Interreg
France-Wallonie-Vlaanderen
UNION EUROPÉENNE
EUROPESE UNIE

ValBran

Valorisation of wheat bran into surfactant molecules

by **Caroline Rémond** (INRA/URCA FARE),

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Representing the ValBran consortium

www.valbran.eu

Facebook page: @Valbiom @interregFranceWallonieVlaanderen #ValBran
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Interreg France-Wallonie-Vlaanderen

62.000 km²
10.800.000 habitants/inwoners

ONDERZOEK EN INNOVATIE
RECHERCHE ET INNOVATION

1. Versterken van het onderzoek en de innovatie van de grensoverschrijdende zone in de strategische sectoren en de sectoren met een sterke complementariteit | Accroissement de la recherche et de l'innovation de la zone transfrontalière dans les secteurs stratégiques et les secteurs à forte complémentarité

2. Grotere overdracht en verspreiding van goede praktijken in de strategische sectoren en de sectoren met een sterke complementariteit in de grensoverschrijdende zone | Accroissement du transfert et de la diffusion des bonnes pratiques innovante dans les secteurs stratégiques et à forte complémentarité de la zone transfrontalière

Projet soutenu par

Interreg France-Wallonie-Vlaanderen

Recherche et innovation

Plus d'infos

www.interreg-fwvl.eu
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Avec le soutien du Fonds européen de développement régional

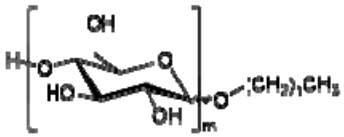
Alkyl glycosides and sugar esters, non-ionic surfactants of interest

Non-ionic surfactants ≈ 50 % of the total surfactant market in Europe

Growing interest for surfactants from renewable ressources: biodegradability, non toxic for humans and environment

Alkyl polyglycosides (APG)

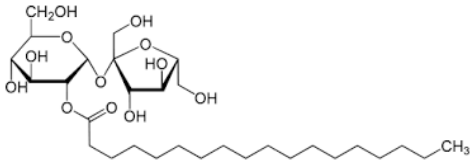
World market: 100,000 T/year
Emulsifiers, foaming agents, wetting agents for cosmetics, detergents, phytosanitary



Appyclean™ (Wheatoleo), Oramix™, Montanov™ (Seppic), …

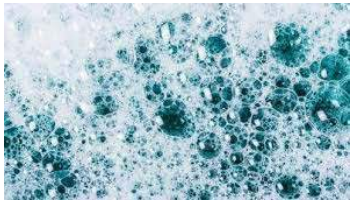
Sugar esters

World market: 10,000 T/year
Emulsifiers for cosmetics and food



CrodestaTM (Croda), products from Sisterna, …

Chemically produced: limited degree of polymerization (DP) for the glycon part which impacts hydrophilic-lipophilic balance, generation of undesirable molecules




Alkyl glycosides and sugar esters, non-ionic surfactants of interest

Wheat bran valorisation into surfactants

- **Wheat bran**, agricultural co-product from milling industries and 1G bioethanol industries
- Main use: **food** (fibers) and **feed**

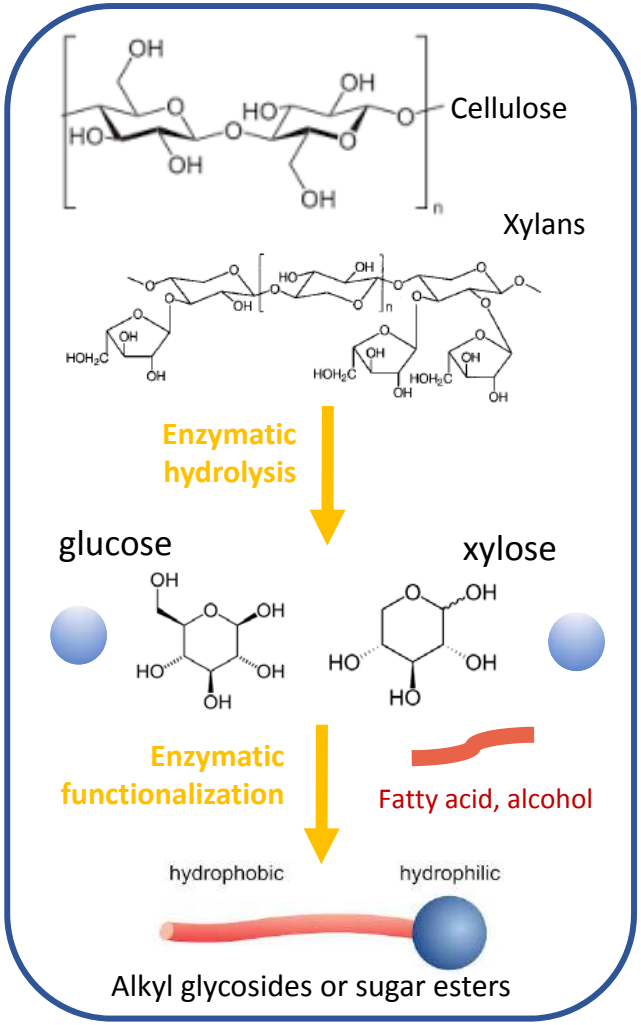
Enzymatic processes environmentally friendly

- Cellulose and xylans fractionation
- Functionalization of sugars from fractionation

Surfactants for high added-value applications

Cosmetics, food…

Wheat bran residues (+ cellulases-hemicellulases): feed



Partners


CATALISTI
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IAR
Laon
Reims

Overview of the project

Enzymatic synthesis of alkyl xylosides

Enzymatic transglycosylation

Wheat bran

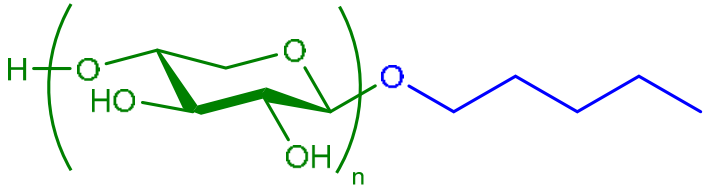
No pretreatment

xylanase

pentan-1-ol / H_2O

48h, 50°C

Example: synthesis of pentyl β-D-xylosides



n = 1 to 3

Enzymatic synthesis of alkyl xylosides

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- Synthesis efficient with wheat bran from Biowanze (Wanze, Belgium) and from ADM (Pomacle Bazancourt, France)

