Bio4Energy Researchers' Meeting, Luleå, November 21-22, 2022

RESIDUES OF QUINOA HARVEST AND PROCESSING FOR PRODUCING BIOPOLYMERS AND BIOFUELS

Carlos Martín Medina

Umeå University, Sweden / Inland Norway University of Applied Sciences

Outline

- Quinoa residues as biorefinery feedstocks
- Our research on biorefining quinoa residues
- Halotolerant bacteria for production of biopolymers
- Our quinoa biorefinery vision

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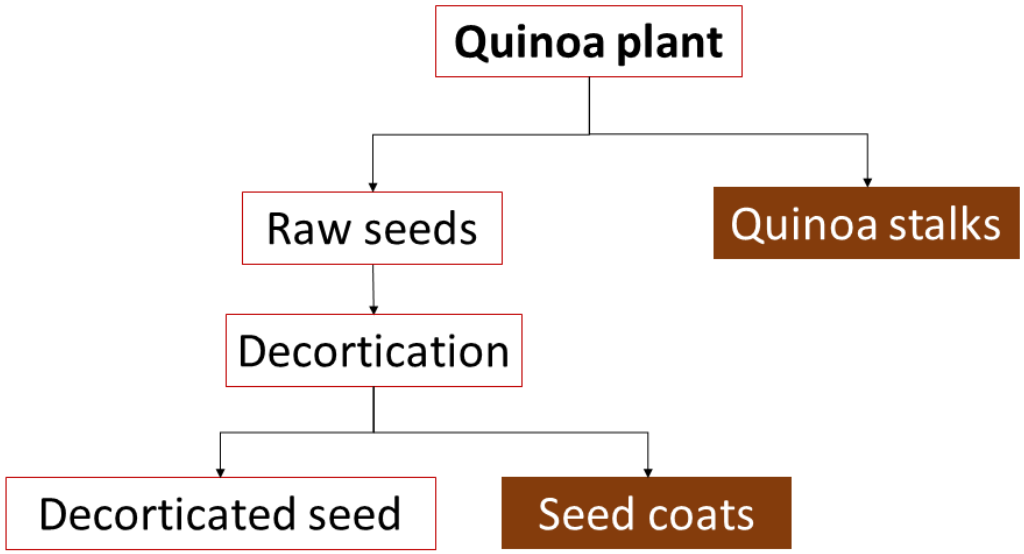
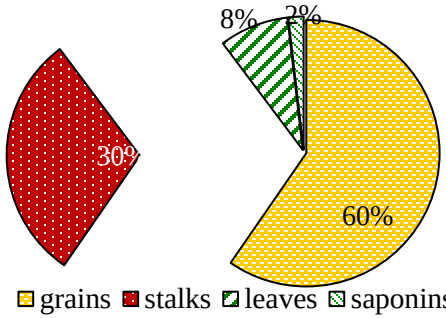
Quinoa residues as biorefinery feedstocks

***Chenopodium quinoa* W.** is s major product of Bolivian agriculture

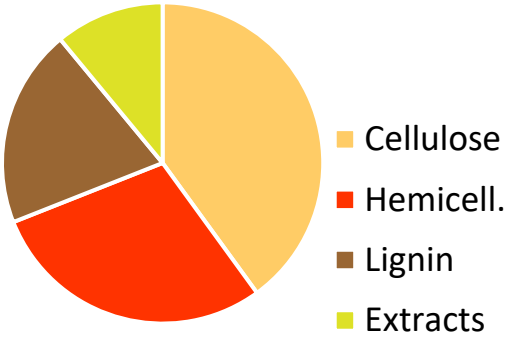


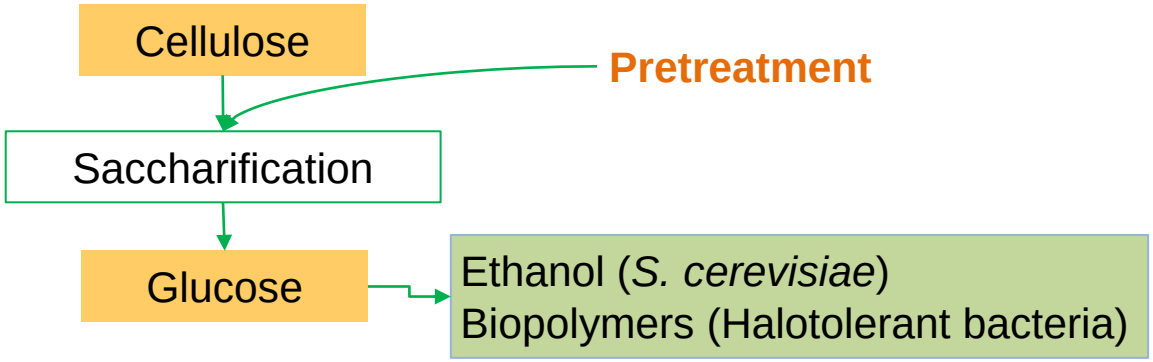


Quinoa stalks are rich in carbohydrates, abundant, cheap, and renewable – **Potential feedstock** for sugar platform-based bio-products

