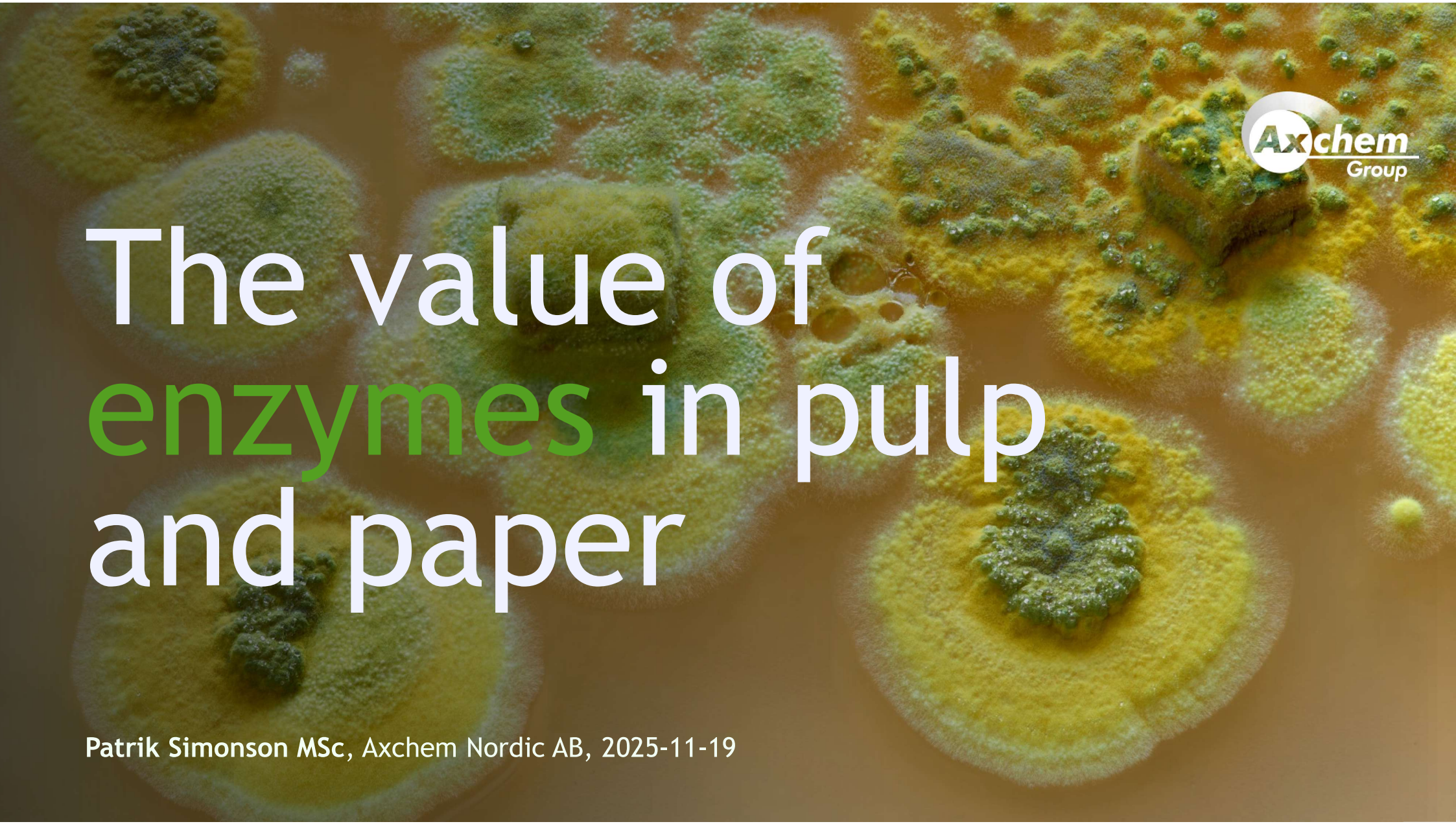


The value of enzymes in pulp and paper

Patrik Simonson MSc, Axchem Nordic AB, 2025-11-19

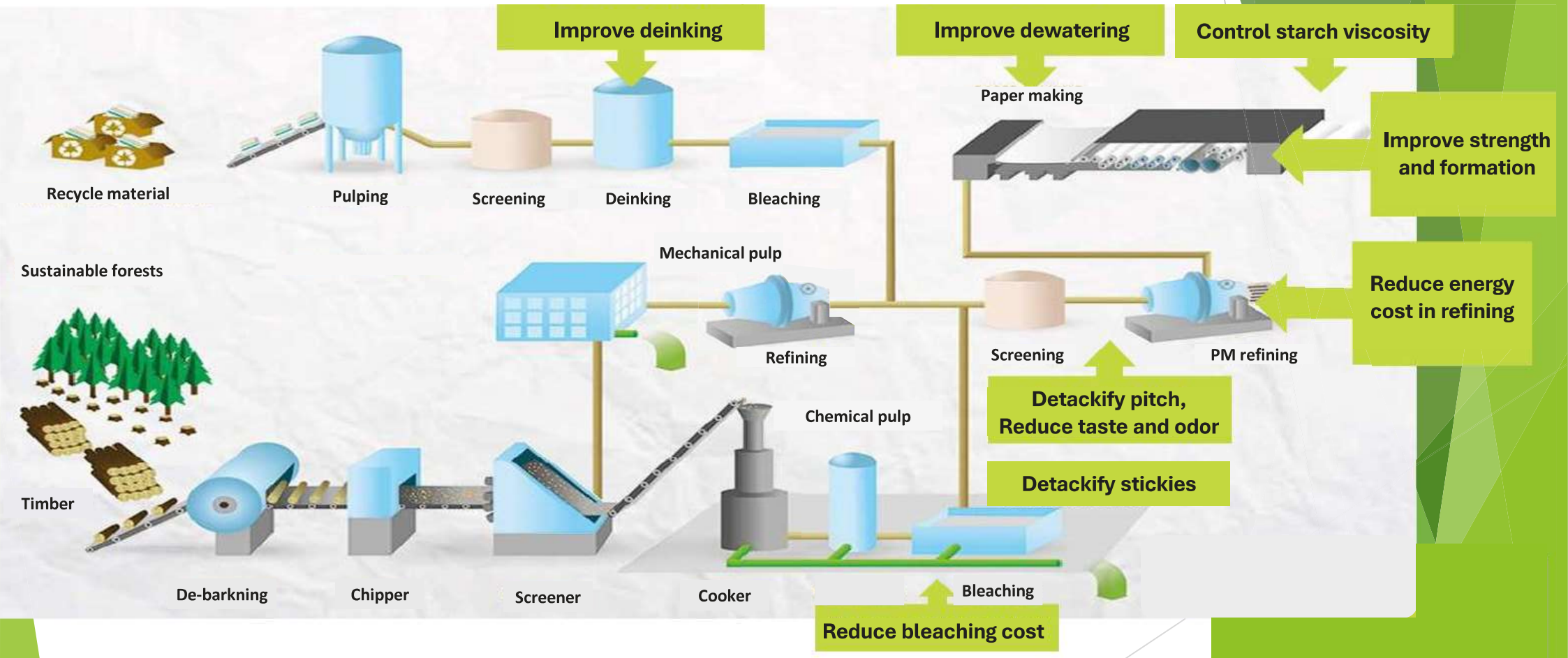
Agenda

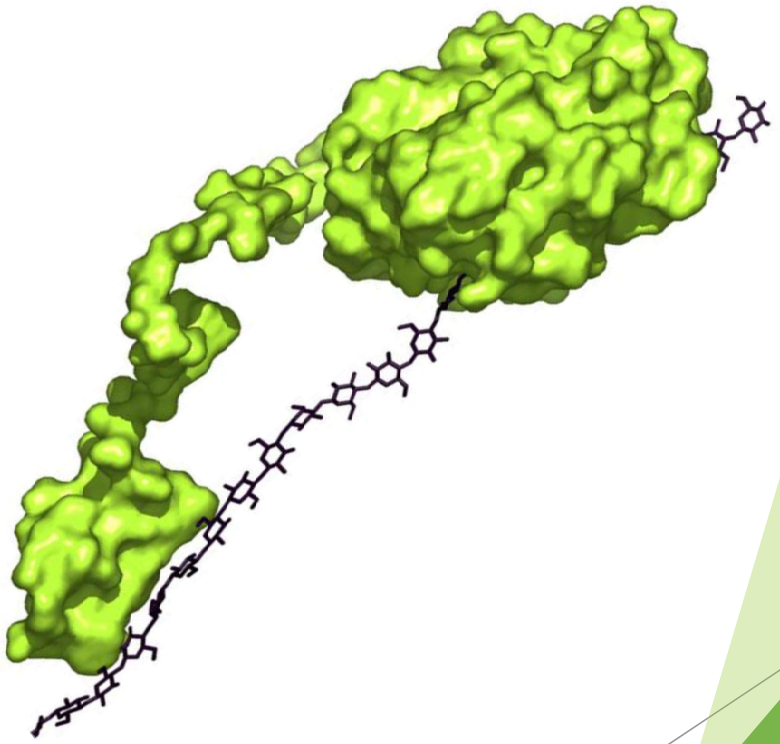
- Trends in our industry:
  Enzymes can play a role
- Some enzyme basics
- Enzymes at work
  - Cellulase
  - Xylanase
  - Lipase
- Perspective

Global trends where enzymes can play a role

Key trend	Role of enzymes
Rising sustainability & compliance pressure	Enzymes can reduce environmental impact, produce more with less & enable circularity
From plastic to fiber-based packaging	Enzymes enhance fiber bonding, recyclability & overall product and sustainability performance
Growing tissue demand & quality expectations	Enzymes enable mills to produce higher-quality tissue more efficiently
E-commerce continues to grow	Enzymes help mills create stronger, more durable packaging to support this growth

Multiple functions in P&P





But what are enzymes?