- Optimization of the transglycosylation reaction conditions:
- Pentyl β-D-xylosides : 4.9 g/L

  450 mg pentyl β-D-xylosides / g xylans present in wheat bran

  → *equivalent to transglycosylation performed from commercial xylans*

  Ochs et al. Green Chem., 2011, 13, 2380

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Enzymatic synthesis of alkyl xylosides

- Up-scaling of the reaction in a 2 liters reactor

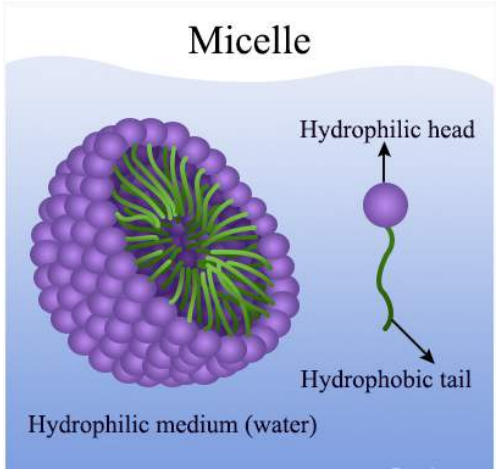
  → same yields of transglycosylation

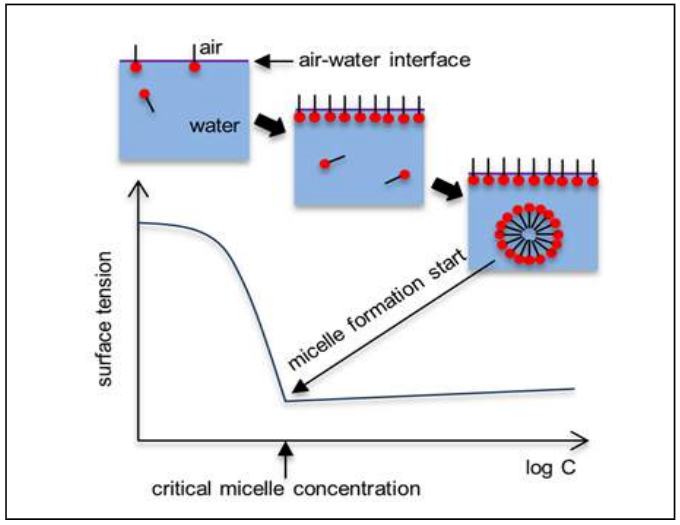
- Reaction efficient for the synthesis of alkyl β-D-xylosides with C chain lenghts from C3 to C10 (propan-1-ol to decan-1-ol)

Properties of the pentyl xylosides

Surface-active properties

- Capacity to decrease the surface tension (γ_{CAC})
- Aggregation behaviour: Critical aggregation concentration (CAC)



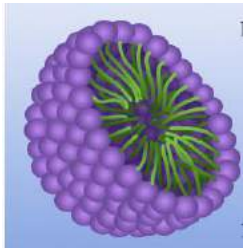


(CAC, γ_{CAC})

Properties of the pentyl xylosides

Surface-active properties - Results

Pentyl β-D-xylosides mixture	CAC ($mg.L^{-1}$)	γ_{CAC} (mN/m)
From WB 1	3089	59
From WB 2	2150	39



Literature (Bouxin *et al.*, 2010)

Octyl α/β-D-xylosides DP1 : CMC = 950 $mg.L^{-1}$

- Poor surface-active properties – longer alkyl chain (C8 or C10)
- But potential hydrotrope properties (under investigation)

Enzymatic synthesis of sugar esters

1st step : production of glucose and xylose hydrolysates from wheat bran

Wheat bran

No pretreatment

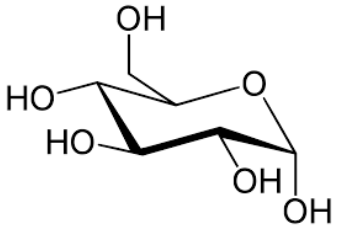
Wheat bran from BIOWANZE (Wanze, BE) and from ADM (Pomacle-Bazancourt, FR)

Enzymatic hydrolysis

H_2O, 50°C

No additives

D-glucose



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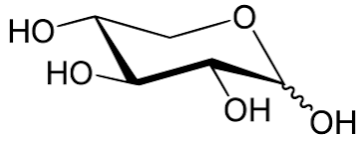
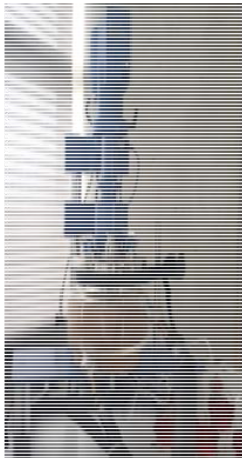
D-xylose



According to enzyme loading and reaction duration:
50 to 100% of glucose and xylose released