Quinoa seed coatings are rich in saponins

Quinoa stalks biorefinery routes





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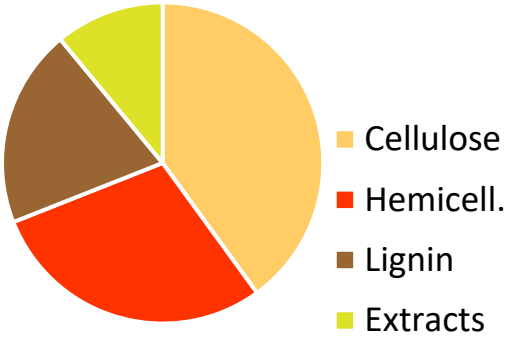
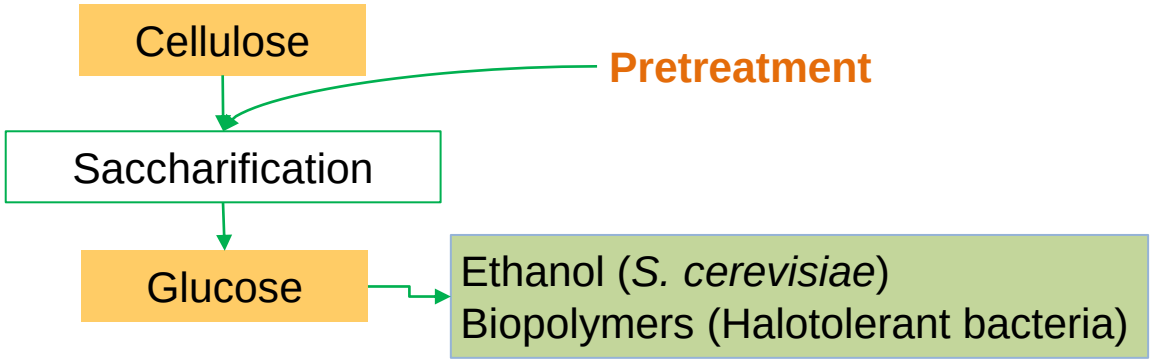
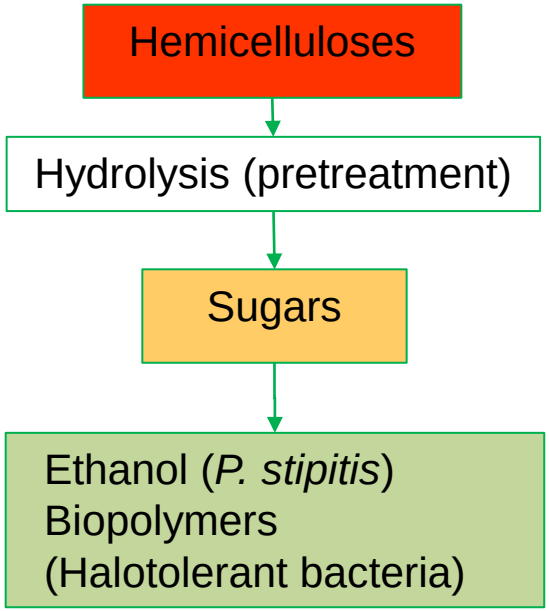
Quinoa stalks biorefinery routes







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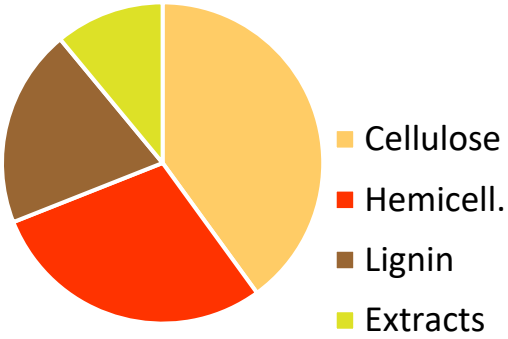
Quinoa stalks biorefinery routes



Cellulose

Pretreatment

Saccharification

Glucose

Ethanol (*S. cerevisiae*)
Biopolymers (Halotolerant bacteria)

