FUNDACIÓN LATU

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

Enzymatic conversion of steam exploded pine into fermentable sugars

Cagno, M.[1] , Reyes, C. [2,3] , Cabot, P.[1] , Tancredi, N.[2,3], Lareo, C.[4]

7/06/23

WCCE11 – 11th WORLD CONGRESS OF CHEMICAL ENGINEERING

CIBIQ2023-II

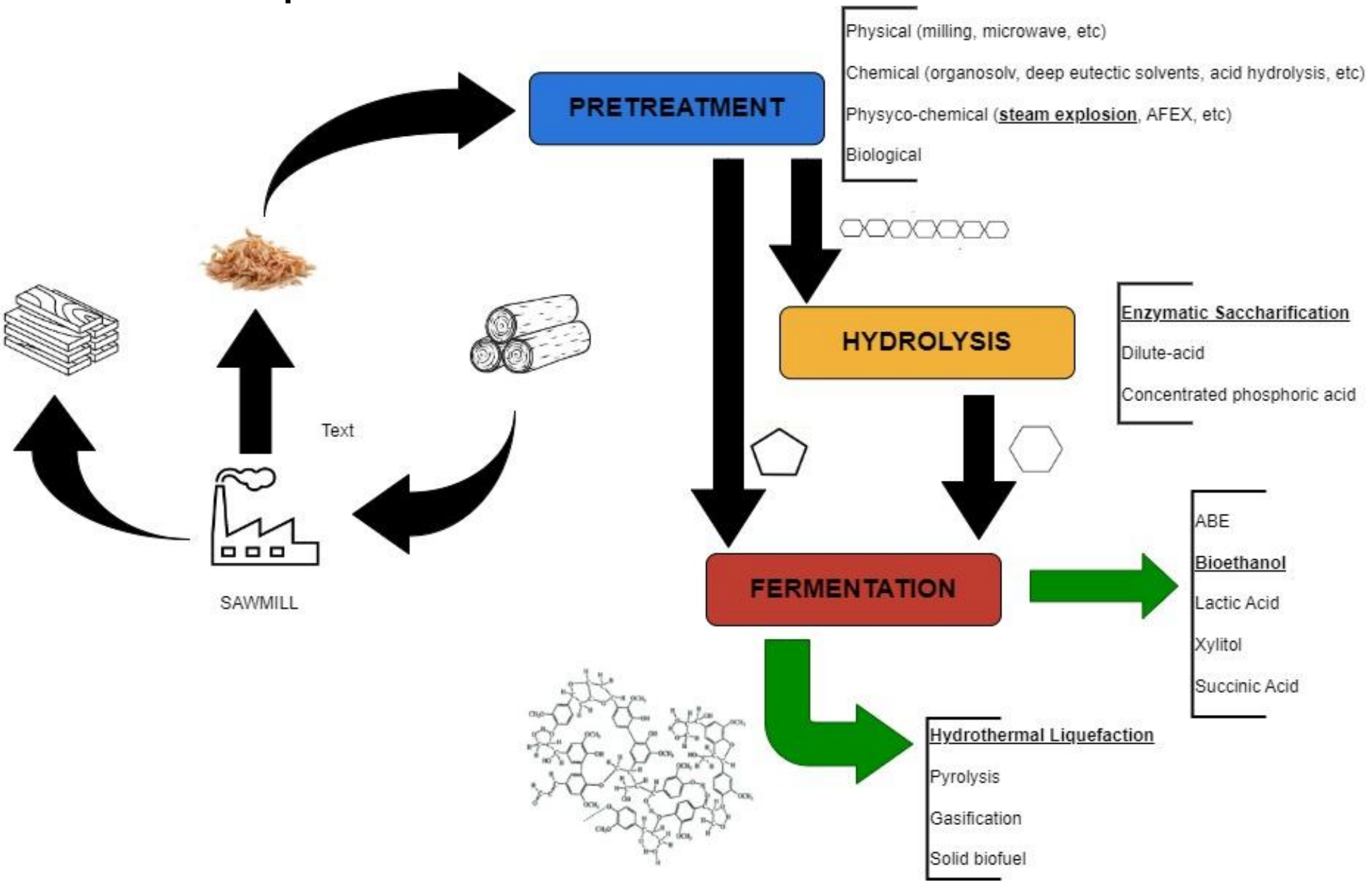
@latitud_uy /latitud-fundacion-latu

www.latitud.org.uy

1Centro de Investigaciones en Biocombustibles 2G, Latitud – Fundación LATU, Uruguay. mcagno@latitud.org.uy
2Energías Renovables, Instituto Polo Tecnológico de Pando, Facultad de Química, Universidad de la República, Pando, Uruguay.
