



BEST

Bioenergy and
Sustainable Technologies



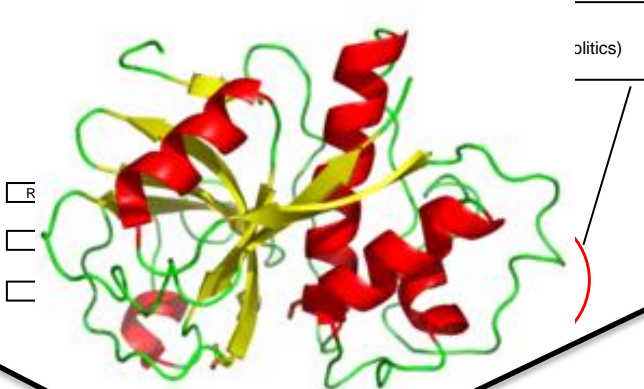
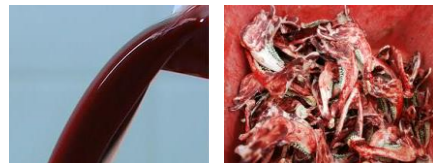
Ein Fonds der
Stadt Wien



Valorisation of industrial by-products from the pulp&paper and rendering industry

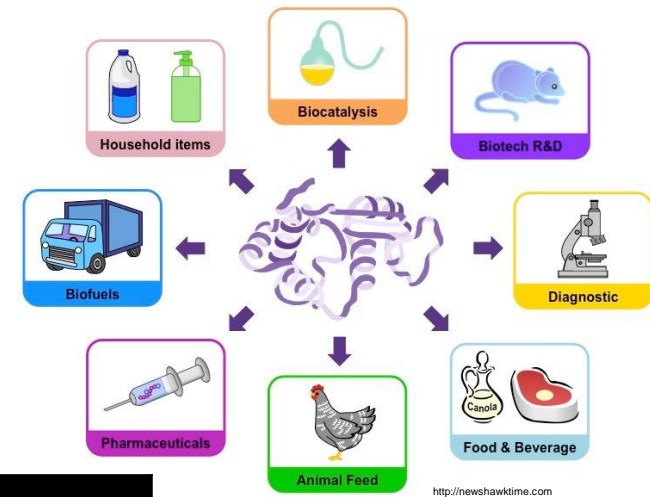
Graz, 22.1.2020

Markus Ortner

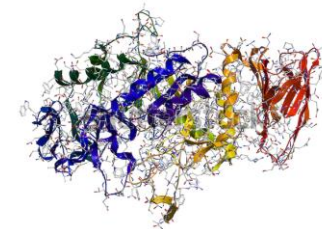
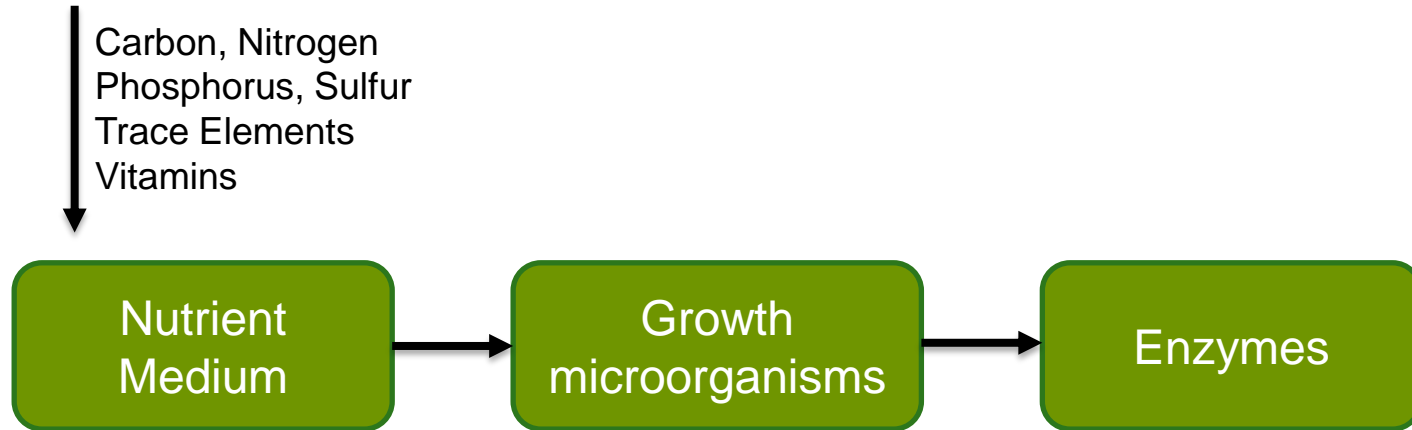