Dependent on process conditions	Drive reactions in all living cells	Protein molecules
Catalysts	Fully biodegradable	Not living organisms
One enzyme = one reaction	Not hazardous	Not an additive, change the substrate

Process conditions and…..

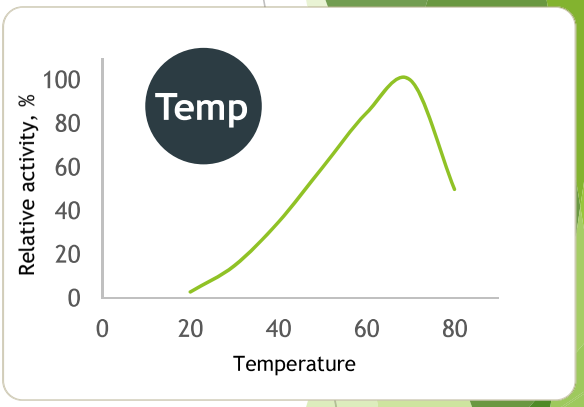
The enzyme molecule

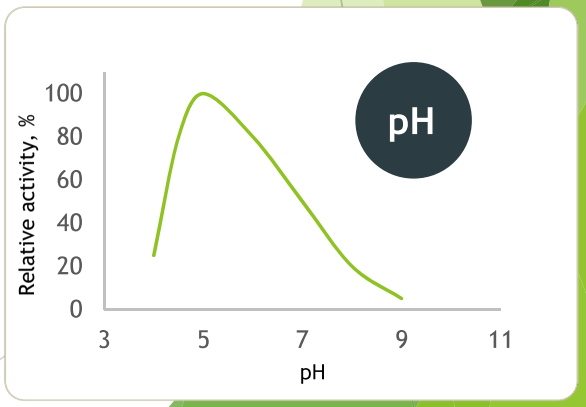
- 200-500 amino acids
- Compact 3D-structure
- Globular D = 5-10nm
- MW 10-100 kDa
- Active on surface of substrate