Hemicelluloses

Hydrolysis (pretreatment)

Sugars

Ethanol (*P. stipitis*)
Biopolymers
(Halotolerant bacteria)

Saccharification residue

Extraction

Lignin

Valorization

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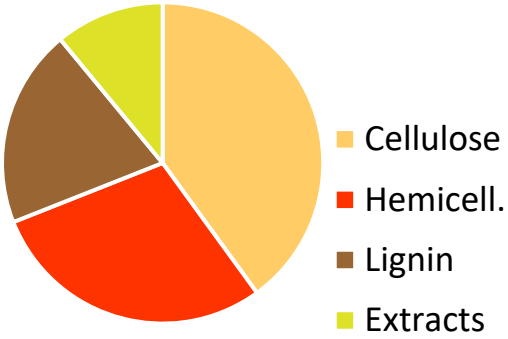
Quinoa stalks biorefinery routes



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Saccharification residue

Extraction

Lignin

Valorization

Extractives

Extraction

Saponins

Valorization

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Our research on biorefining of quinoa residues

Extraction of saponins from seed coatings

Evaluation as enhancers of enzymatic saccharification and in soil bioremediation

Oliva-Taravilla et al.
Molecules 25, 3559, 2020

Hydrothermal pretreatment of quinoa stalks

Enzymatic saccharification of hydrolysates

Carrasco et al.
Energies 14, 4102, 2021

Microbial fermentations

- Biopolymers (EPS by *B. atrophaeus* and PHB by *H. boliviensis*)
- Ethanol *by S. cerevisiae* and *P. stipitis*

Chambi et al.
Fermentation 8, 79, 2022

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Halotolerant bacteria

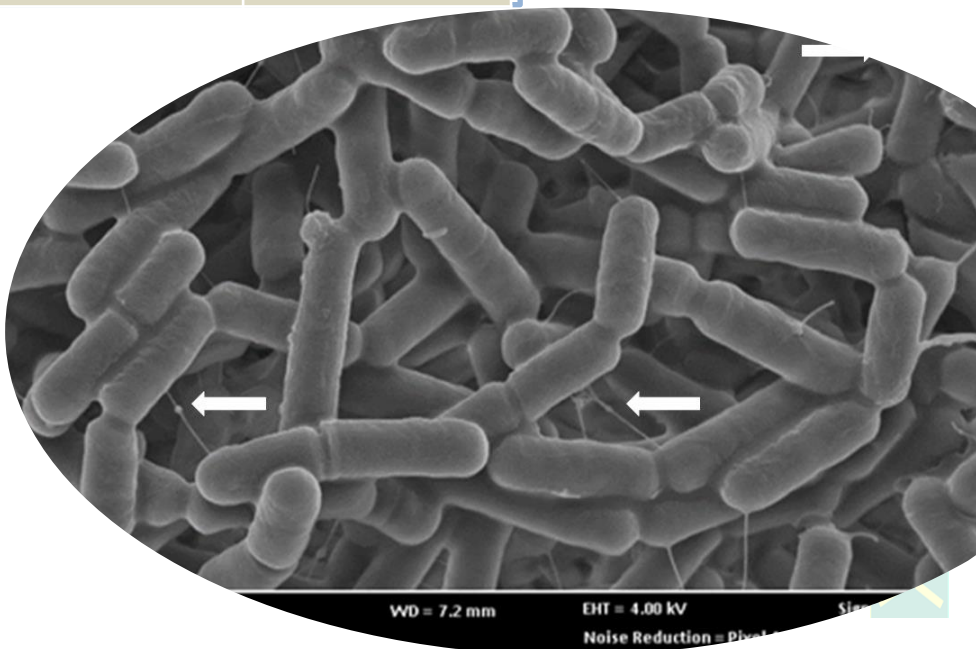
- Isolated from Bolivian Altiplano
- Produce biopolymers, e.g., **exopolysaccharides** (EPS) or **polyhydroxyalkanoates** (PHA) as adaptive mechanism to support growth under high salinity
- *Halomonas boliviensis*, *Halomonas andesensis*, ***Bacillus atrophaeus***

Cultivation of *Bacillus atrophaeus* BU4

- In synthetic media and in hydrolysates (cellulosic and hemicellulosic) of quinoa stalks