Hydrolysate rich in glucose and xylose

Starch and wheat bran residues

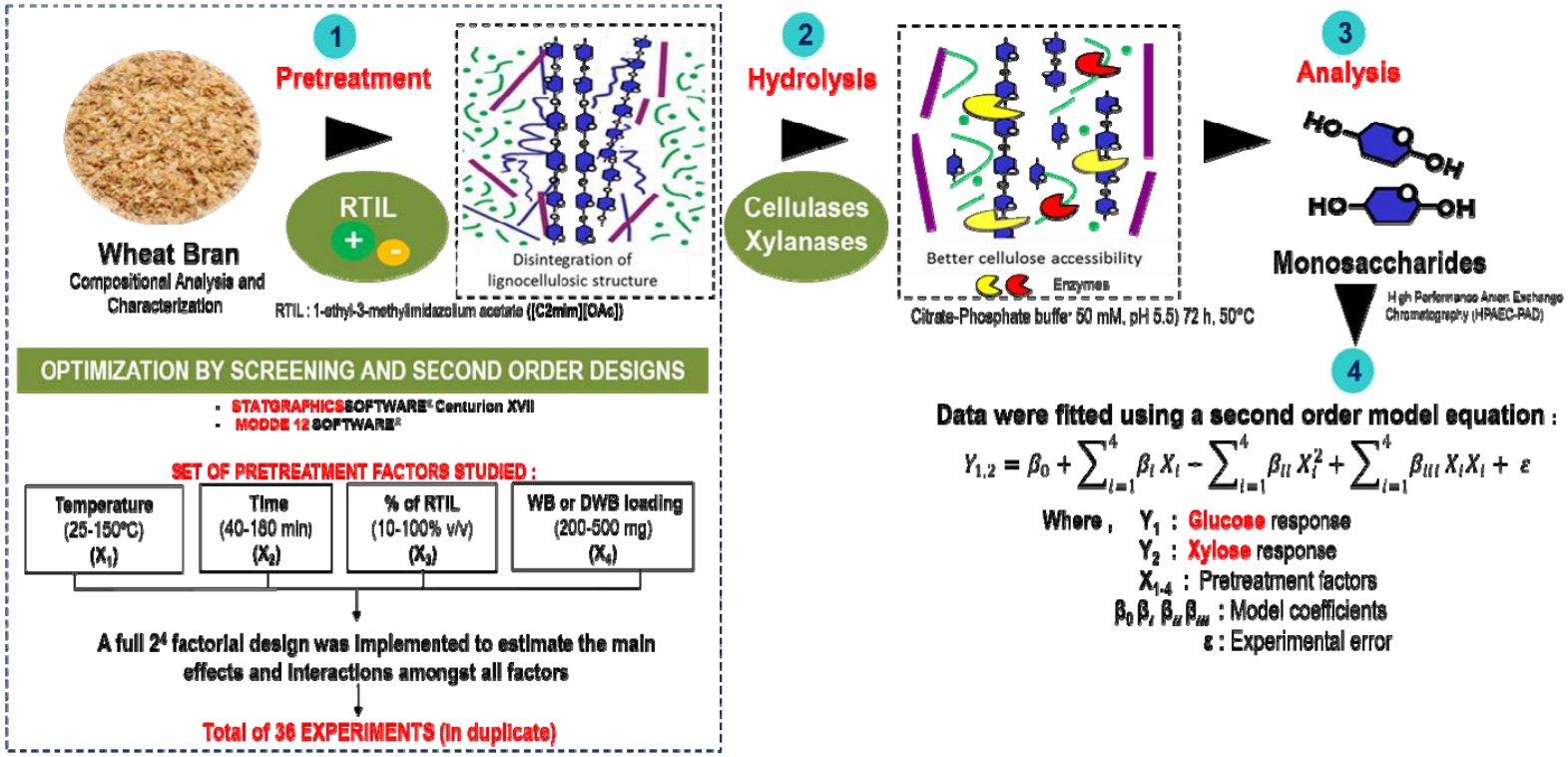
Enzymatic synthesis of sugar esters

1st step : production of glucose and xylose hydrolysates from wheat bran

Scientific and technological lock: recalcitrance properties of wheat bran

▼

Prescribed solution: Room Temperature Ionic liquid (RTIL) pretreatment prior enzymatic hydrolysis