Factors influencing enzyme functionality

- Temperature
- Conductivity
- pH
- Dose level
- Contact time

*Example on **pH & temp optimum** for one enzyme*





P&P ENZYMES

Cellulase
Strength provider and energy savings

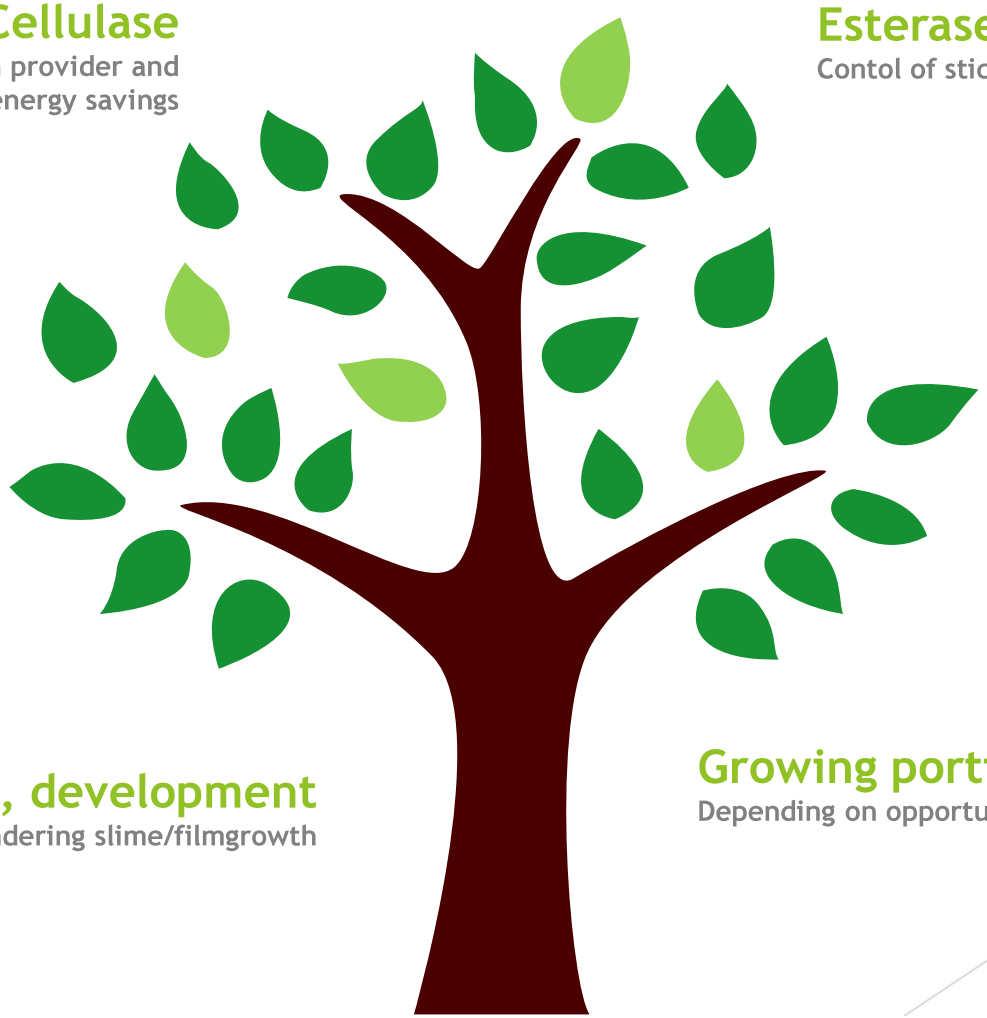
Esterase
Contol of stickies

Amylase
Viscosity control of starch

Lipase
Control of pitch, reduction of taste and odor

Xylanase
Efficiency in chemical pulp bleaching

Catalas
Quenching peroxides



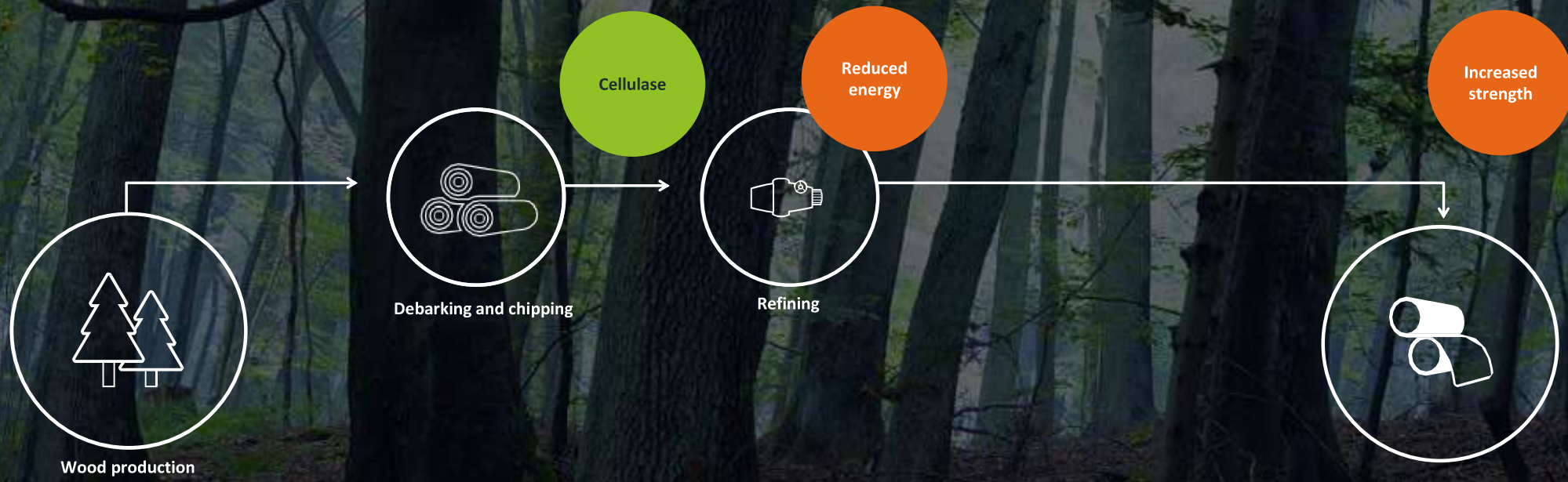
Microlife control, development
Hindering slime/filmgrowth

Growing portfolio
Depending on opportunity and need


Let’s dive into some
interesting enzymes!

Changes when using a **cellulase** in the refining process

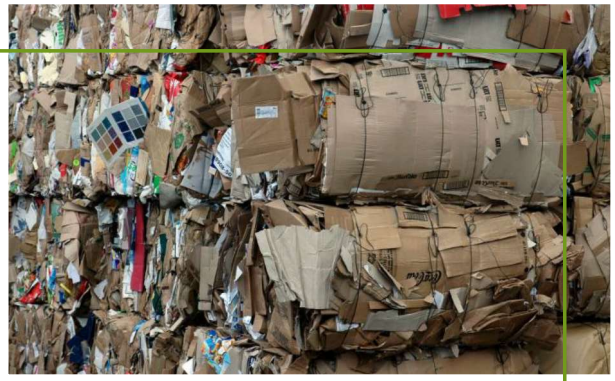
Chemical refining/energy savings/more strength/more HW fiber + filler