3Fisicoquímica, Facultad de Química, Universidad de la República, Montevideo, Uruguay.
4Depto. Bioingeniería, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay .

Introduction

Objective: to obtain fermentable sugars from industrial pine residues



latitud.org.uy

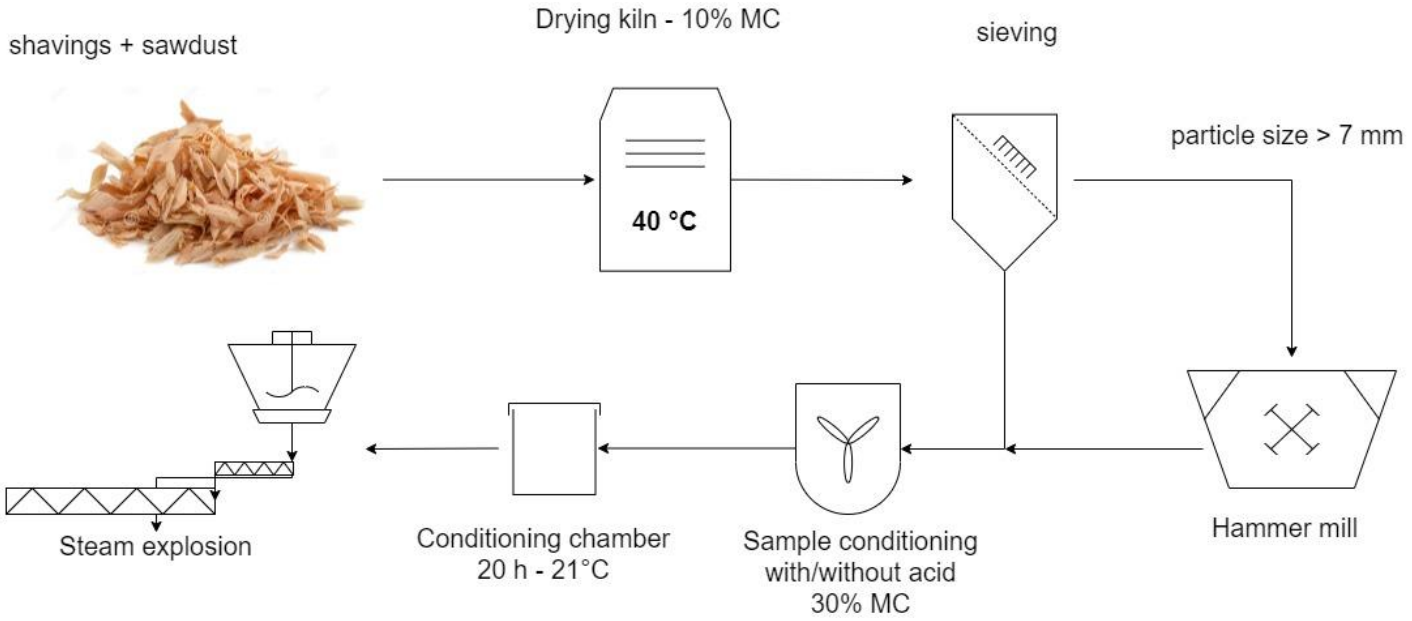
Introduction

- The sample was taken from a sawmill located in the North of Uruguay - Frutifor
- Processing capacity of 50.000 m^3/month pine logs
- Production: 10.000 ton/month of pine boards within different thickness, width and classes. .
- Monthly residue generation:
  - 1,000 ton of bark
  - 4,500 ton mix of sawdust and shavings
  - 10,500 ton chips