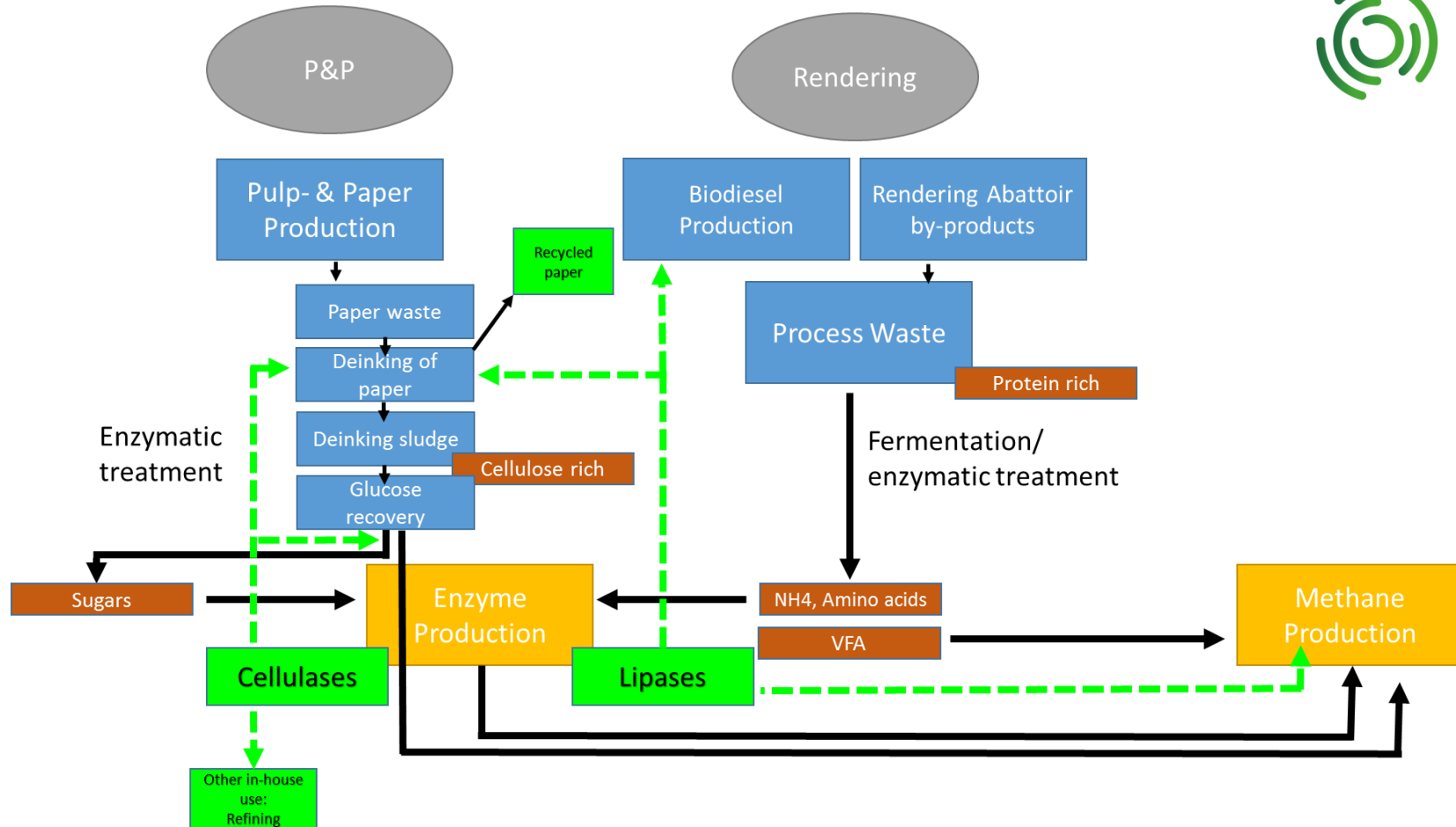
?

Technical Enzymes



Process	Enzyme	Effect
Brewery	Amylase	Sugar release
Detergent	Protease, Lipase	Degradation lipids, proteins
Cheese production	Protease	Clotting of milk
Meat Industry	Protease (Papain)	Tendering
P&P	Laccase, Cellulase, Xylanase	Pulping, Bleaching
Rendering	Lipase	Biodiesel





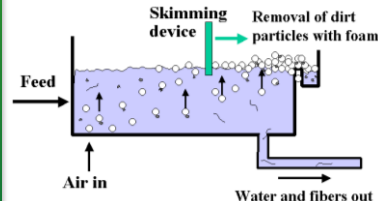


Industrial by-products – a basis for nutrient media?

• Deinking sludge (rejects)



- Fillers (CaCO_3 , Kaolin)
- Fibres
- Extractives (soluble ink, binder)
- Fines (insoluble ink, glue components)
- Heating value 7-12 GJ/t