Enzyme Benefits

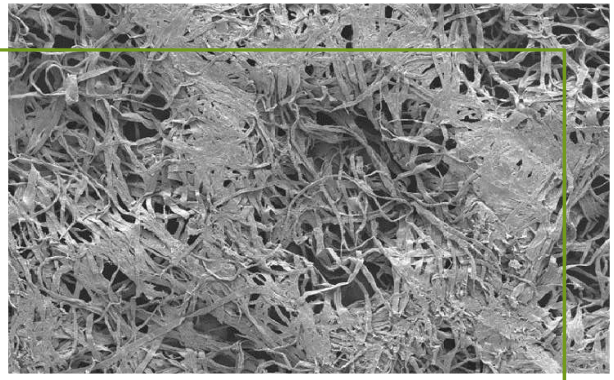
Most common objectives of enzymatic fiber modification

Enhanced refining



Fiber substitution

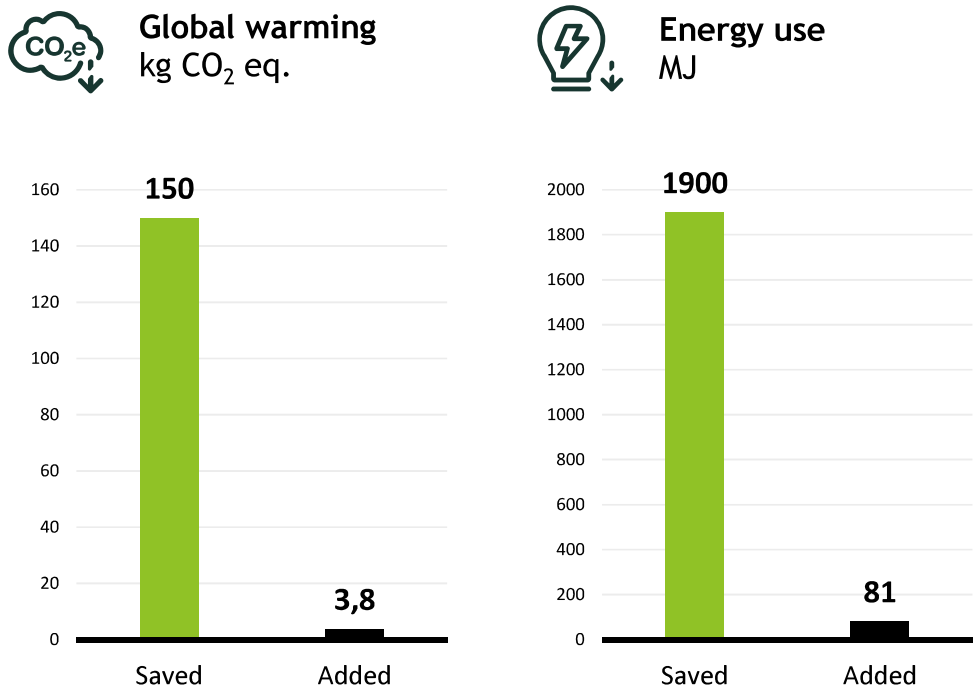
Increased production



Improved structure & strength

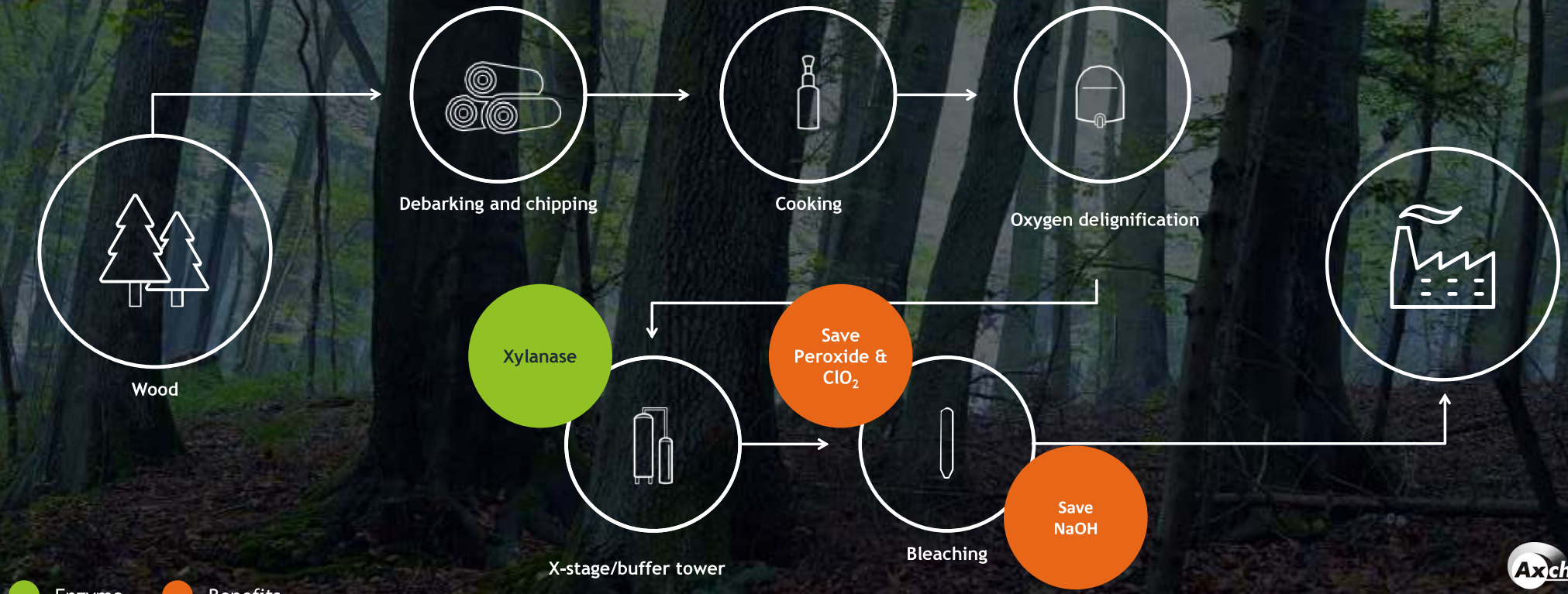
New products

Saved and added environmental impacts when using a **cellulase** for refining of one ton pulp. The start is increased strength!



Changes when a **xylanase** is used in bleach boosting

- Bleach chemical reduction and higher obtainable brightness.
- Higher kappa from cooker possible, much less brightness loss over time.