latitud.org.uy

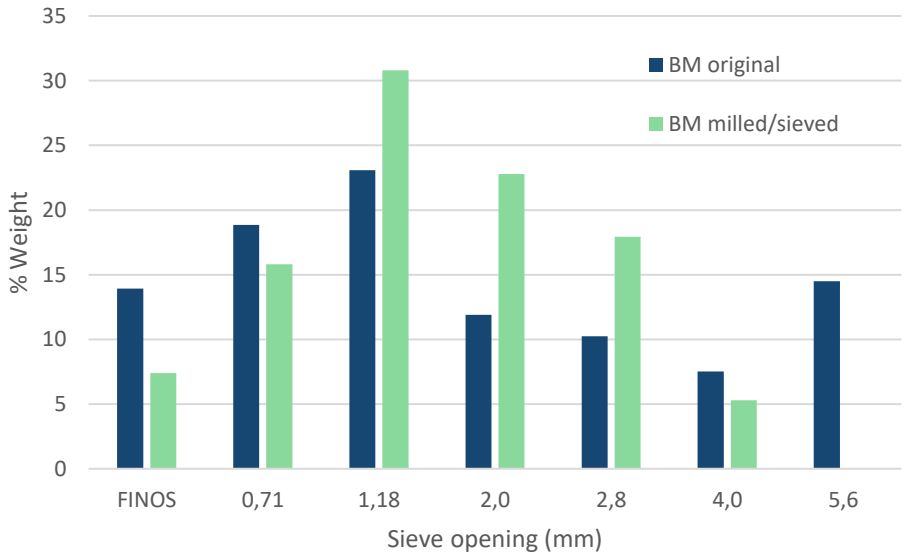
Methods

Sample conditioning



Component	% w/w db
Glucan	42,4
Xylan	6,9
Galactan	2,2
Arabinan	nd
Mannan	10,8
Acetyl	1,6
Acid insoluble lignin	28,7
Acid soluble lignin	4,5
Extractives[a]	3,3
Ashes	0,3

[a] water and ethanol as solvents



BUENOS AIRES 2023
WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

FUNDACIÓN LATU

latitud.org.uy

Methods

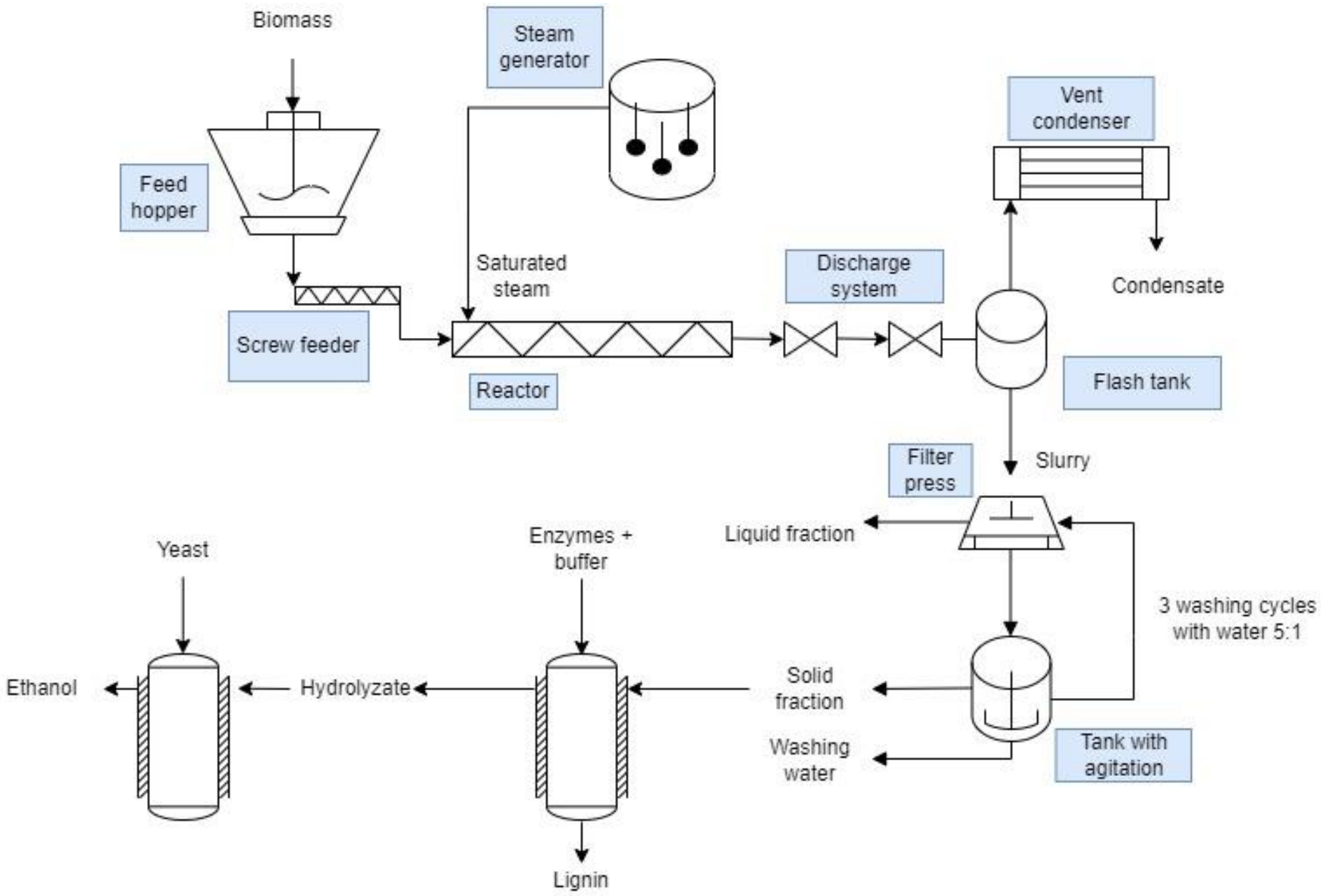
BUENOS AIRES 2023
JUNE 4 - 8
WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