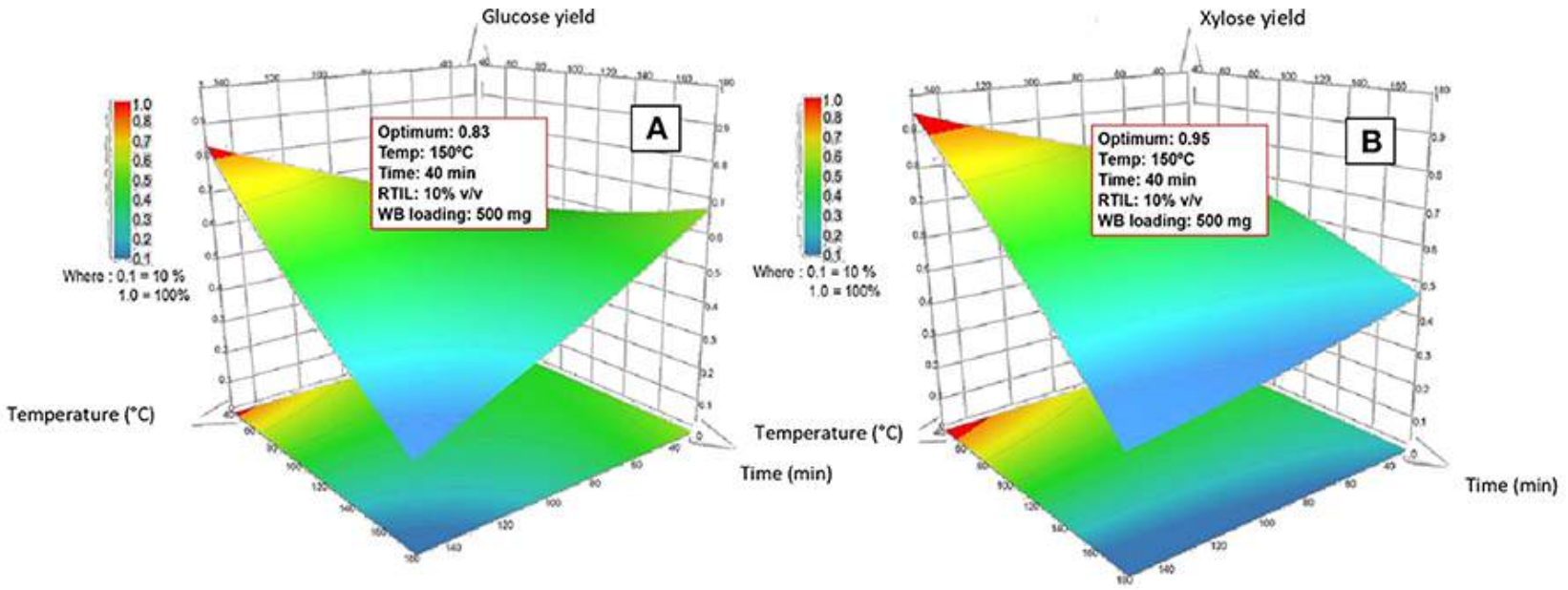


Optimization of conditions pretreatment by PLS-Surface Response Design

Enzymatic synthesis of sugar esters

1st step : production of glucose and xylose hydrolysates from wheat bran

Response surface plots of sugar (A: glucose, B: xylose) release after enzymatic hydrolysis



Optimal conditions of pretreatment: diluted-[C2mim][OAc] in water (10 % v/v) at 150 °C for 40 min

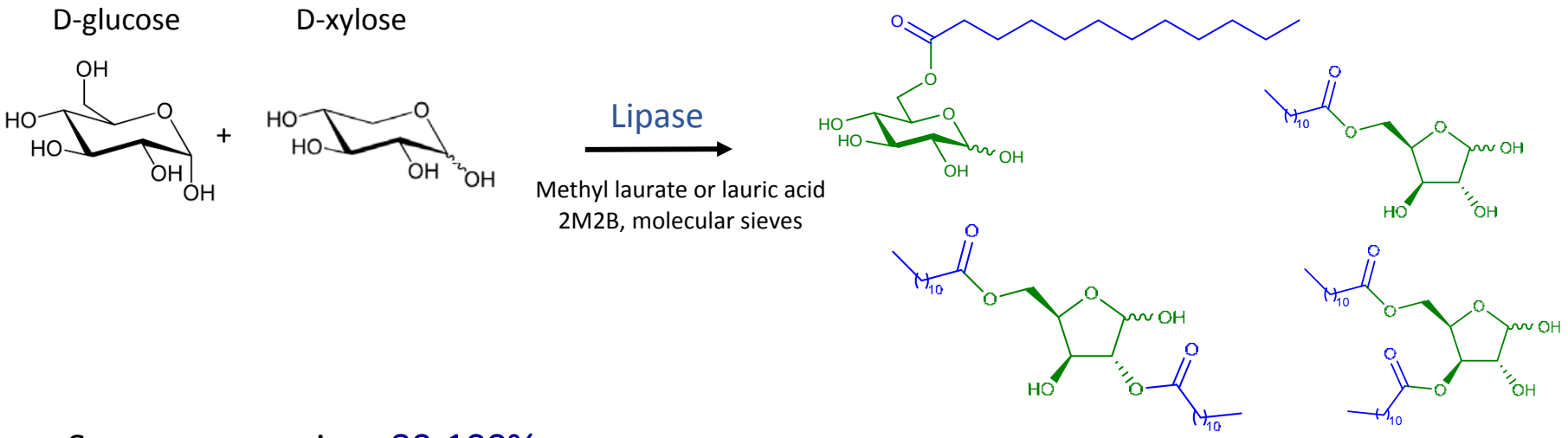
Competitive yields achieved: $Y_{glucose}$ = 83 % and Y_{xylose} = 95 %

Araya-Farias *et al*. (2019). Frontiers in Chemistry. 7:585

Enzymatic synthesis of sugar esters

2nd step : production of sugar esters from glucose and xylose hydrolysates

Example: synthesis of laurate glucose and xylose esters



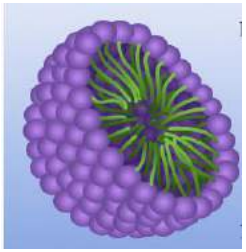
- Sugars conversion: 80-100%
- Modulation of glc esters and xyl esters ratios and of mono- and diesters ratios according to D-glc/D-xyl ratio (hydrolysate) and reaction conditions
- (Trans)esterification efficient with fatty acids and fatty acids esters with C chain lenght from C8 to C18

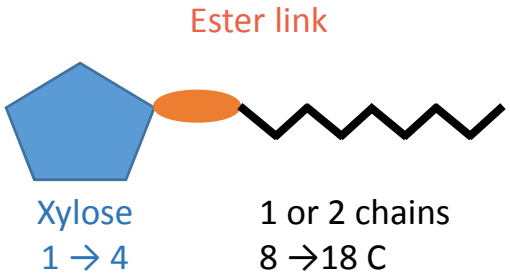
Méline *et al*. Enz. Microbial. Technol. 2018

Properties of the sugar esters

Surface-active properties

- Structure-activity relationships of purified molecules from (trans)esterification reactions





XC8	Xylose octanoate monoester
X(C8)2	Xylose octanoate diester
XC12	Xylose laurate monoester
XC14	Xylose myristate monoester
XC18	Xylose stearate monoester
X2C12	Di-Xylose laurate monoester
X3C12	Tri-Xylose laurate monoester
X4C12	Tetra-Xylose laurate monoester
XyC12	Xylo-oligosaccharides laurate monoesters