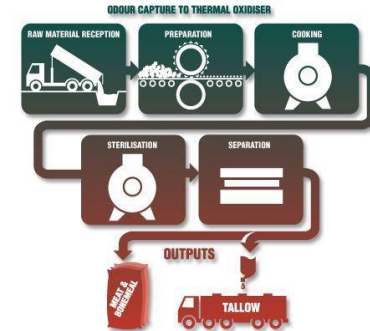
Carbon rich



• Slaughter Blood

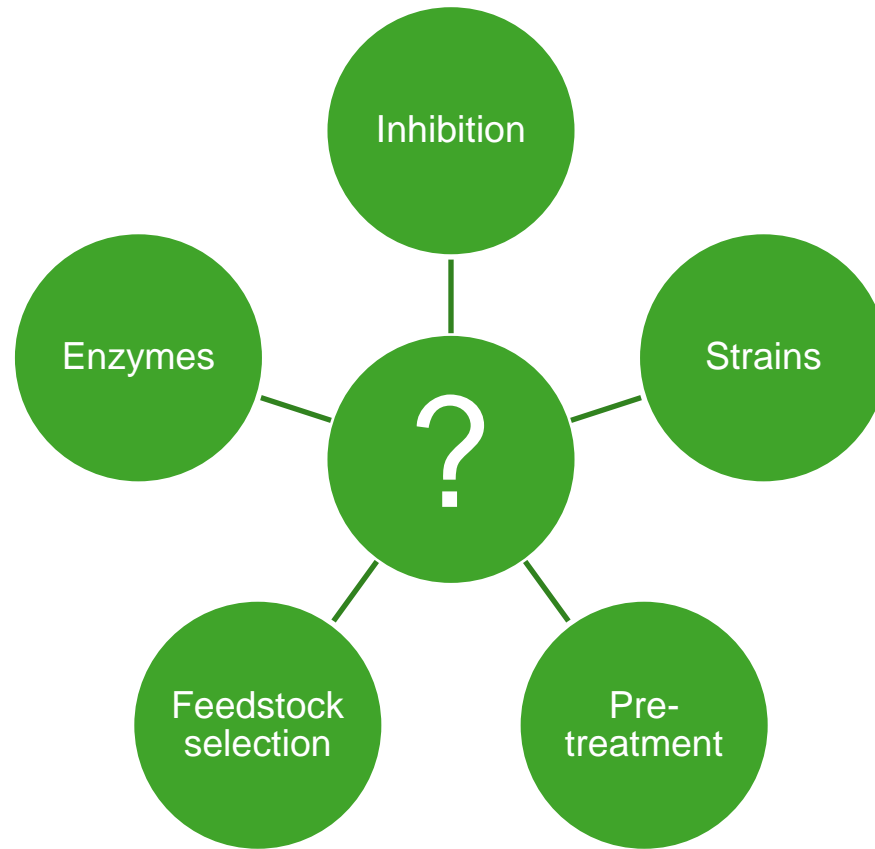


- ODM (20 %)
- TKN (30 kg/t)



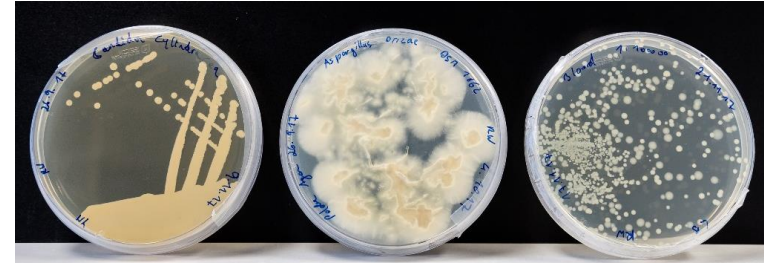
Nitrogen rich





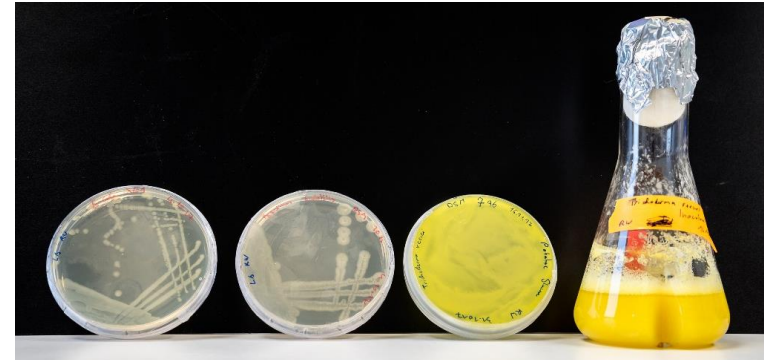
Enzyme producers

- *Trichoderma reesei* - cellulase
- *Aspergillus niger*- protease
- *Candida oryzae*- lipases
- *Bacillus subtilis*- protease
- *Bacillus licheniformis*- proteases