	GSM-45	GSM-30	GSM-15	C.Hydr-45	C.Hydr-30
Glucose	45	30	15	45	30
Xylose	5			5	3

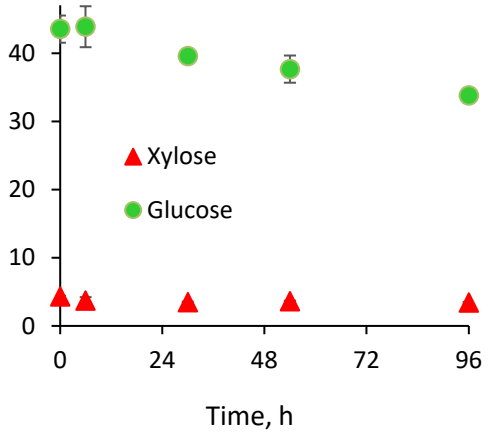
	XSM-16	XSM-8	HC.Hydr-16	HC.Hydr-8
Xylose	16	8	16	8



Sugar consumption during cultivation

In synthetic media

Glucose-based



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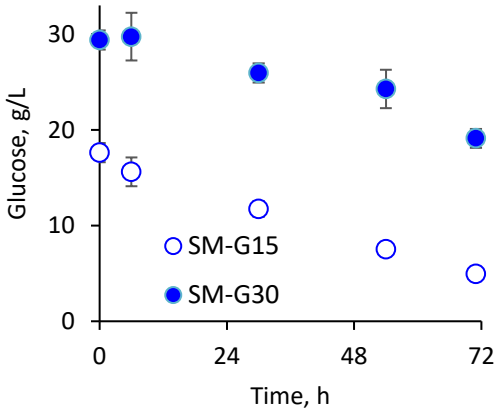
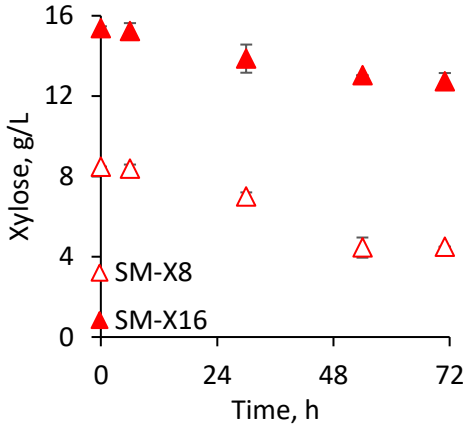


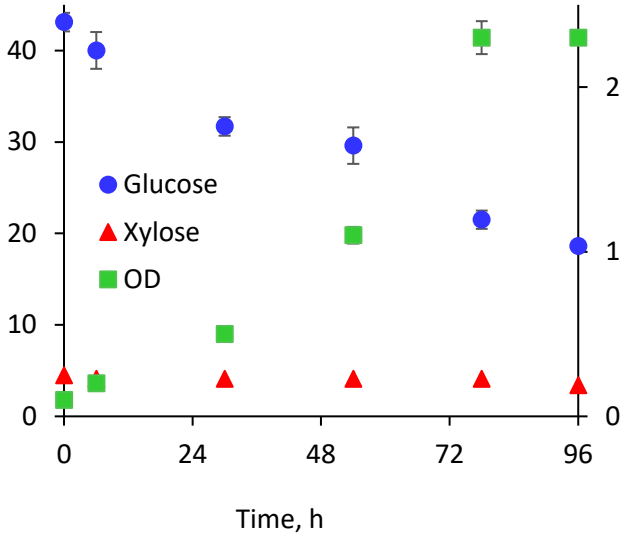
Xylose-based

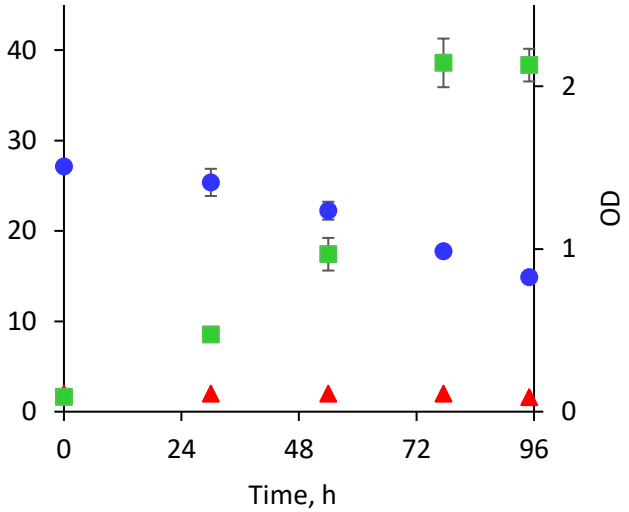


- Higher glucose consumption than that of xylose
- More dynamic cultivations at lower initial sugar concentrations