Number of alkyl chains

Length of alkyl chains

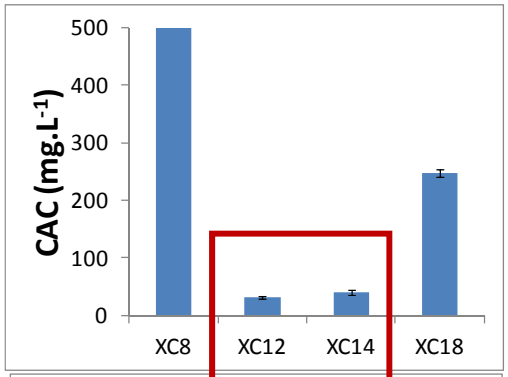
Number of xylose residues

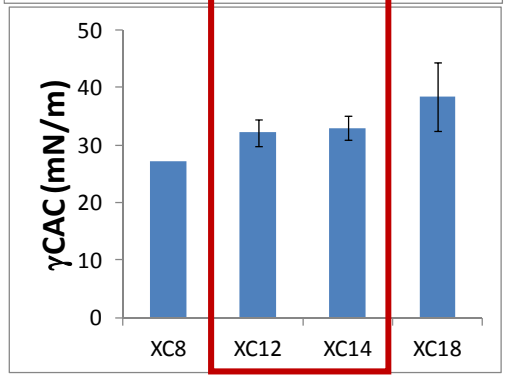
Properties of the sugar esters

Surface-active properties

➢ Structure-activity relationships of purified molecules- Results

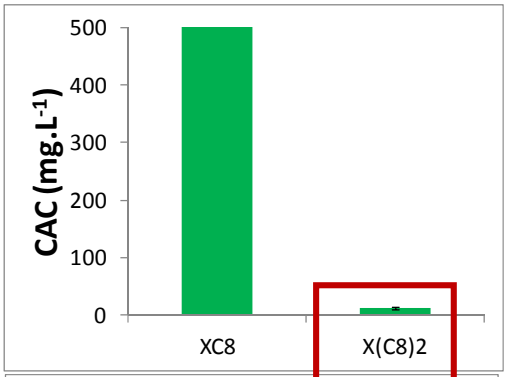
Length of alkyl chains

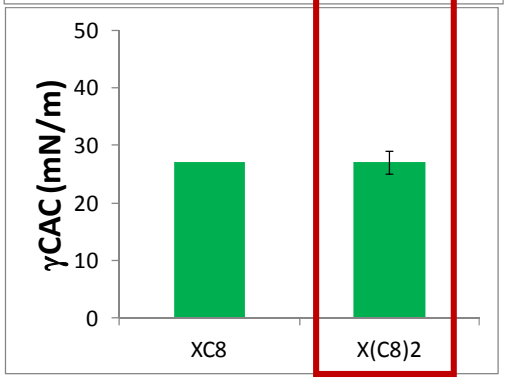




Middle chain length

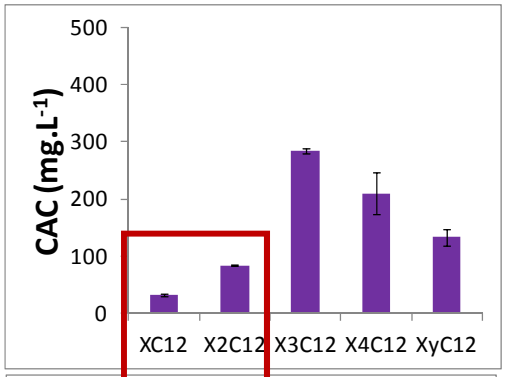
Number of alkyl chains

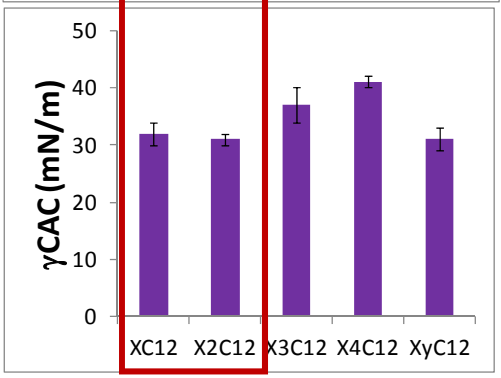




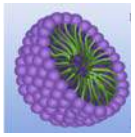
Two alkyl chains

Number of xylose residues

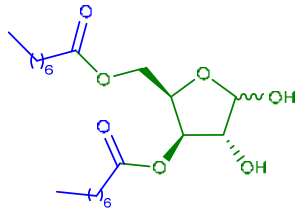




Limited number of xylose residues



The best candidate:

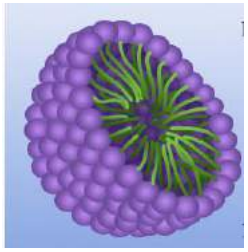


X(C8)2
Xylose octanoate diester

Properties of the sugar esters

Surface-active properties

- Structure-activity relationships of **mixtures from (trans)esterification reactions obtained from wheat bran**