latitud
FUNDACIÓN LATU

latitud.org.uy

Steam explosion pretreatment



Methods

Steam explosion pretreatment

STEAM EXPLOSION REACTOR

- Continuous process
- Capacity: 10 kg/h
- Maximum temperature: 200°C (15 bar)
- Residence time: variable speed time control screw

Experiment	Reaction conditions		pH liquid fraction	S_o	CSF
	T (°C)	$[H^+]$ (mg g^{-1} DB)			
EV180/0-A	180	-	3.2	3.2	0.0
EV180/0-B	180	-	3.5	3.2	-0.3
EV180/1-A	180	10	1.8	3.2	1.4
EV180/1-B	180	10	1.7	3.2	1.6
EV190/0.5-A	190	5	2.1	3.5	1.4
EV190/0.5-B	190	5	1.6	3.5	1.9
EV200/0-A	200	-	3.8	3.8	0.0
EV200/0-B	200	-	3.1	3.8	0.7
EV200/1-A	200	10	1.6	3.8	2.2
EV200/1-B	200	10	1.6	3.8	2.2

Residence time: 7.5 min

$$S_0 = \log\left(t \cdot e^{\frac{T-100}{14.75}}\right)$$

(Overend et al., 1987)

CSF = S_0-pH

(Chum et al., 1990)