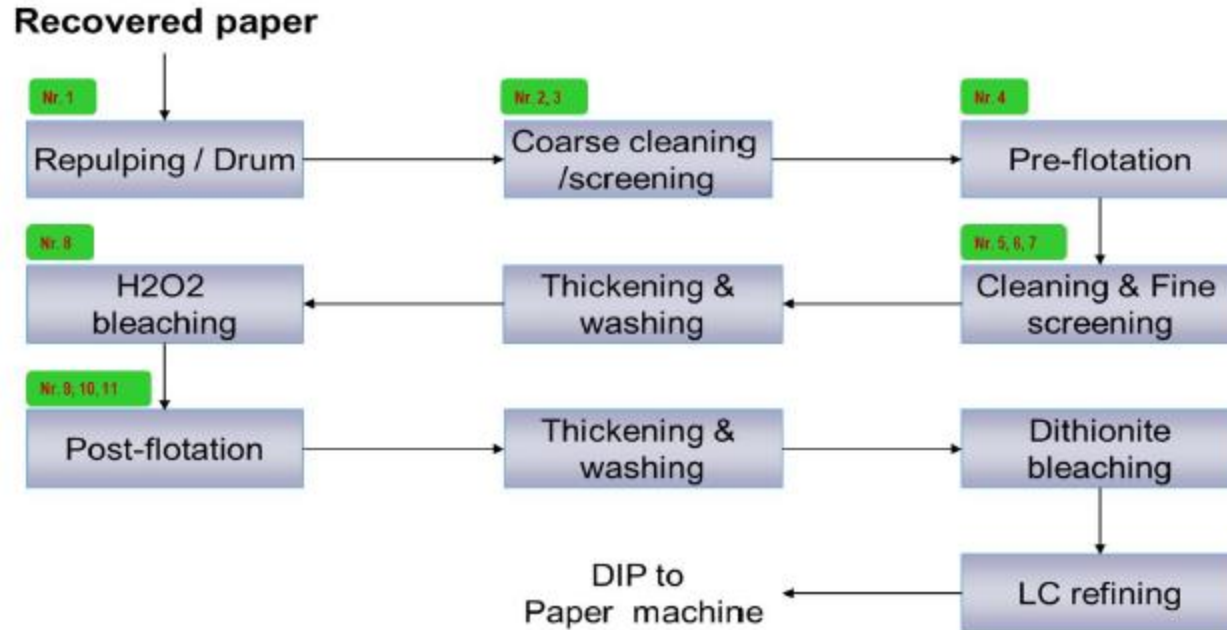
Recombinant hosts

- *Sacharomyces cerevisiae*
- *Pichia pastoris*
- *Escherichia coli*





Deinking process – where to take samples?





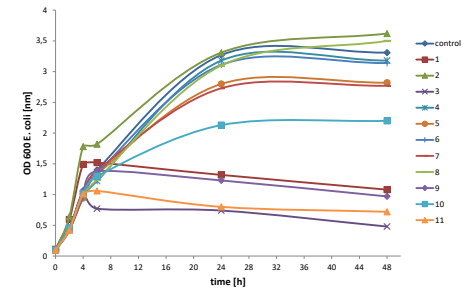
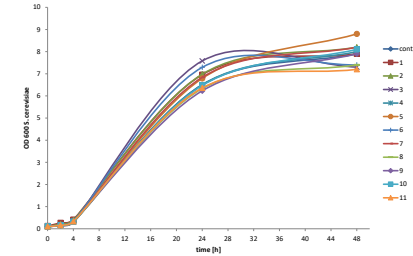
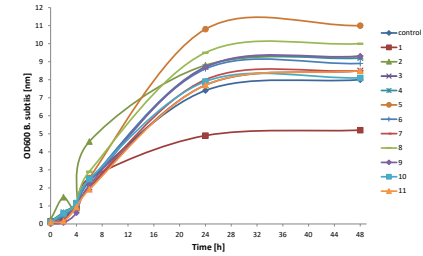
	Sample	Characteristics
1	Reject drum	Plastics, coarse fraction.
2	Reject sorting/clips	Metals and fibers
3	Overflow Beltrix	Fine fraction
4	Reject flotation 1	Inks, fibers, fillers
5	Reject cleaner - Fibermizer	Fibers
6	Reject fine screening 4A	Large fibers and stickies
7	Reject fine screening cleaner	Large fibers and stickies
8	Reject flotation 2	Inks, fibers, fillers
9	Reject microflotation 2	Fine fraction
10	Reject sludgecontainer	Mixture of rejects 4-9
11	Wastewater	Waste water collected



Deinking sludge – inhibitory to microorganisms?



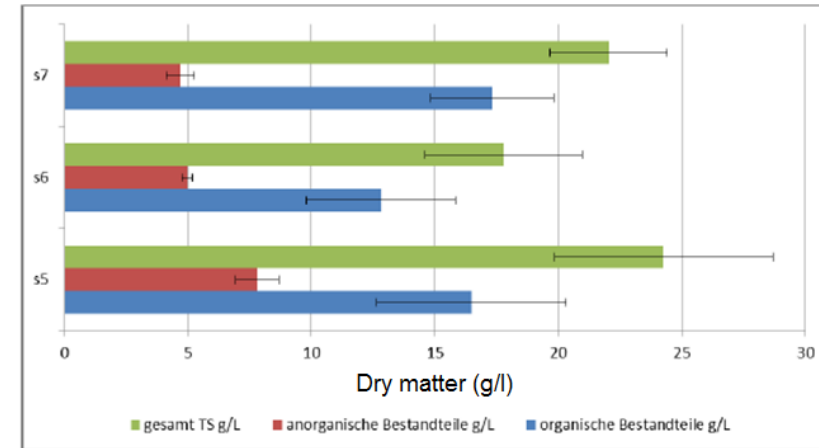
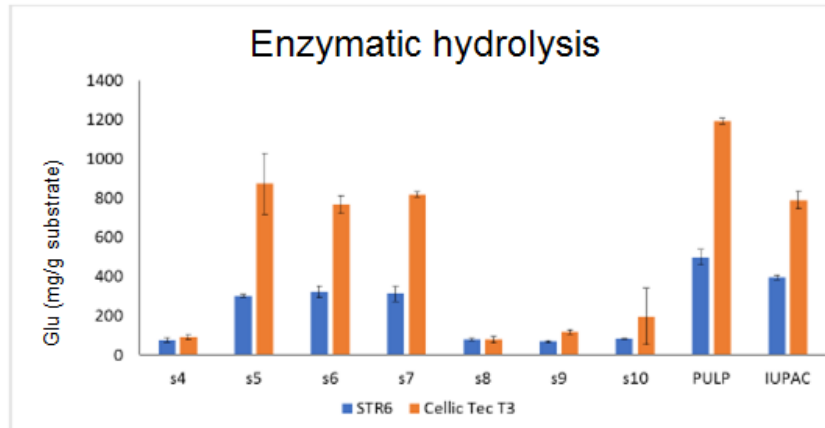
	E. Coli (Bak)	T.Reesei (Pilz)	A.Oryzae (Pilz)	B. Subtilis (Bak)	P. Pastoris (Pilz)	S. Cerevisiae (Pilz)
1	+++	-	-	+++	+++	-
2	-	-	++	-	-	-
3	+++	-	+	-	-	-
4	-	-	++	-	-	-
5	+	-	-	-	-	-
6	-	-	-	-	-	-
7	+	-	-	-	-	-
8	-	-	++	-	-	(+)
9	+++	-	+	-	-	-
10	++	-	-	-	-	-
11	+++	-	-	-	-	(+)