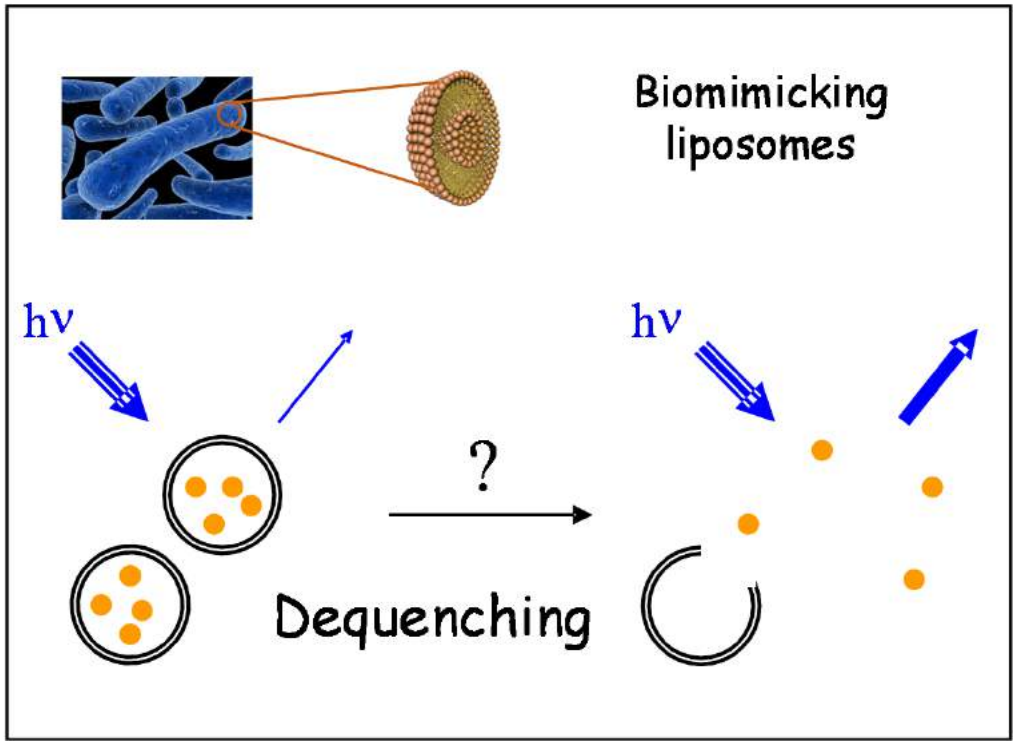


D-glc and D-xyl lauryl esters mixture	CAC ($mg.L^{-1}$)	γ_{CAC} (mN/m)
Mixture with mono-esters mainly	44.4	24.4
Mixture with di-esters mainly	48.3	27.5