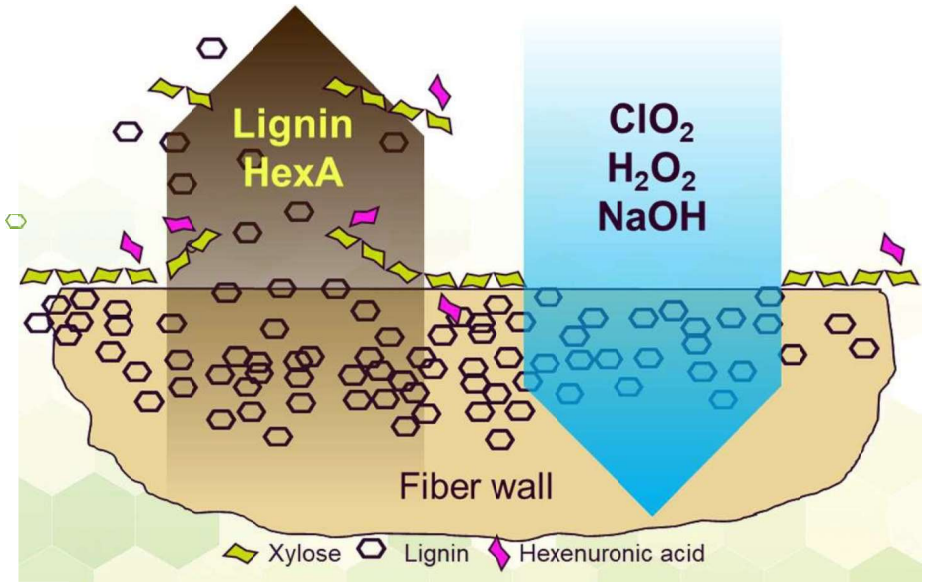


How does Xylanase work?

- In the end of the kraft cook xylan is precipitated onto the brown fiber.
- Xylanase clean the surface by breaking down the xylan backbone.
- Less bleach chemicals will be needed for required final brightness.

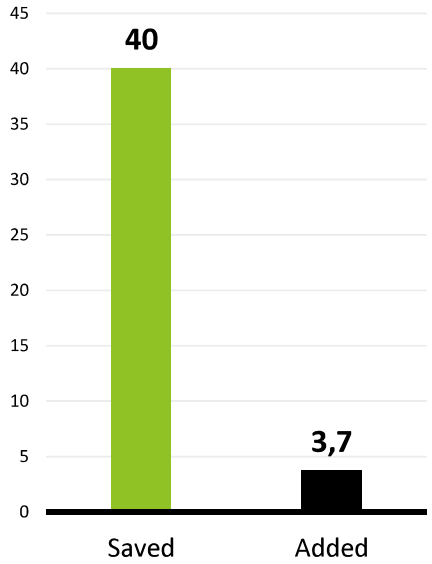
Cuts in the xylan chain:

1. Release locked lignin
2. Break complexes between fiber, lignin and xylan
3. Reduce the level of hexaneuronic acid that in return reduce needed bleaching agent
4. Bleaching chemistry will get better access into the fiber.