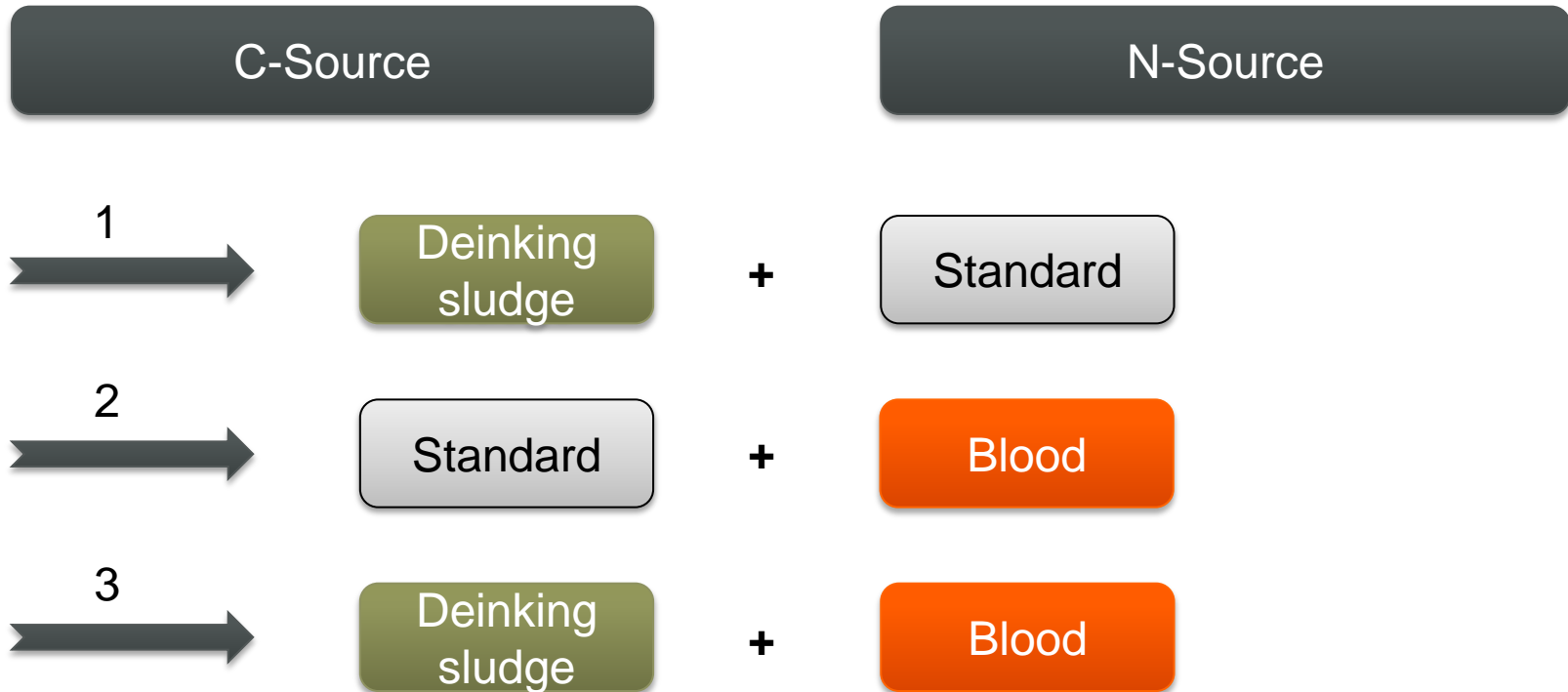
Which sludge fractions are most suitable?

- Criteria (organic dry matter, cellulose content, amount)