Sugar consumption during cultivation

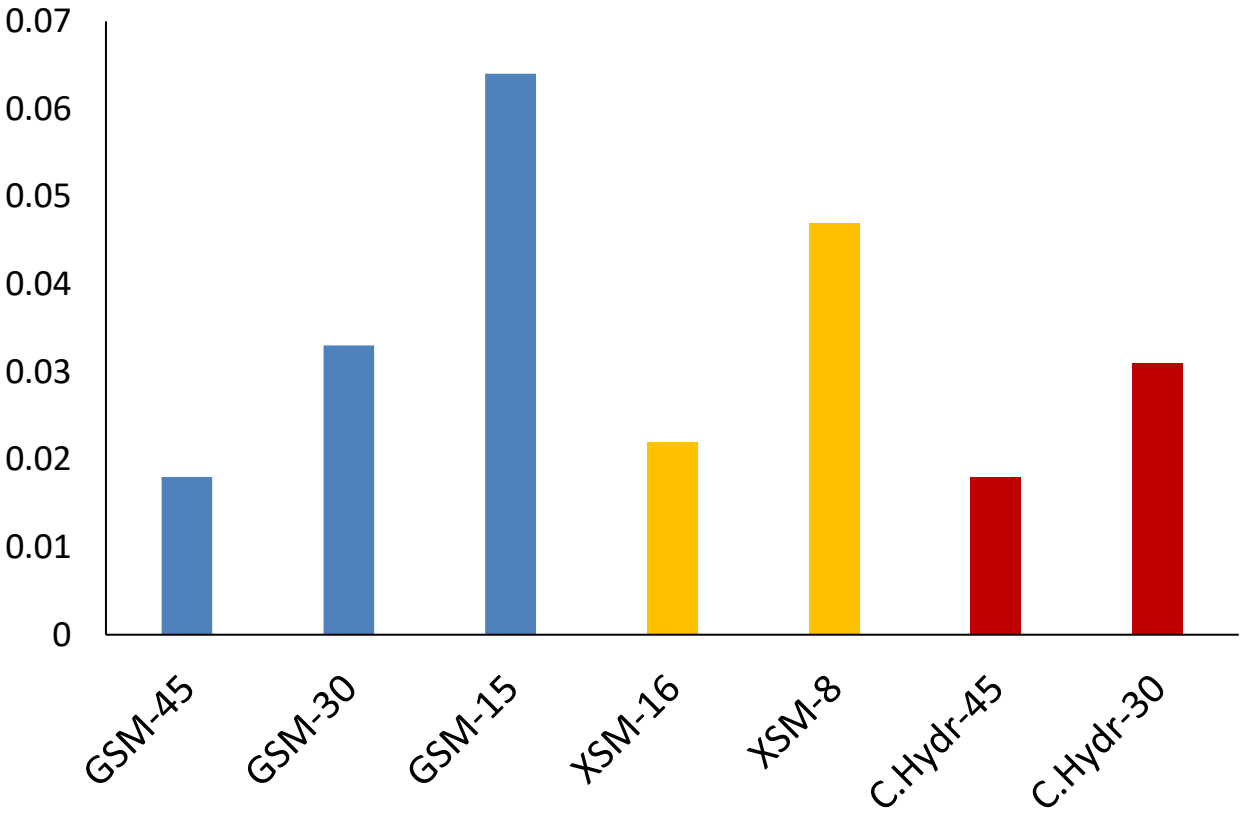
In hydrolysates





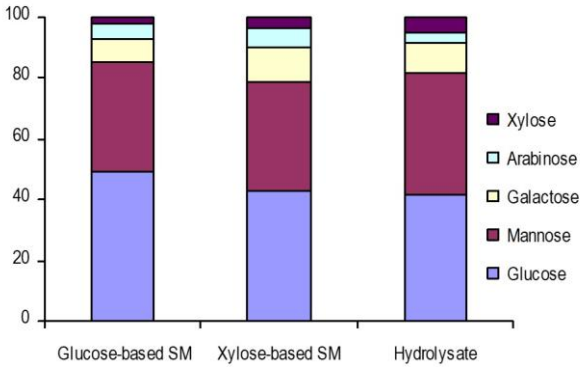
- Sugar consumption pattern in cellulosic hydrolysates comparable with that in synthetic media