Properties of the sugar esters

Potential as antibacterial agent

- Permeabilization of bacterial plasma membrane



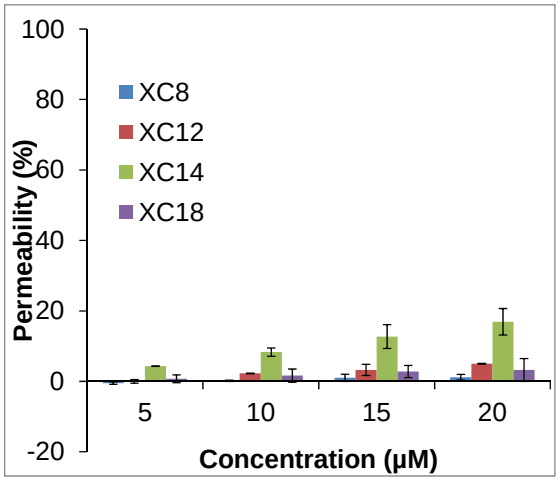
Properties of the sugar esters

LIÈGE université Gembloux Agro-Bio Tech

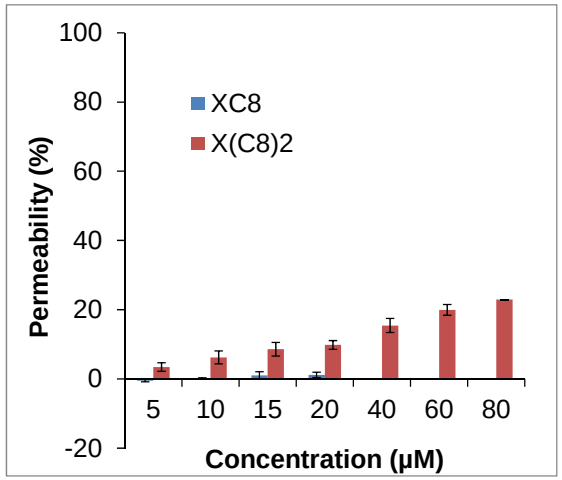
Potential as antibacterial agent

➢ Permeabilization of bacterial plasma membrane - Results

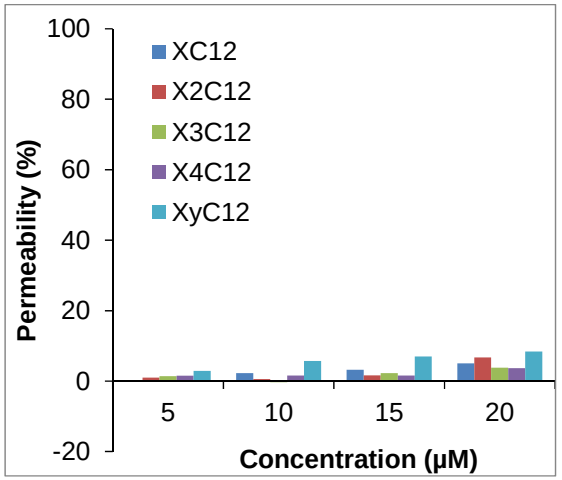
Length of alkyl chains

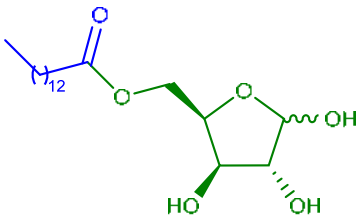


Number of alkyl chains

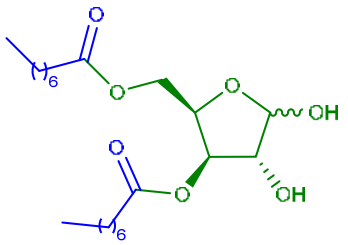


Number of xylose residues





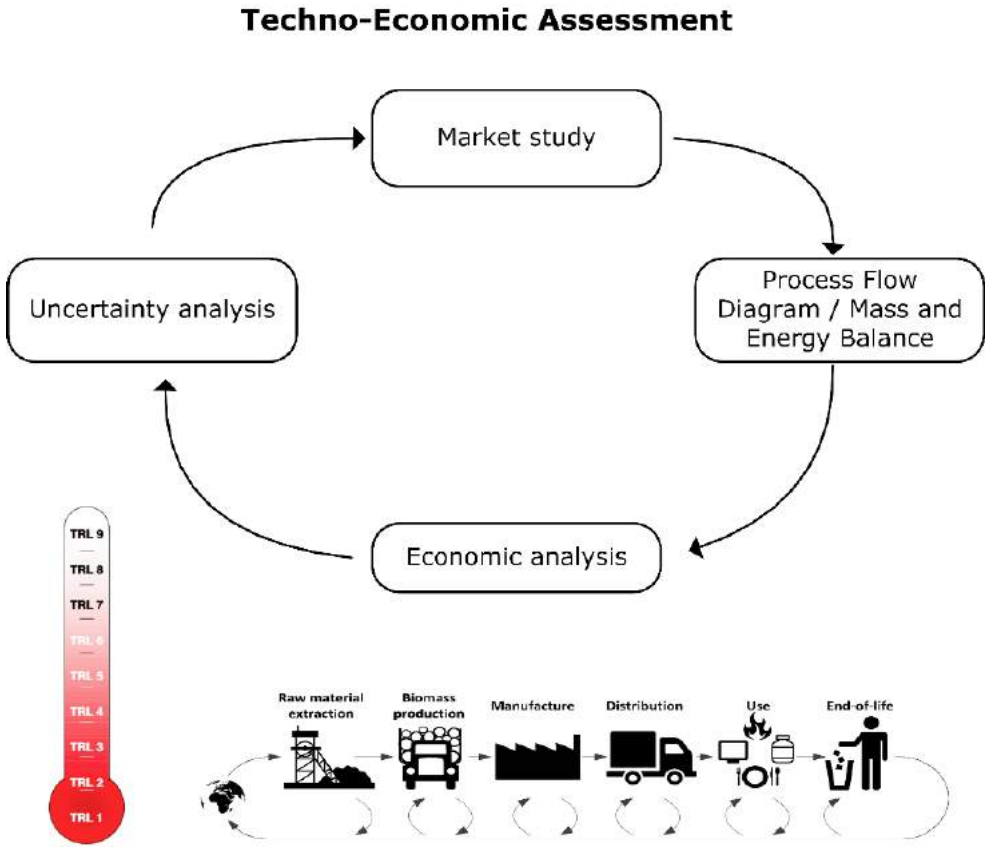
- Moderate permeability of bacterial membranes
- The best candidates : XC14 and X(C8)2



TEA - TECHNO-ECONOMIC ASSESSMENT

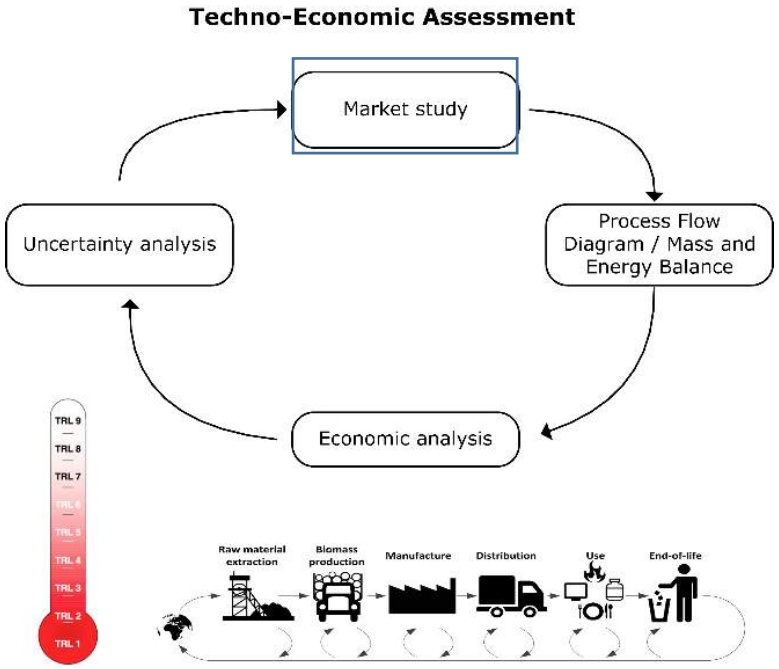
by **Yamini Satyawali**
VITO, Flemish Institute for Technological Research