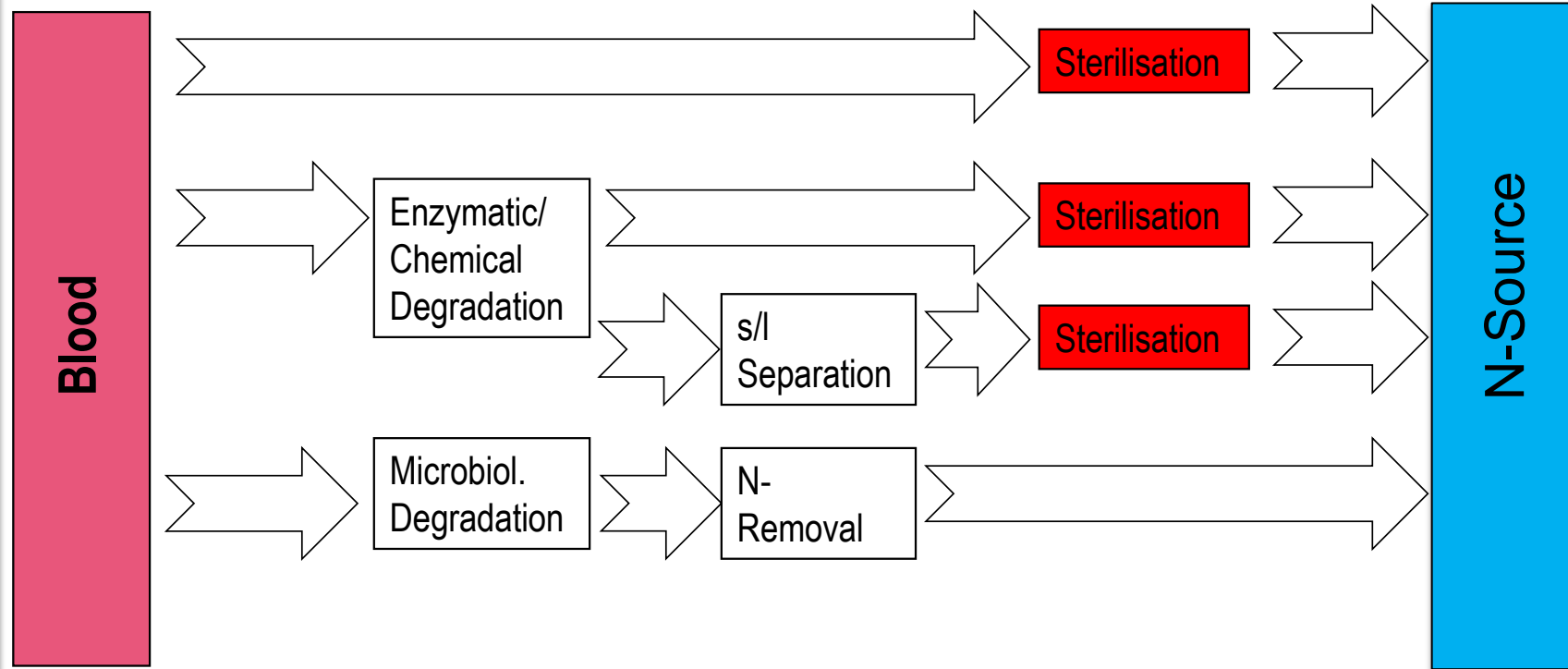




Preparing the fermentation media: Component replacement (N and C)