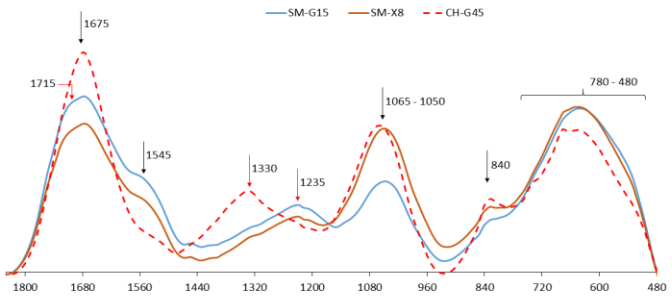
EPS yield, g/g consumed sugar

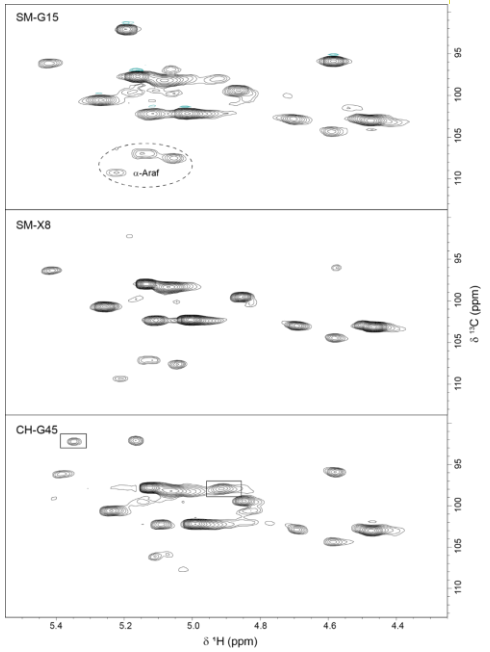


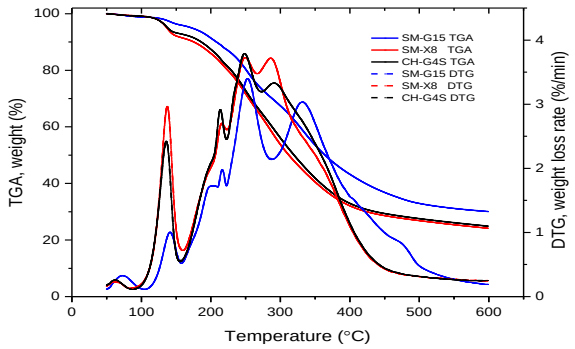
- EPS yield per consumed sugar increased with decrease of initial concentration
- EPS yield higher for glucose
- EPS yield comparable in SM and hydrolysate

