer mill: spread out on the particle surface (red arrows)

All lipids (Sudan black B)



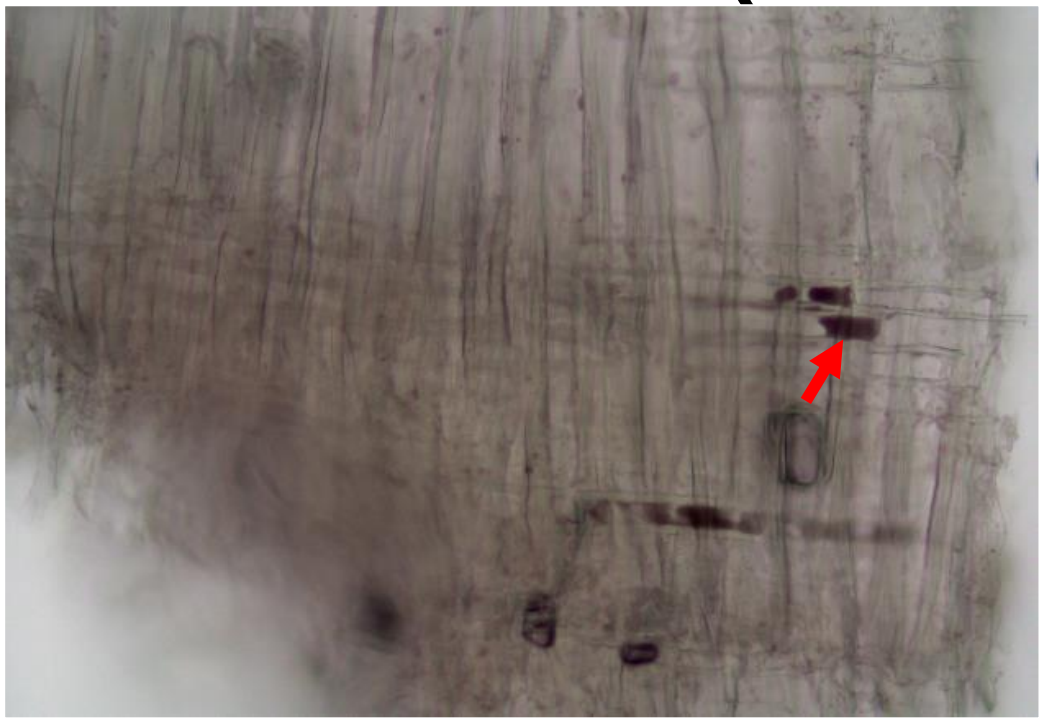
MBSM



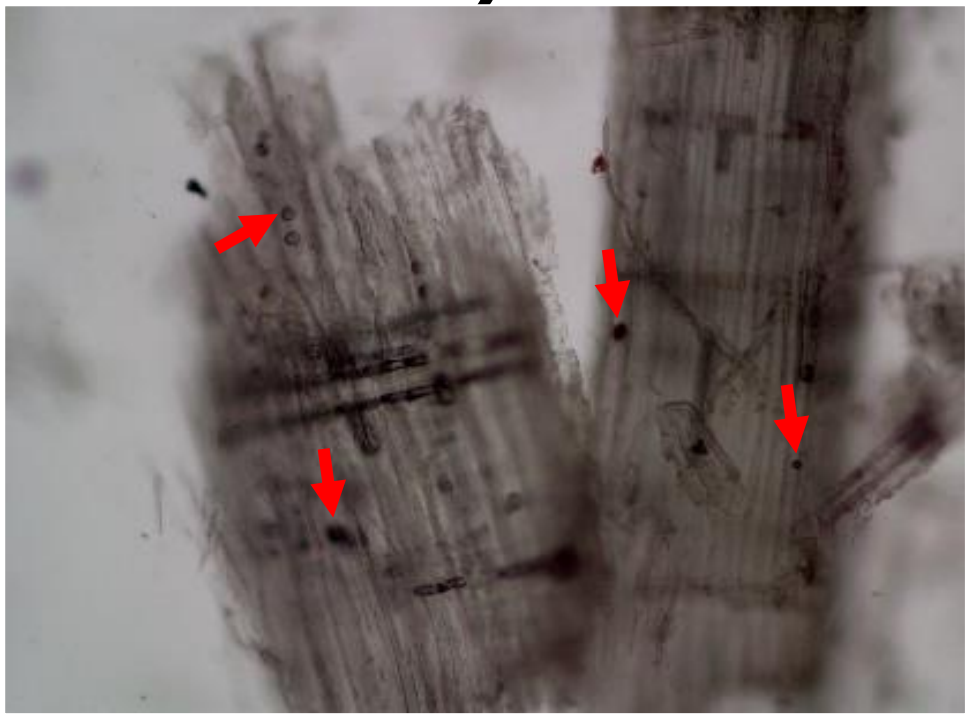
Hammer mill

- MBSM: all lipids (blue-black staining; red arrows) in ray regions (red arrows)
- Hammer mill: dispersed more over particle surfaces (red arrows)

Unsaturated fats (Osmium tetroxide)



MBSM



Hammer mill

- MBSM: unsaturated fats (black staining; red arrow) in parenchyma cells
- Hammer mill: dispersed more over particle surfaces (red arrows)

Conclusions

- MBSM powder had comparatively higher smooth surface
- Fibre cell walls of MBSM powder possibly retain their native crystalline structure
- Hammer mill powder showed some deformation/damages of fibre cell walls
- Fiber defibration and fibrillation were observed more with hammer mill powder
- Extractives were in parenchyma cell or ray regions for MBSM powder
- These were spread out on the surface of hammer mill powder

Thank you for your attention

Swedish Energy Agency

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