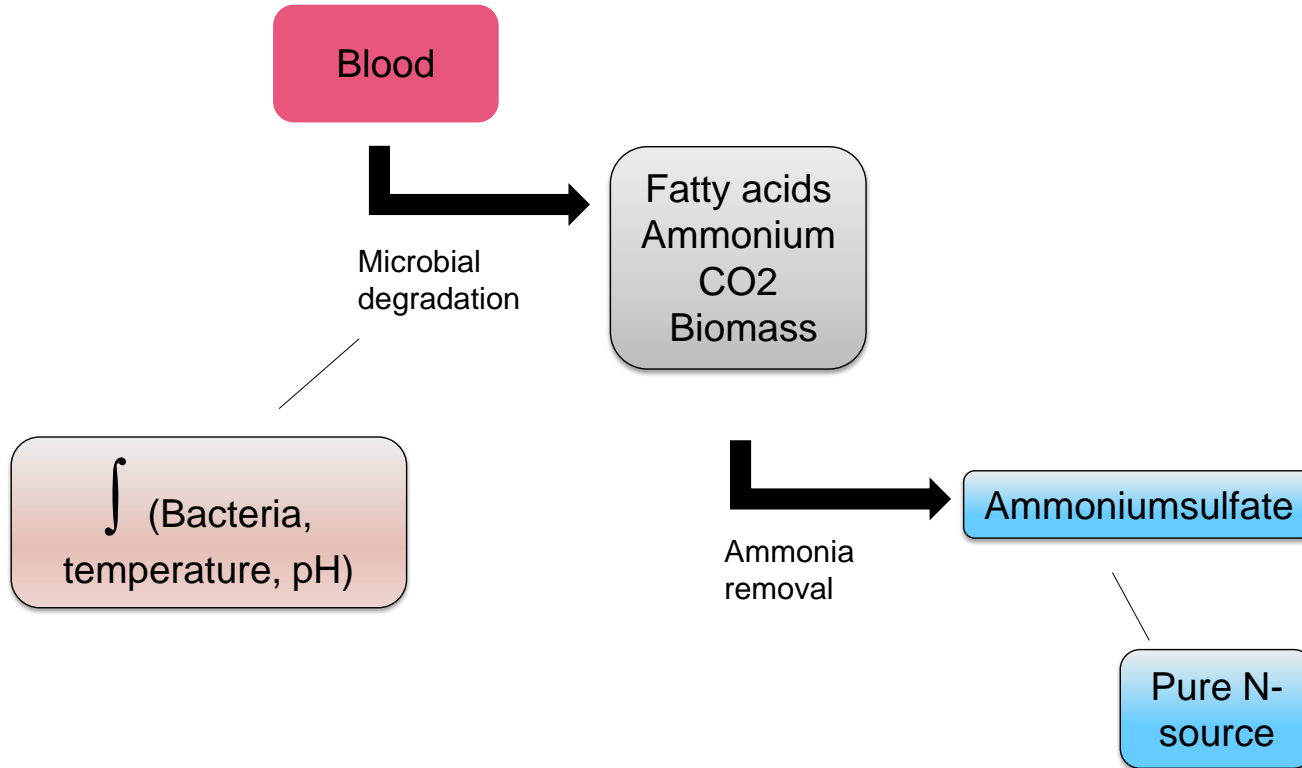


Nitrogen source





Ammonia separation from blood fraction





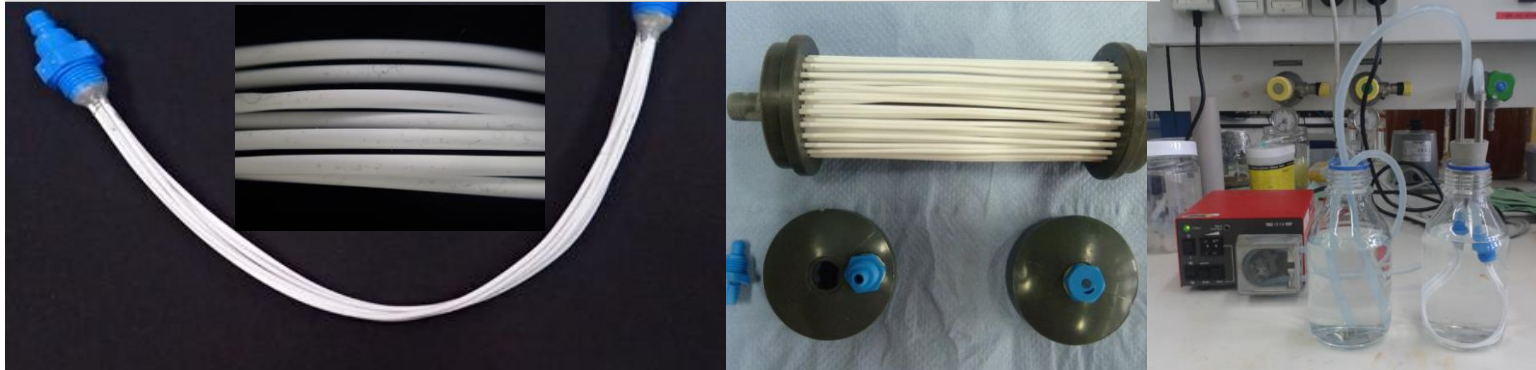
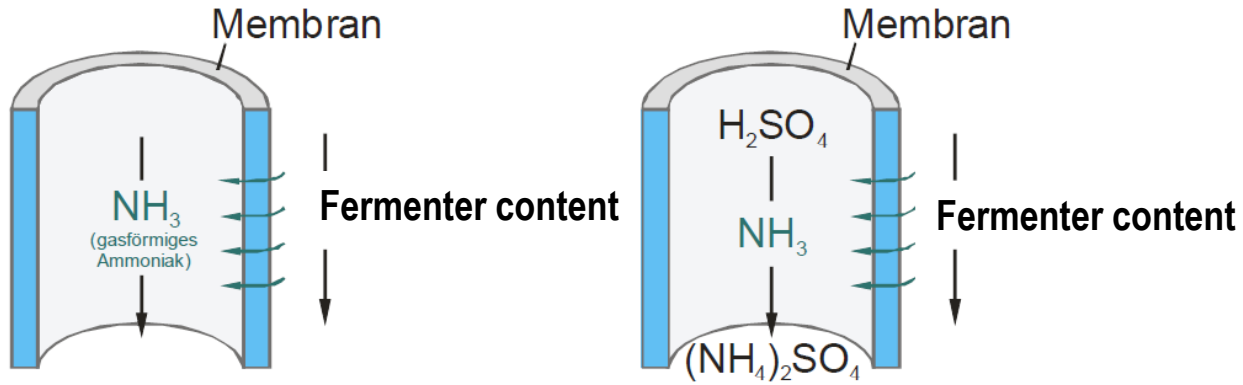
Microbial degradation of blood – relevant parameters

	MIN	MAX
NH ₄ (kg/m ³)	15	30
NH ₄ release rate (%)	95.9	99.6
VFA (g/m ³)	58,000	99,500
pH		
Gas (m ³ /t)	7.5	14.5
CO ₂ (%v/v)	90.5	99.6
H ₂ S (% v/v)	0	4.4
Iron (% w/w)	0.2	0.4