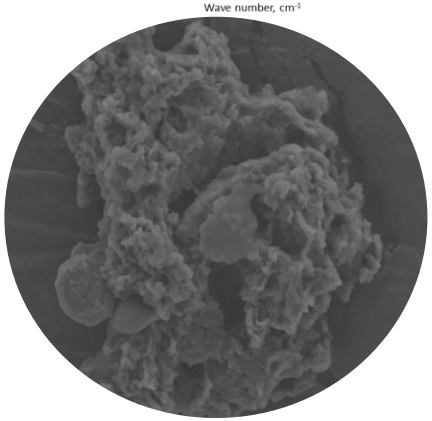
EPS characterization

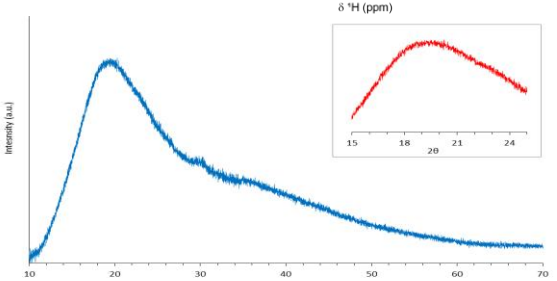






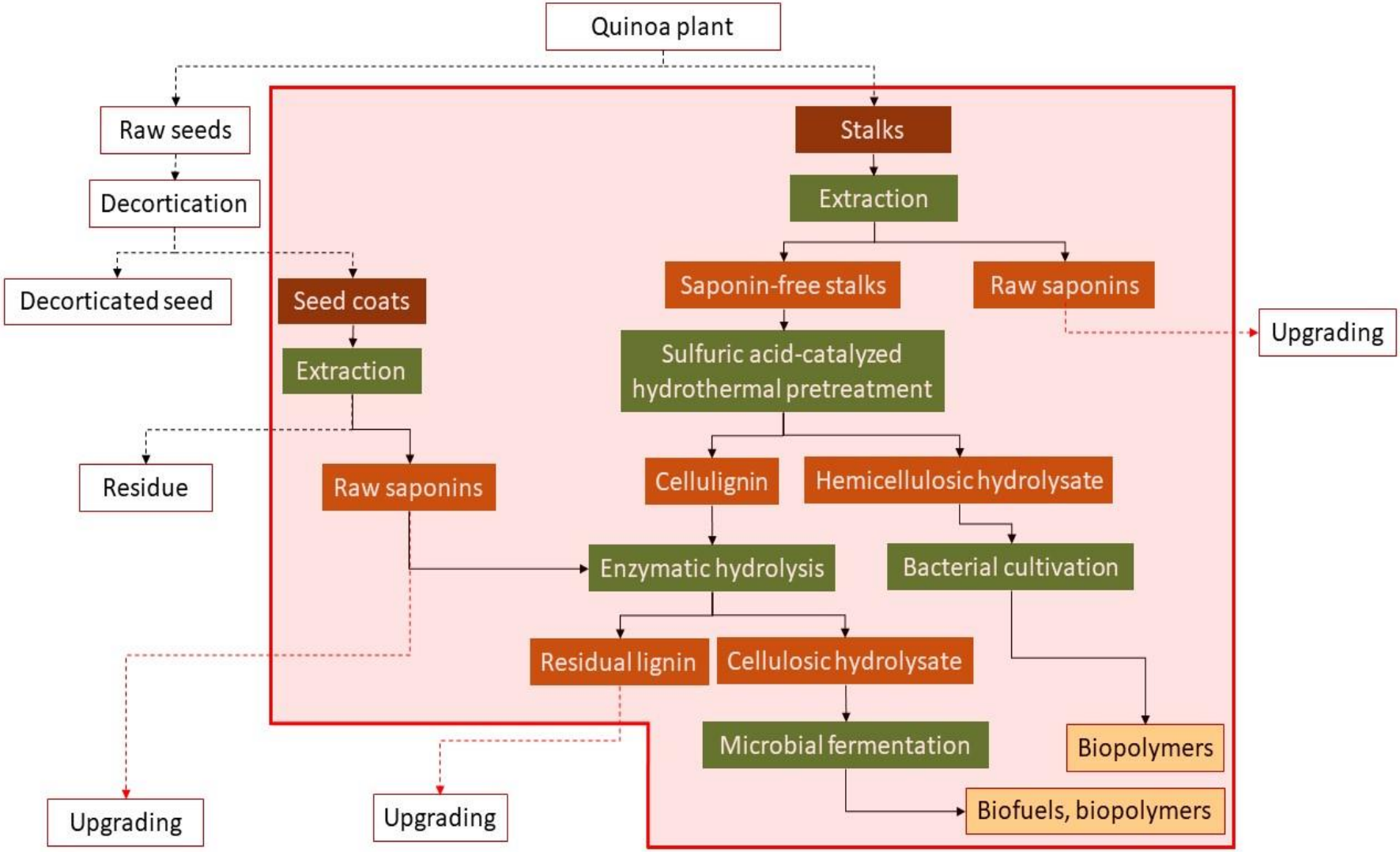






- ✓ NMR, HPSEC, FTIR, SEM and TGA revealed similarities between EPS from glucose- and xylose-based synthetic media
- ✓ EPS from cellulosic hydrolysates are slightly different
- ✓ Good thermal stability, amorphous nature, water-retention capacity
- ✓ Useful features for applications