latitud.org.uy

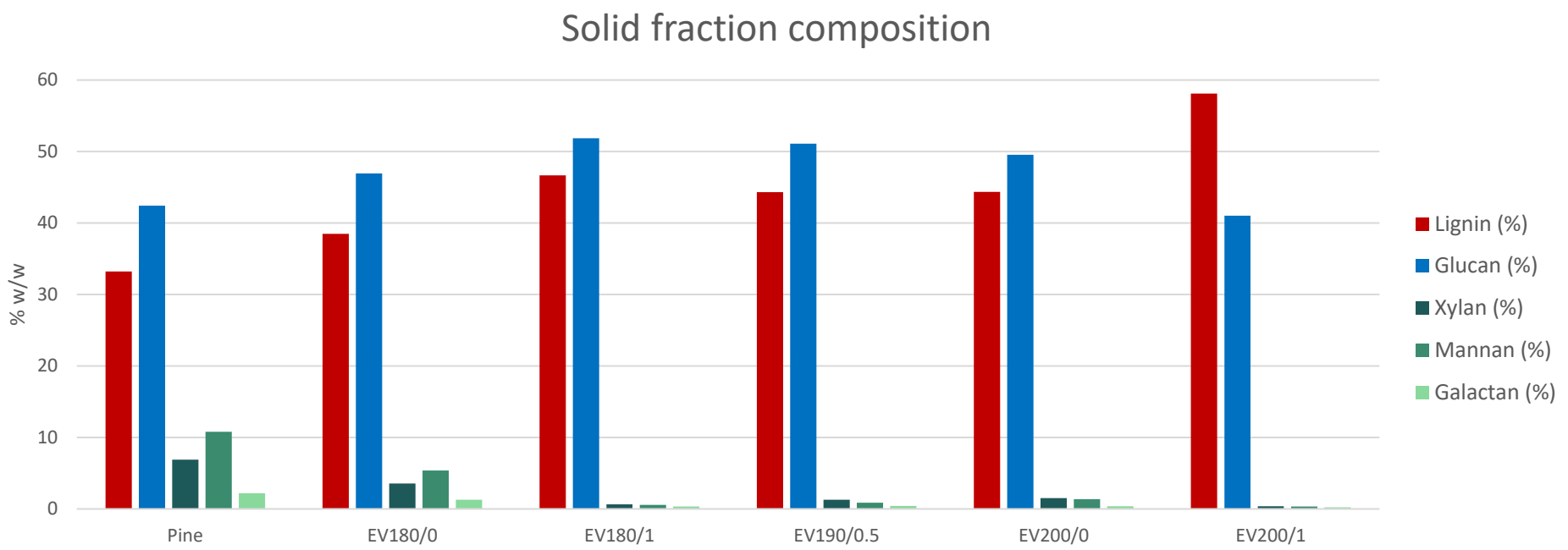
Results

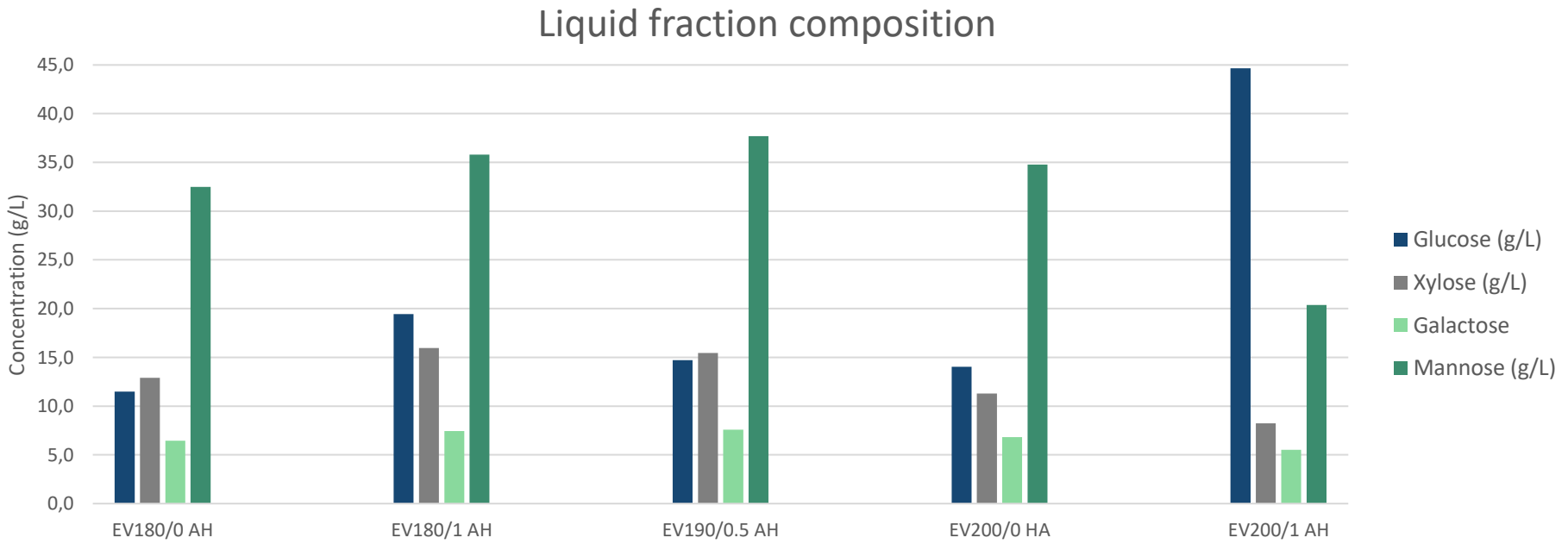
BUENOS AIRES 2023
JUNE 4 - 8
WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