Techno-economic assessment

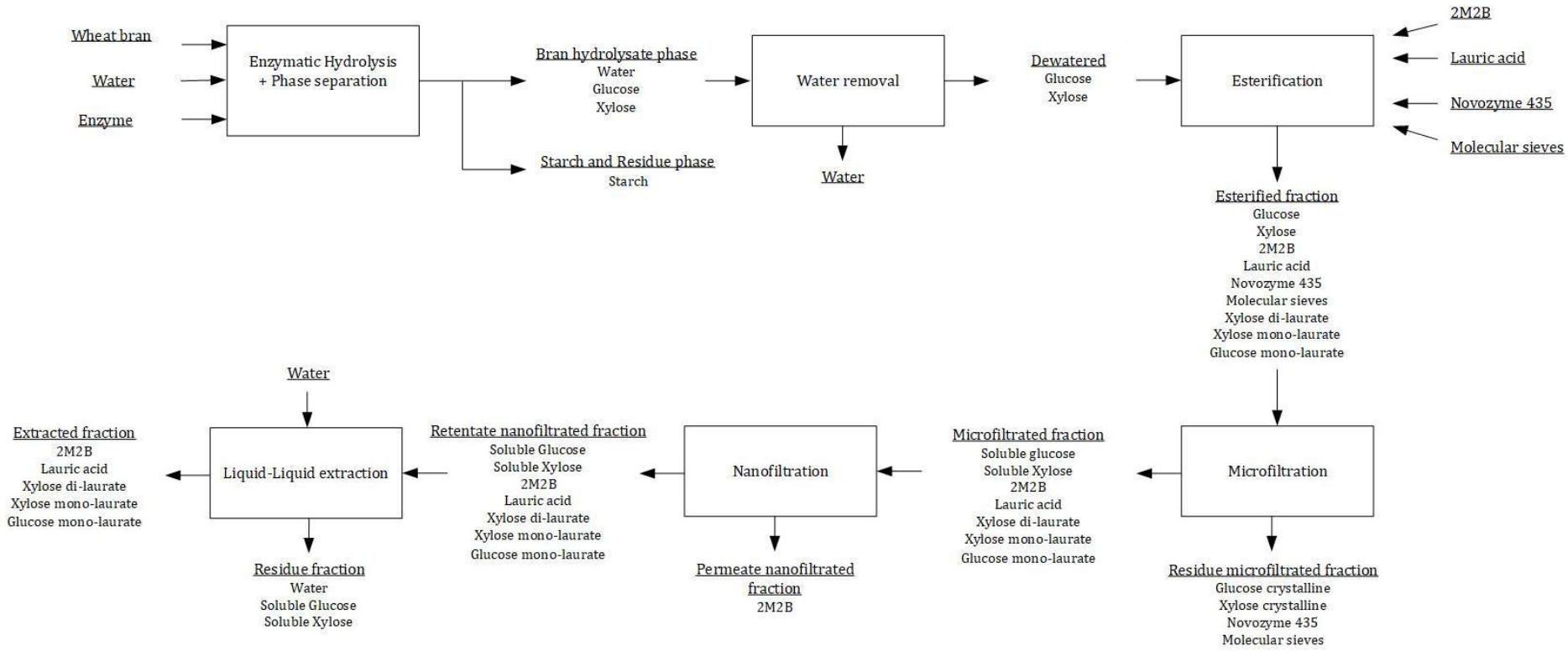


Techno-economic assessment – Market study

- Market study collects information on e.g.
  - Market demand and growth
  - Product characteristics
  - Prices
  - Competitors
  - Legal aspects
  - …



Techno-economic assessment – Technical assessment



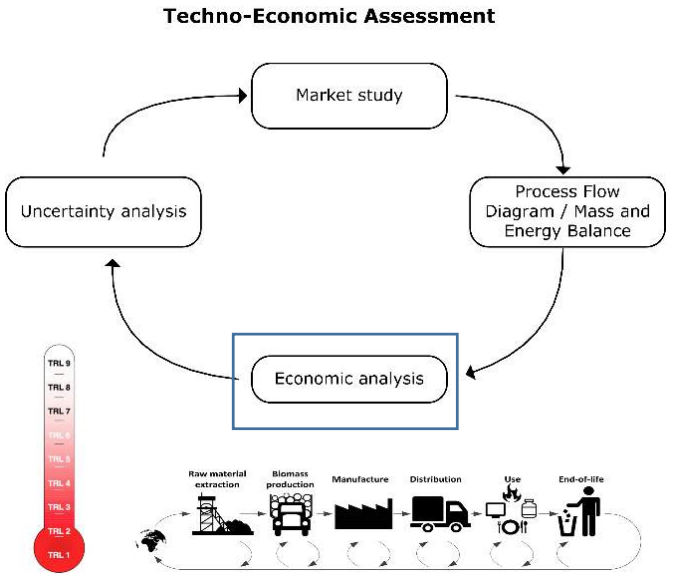
Techno-economic assessment – Economic assessment

- Economic Assessment

  Calculation of:
  - CAPEX
  - OPEX
  - Revenues

  →Integrated with Mass and Energy balance

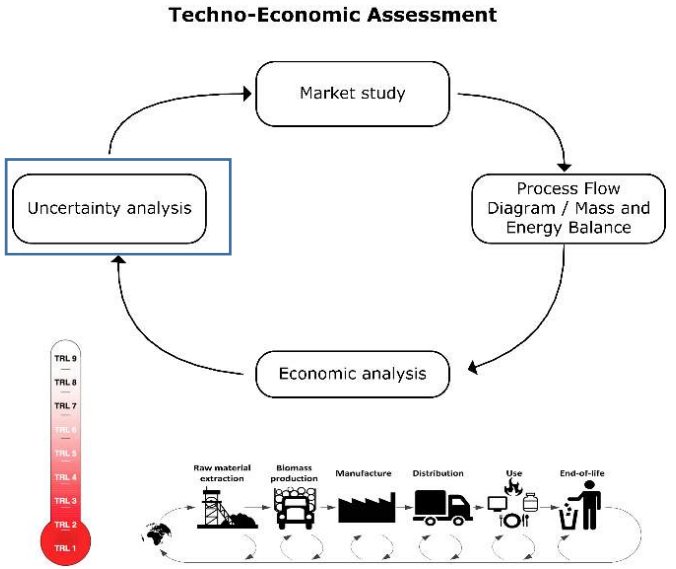
  Result:
  - Production cost
  - Investment criteria such as Net Present Value, Internal Rate of Return and (Discounted) Payback Period



Techno-economic assessment – Uncertainty

- Uncertainty analysis
  - Many uncertainties in technical and economic parameters
  - Monte Carlo assessment to see which parameters have the highest impact on e.g. the production cost or NPV

→ For the most important parameters: Can we improve them?
  - If yes, how would it impact the viability?
  - If no, do we have alternatives available?



Bio-based surfactants from ValBran: Opportunities for testing applications

Under progress: technological transfer - WP6

- Economical feasability (TEA)
- Environmental impact (LCA)

Surfactants from ValBran can be provided to companies for evaluation

Contact: caroline.remond@univ-reims.fr

Interreg
France-Wallonie-Vlaanderen
ValBran

Janvier 2017 – Décembre 2020

Januari 2017 – December 2020

Coût total : 1.745.826,28 € | Financement FEDER : 872.913,12 €

Totale kost : 1.745.826,28 € | EFRO-financiering : 872.913,12 €

Avec le soutien du Fonds européen de développement régional, de la Région Grand Est, de la Wallonie et de la Province West-Vlaanderen.

Met steun van het Europees Fonds voor Regionale Ontwikkeling (EFRO), Grand Est, Wallonië en Vlaanderen.

European Union
European Regional Development Fund

Grand Est
ALSACE CHAMPAGNE-ARDENNE LORRAINE

west-vlaanderen
de gedreven provincie

Wallonie

Merci pour votre attention

Dank u wel voor uw aandacht

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