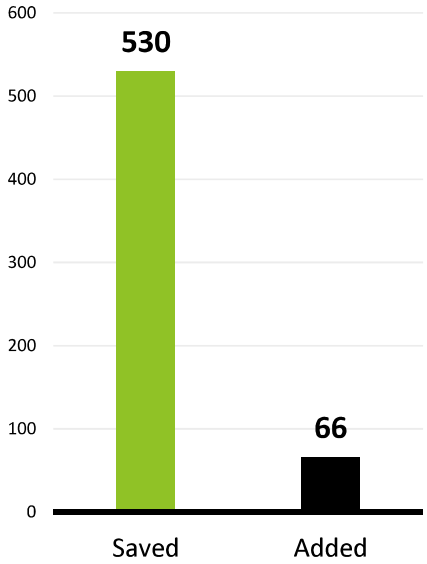


ECF bleaching aided by enzyme lets you achieve higher final brightness while cutting **chemical use by 20%+.** It helps lower emissions and reduce energy consumption

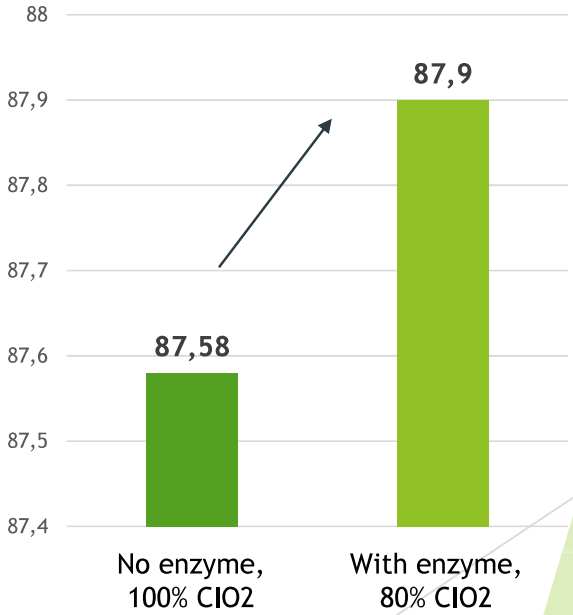
Global warming
kg CO_2 eq.