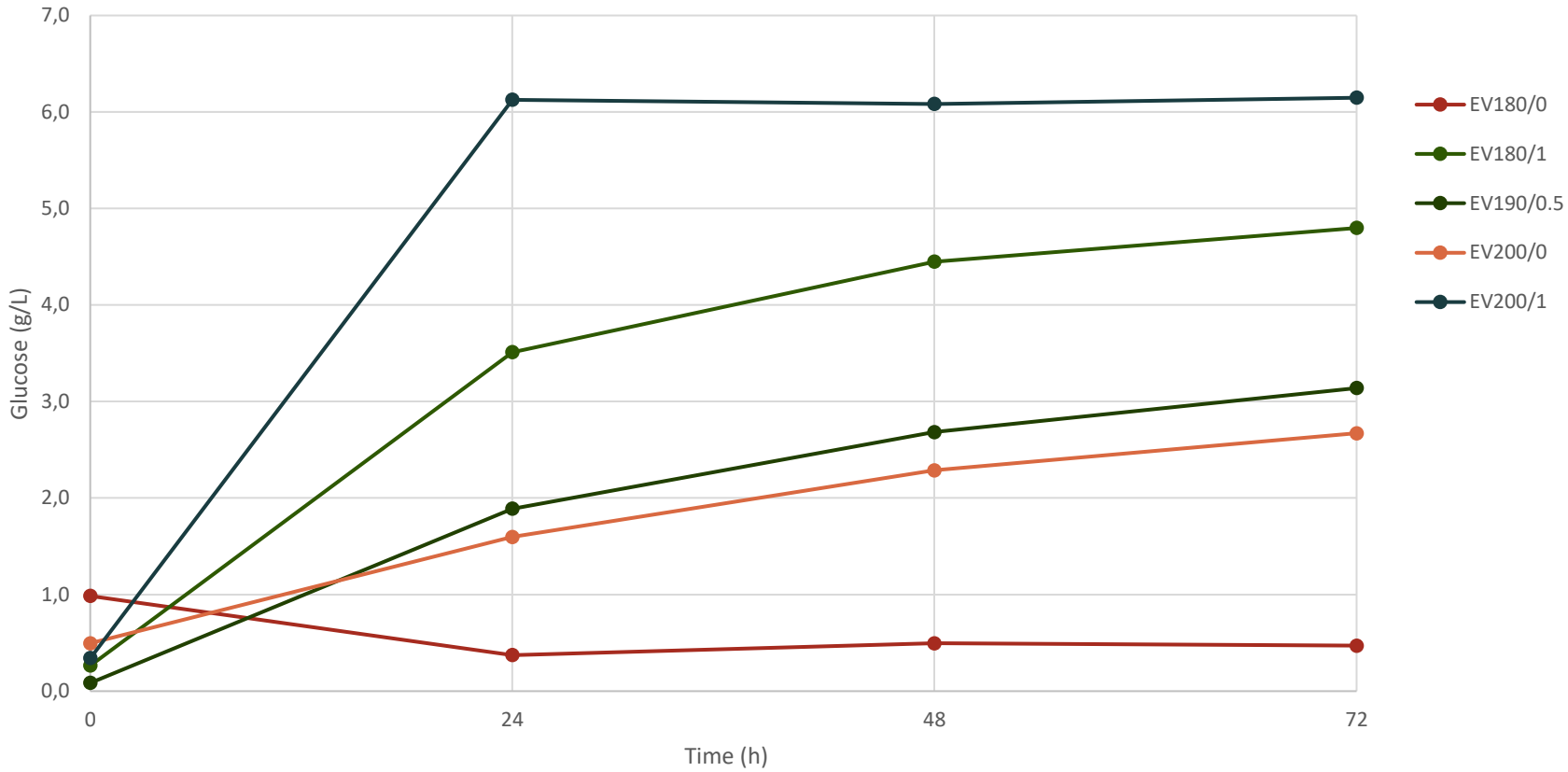
latitud
FUNDACIÓN LATU

latitud.org.uy





Results



LOW SOLIDS ENZYMATIC SACCHARIFICATION

- 2% w/w solid
- 72 h
- Cellulases blend (Sigma-Aldrich)
- 100 mL volume
- 50 FPU/g Glucan