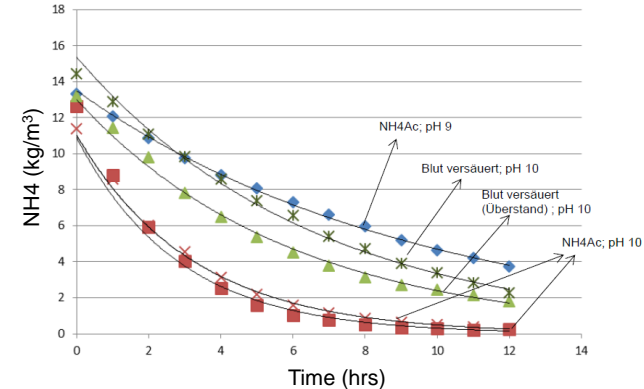
Nitrogen separation



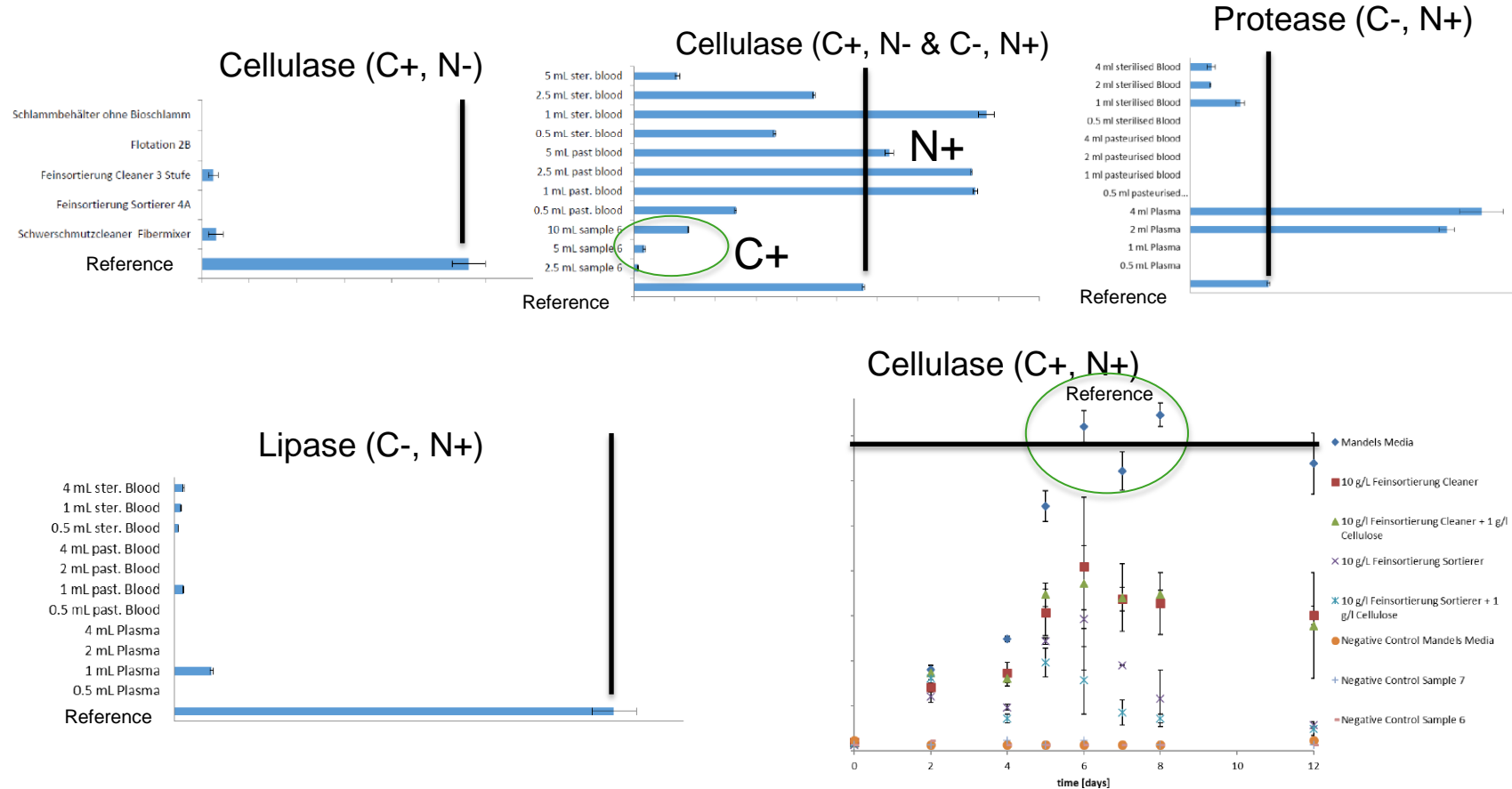


Continuous N-removal with membrane contactors at constant pH (pH-stat)

	NH4Ac	NH4Ac	NH4Ac	Blood ferm.	Blood ferm.
NH4 (Start) g/l	13.4	12.7	11.4	13.2	14.4
NH4 (End) g/l	3.7	0.2	0.3	1.8	2.3
pH	9.00	10.00	10.00	10.00	10.00



Enzyme production using alternative media





Enzyme activities

	C	N	Activity	Strain	Comment
Cellulase	+	-	Low	<i>T.reesei</i>	C: F5, F6, F7, F8
	-	+	High		Ammonium, Pasteurized + Sterilised
	+	+	Low/med		C: F6, F6; N: Pasteur. + Sterilised
Protease	-	+	High	<i>Bacillus licheniformis</i>	Only with Plasma + Ammonium
	-	+	Low		Pasteurized blood
	-	+	Medium		Sterilized blood
Lipase	-	+	High	<i>Candida cylindracea</i>	Ammonium
	-	+	Low		Pasteurized , sterilized blood



Summary and outlook

- Proof of concept successfully confirmed
- Alternative cultivation media substituting C and N
- Enzyme produced based on waste streams from P&P and the rendering industry
- Nitrogen source
 - Microbial degradation of blood
 - Separation of ammonia
 - Blood derived ammonia, pasteurized and sterilized blood as Nitrogen source confirmed
- Carbon source
 - Enzyme production/activity proof of concept confirmed
 - Deinking sludge remains still challenging (inhibition, low activities)
- Large Scale enzyme experiments at company planned
 - Pulping & Bleaching

Acknowledgement



heinzel[®]paper
LAAKIRCHEN PAPIER AG



SARIA[®]
SARIAGroup





Thank you for your
attention