Energy use
MJ



Reduce chemical use and increase brightness



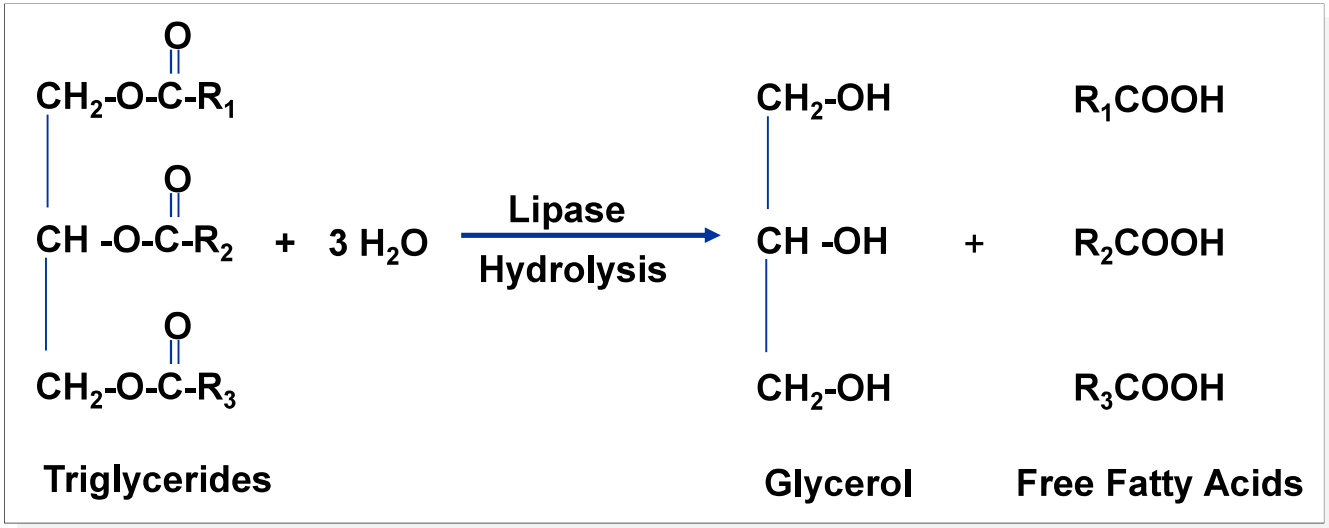
Data per ton pulp

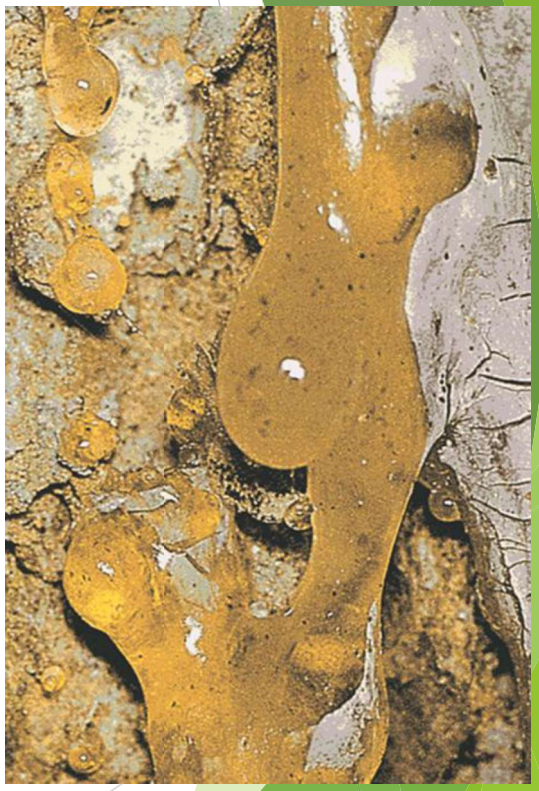
Changes when using a lipase

- Increased quality, strength, less spots and holes
- Higher run-ability / less deposits
- Reduce smell and odor carry over

Changed surfaces with Lipase

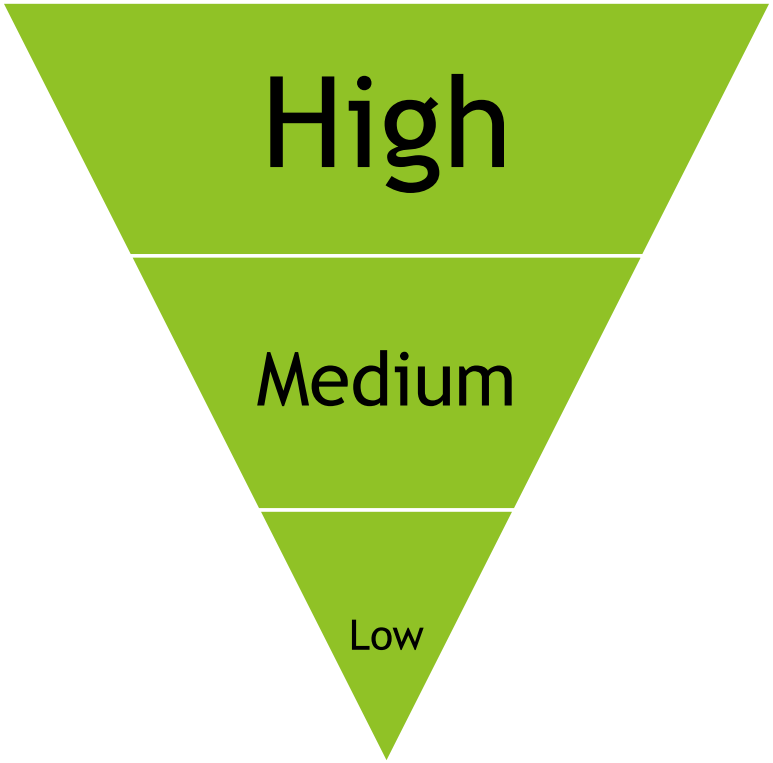
Lipase catalyse hydrolysis of ester bonds in triglycerides to form free fatty acids and glycerol.





Fiber, fines & pitch changes from being hydrophobic to more hydrophilic.
Hydrophilic pitch do not agglomerate.
Free fatty acids are water soluble and can be washed out.

Values with Lipas



- The use of more fresh chips. (TMP)
  - Less bleaching chemistry
  - Higher quality/strength
- Improved run ability on PM
  Less frequent stops for cleaning
  Less taste and odour
- Less deposits
- More
  Free fatty acids are easy to break down

Axchem Nordic

You might be wondering: If enzymes offer so many benefits, why aren’t they already the industry standard?

Enzymes 20 years ago didn't deliver…

Early enzymes were a poor fit in harsh pulp & paper conditions

Mills were forced to change conditions to fit enzymes. A cost and trouble

Negative side effects incl. reduced pulp quality, excessive COD release and increased effluent load

VS

…but today's enzymes are purer, more stable, tested & built for industry conditions

Modern enzymes can **withstand high pH and temperature**, making them robust for today's pulp and paper mills

Today's enzymes are better built for harsh **mill conditions lowering cost for chemicals**, energy and water

Today's enzymes **deliver performance without compromising pulp quality**, COD generation, effluent load or yield.

Thank you
Q&A