Condition	Hydrolysis efficiency (%)
EV180/0	4.5
EV180/1	41.6
EV190/0.5	27.6
EV200/0	24.3
EV200/1	67.4

latitud.org.uy

Results

latitud.org.uy

Low solids enzymatic saccharification

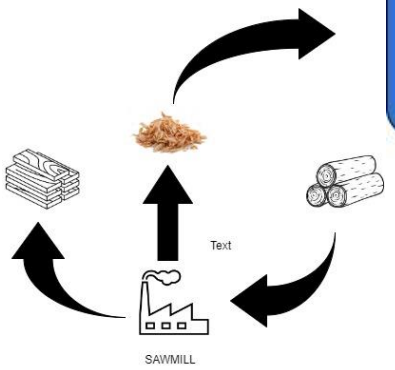
Experiment	g SF / g BMdb	g Glu / g FS	Cellulose hydrolysis (%)	Overall yield (kg Glucose/ton BM_{db}
EV180/0	0.79	52.1	4.5	19
EV180/1	0.58	57.6	41.6	138
EV190/0.5	0.63	56.8	27.6	97
EV200/0	0.63	55.0	24.3	83
EV200/1	0.76	45.6	67.4	231

HIGH SOLIDS ENZYMATIC SACCHARIFICATION

- 72 hrs
- Cellulases blend (Sigma-Aldrich)
- 100 mL volume
- 25 FPU/g Glucan
- 5% w/w Tween 80

Solids concentraction (w/w %)	pH	Final glucose concentration (g/L)	Cellulose hydrolysis (%)	Overall yield (kg Glucose / ton BM_{db}
18	5	75.5	59.2	183
18	6	76.0	59.5	185
22	5	88.7	47.8	147
22	6	95.8	51.5	159

Conclusions



STEAM EXPLOSION
200°C / 7,5 min
30% MC
1% w/w$_{db}$ H_2SO_4

LIQUID FRACTION		
	Concentration (g/L)	Yield (kg/ton BM$_{db}$)
Glucose	44.6	17
Xylose	8.2	3
Galactose	5.5	2
Mannose	20.4	8

ENZYMATIC SACCHARIFICATION
18% w/w - 72 h
25 FPU/glucan
pH = 5

ENZYMATIC HYDROLYSATE	
Final glucose concentration (g/L)	75.7
Overall yield (kg Glucose / ton BM$_{db}$)	184

HYDROTHERMAL LIQUEFACTION	
T (°C)	350
Solid:Liquid	9:1
Maximum Yield (%)	41.3
kg biocrude / ton BM$_{db}$	196

FERMENTATION
12 h

BIOETHANOL	
Initial glucose concentration (g/L)	76.0
Final ethanol concentration (g/L)	37.5
Fermentation yield (%)	96.6
Overall yield (Lethanol/ton BM$_{db}$)	114

- In the most severe condition of steam explosion pretreatment (200°C and 1% w/w H2SO4), the highest yield of fermentable sugars was achieved. The addition of acid at high temperatures during the pretreatment of pine improved the accessibility of enzymes to cellulose.
- The hydrolysate of fermentable sugars was obtained with a concentration of 75 g/L and a global yield of 184 kg of glucose per dry ton of biomass.

BUENOS AIRES 2023
JUNE 4 - 8
WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

latitud
FUNDACIÓN LATU

latitud.org.uy

Acknowledgments

ANII AGENCIA NACIONAL DE INVESTIGACIÓN E INNOVACIÓN

Energías Renovables

polo tecnológico química - biotecnología

UDELAR FQ FACULTAD DE QUIMICA

CIDEB

FACULTAD DE INGENIERÍA UDELAR

FUNDACIÓN LATU

@latitud_uy

/latitud-fundacion-latu

www.latitud.org.uy