Our quinoa biorefinery vision



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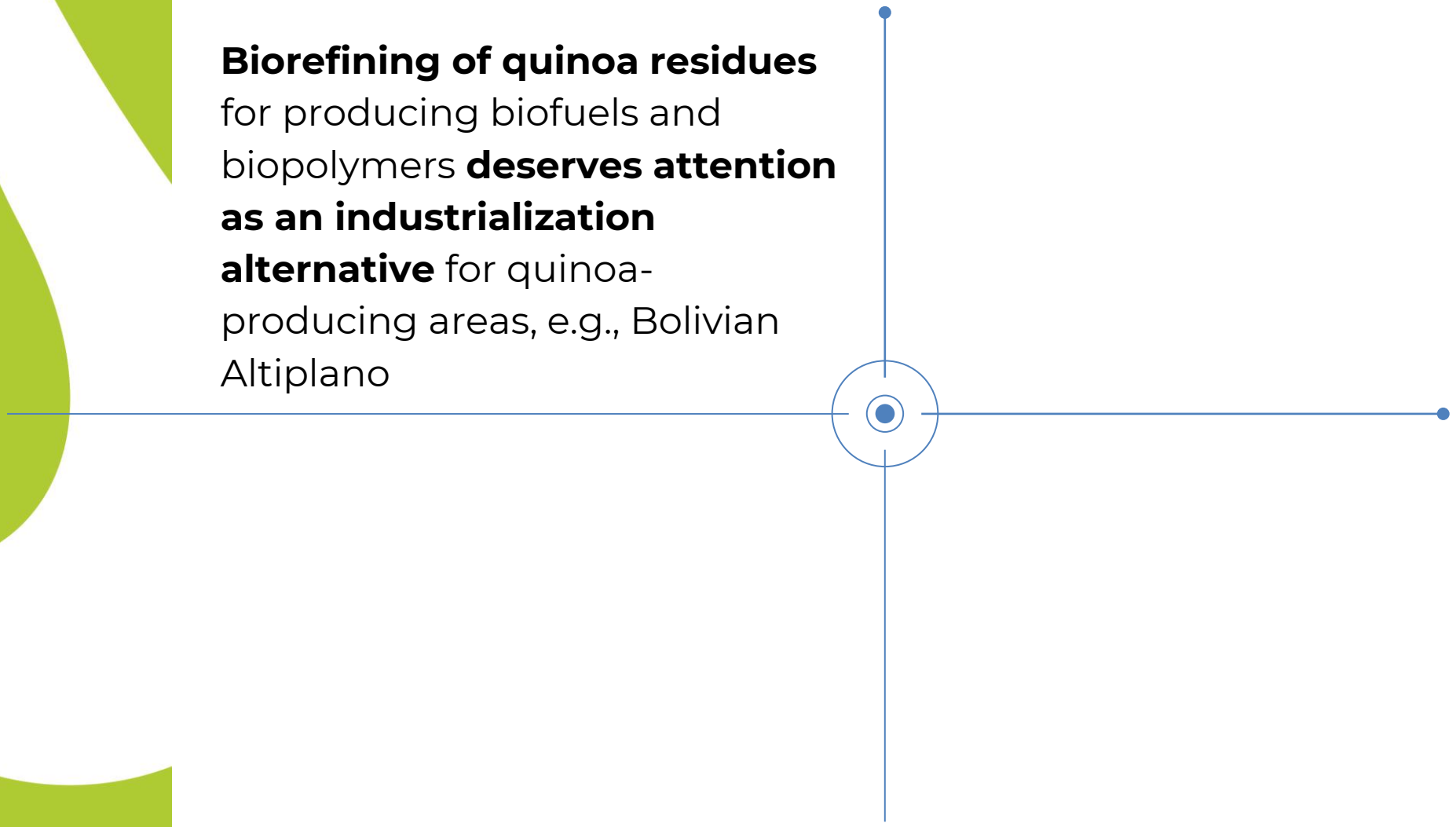
Final remarks

Biorefining of quinoa residues for producing biofuels and biopolymers **deserves attention as an industrialization alternative** for quinoa-producing areas, e.g., Bolivian Altiplano



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Removal of saponins is a favorable strategy **for improving the effectiveness of hydrothermal pretreatment** of quinoa stalks.

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Quinoa saponins are effective **additives for enhancing enzymatic saccharification** of pretreated lignocellulose.

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Removal of saponins is a favorable strategy **for improving the effectiveness of hydrothermal pretreatment** of quinoa stalks.

Cellulosic **hydrolysates of quinoa stalk are suitable substrates** for producing EPS using halotolerant *B. atrophaeus* BU4

Quinoa saponins are effective **additives for enhancing enzymatic saccharification** of pretreated lignocellulose.

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Acknowledgements

- ✓ My colleagues **Cristhian Carrasco**, **Leif Jönsson**, **Luis A. Romero-Soto**, **Diego Chambi** and **Alfredo Oliva-Taravilla**
- ✓ Swedish Research Council
- ✓ Bio4Energy strategic research environment
- ✓ Swedish International Development Cooperation Agency

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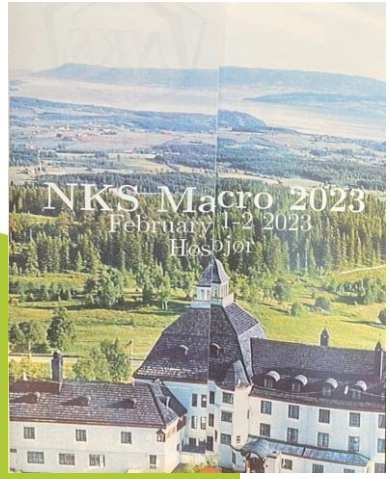
NKS MAKRO Scientific Symposium Polymers and Soft Matter" – *March 2-3, 2023, Hotel Norge Høsbjør, Innlandet, Norway.*



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3rd International Workshop on Biorefinery of Lignocellulosic Materials" – *September 12-15, 2023, University of Córdoba, Spain*

Thanks a lot, dear friends!

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