9th International Conference on Sustainable Solid Waste Management

Organic waste valorisation into bioenergy and bioproducts through a cascade combination of bioprocesses

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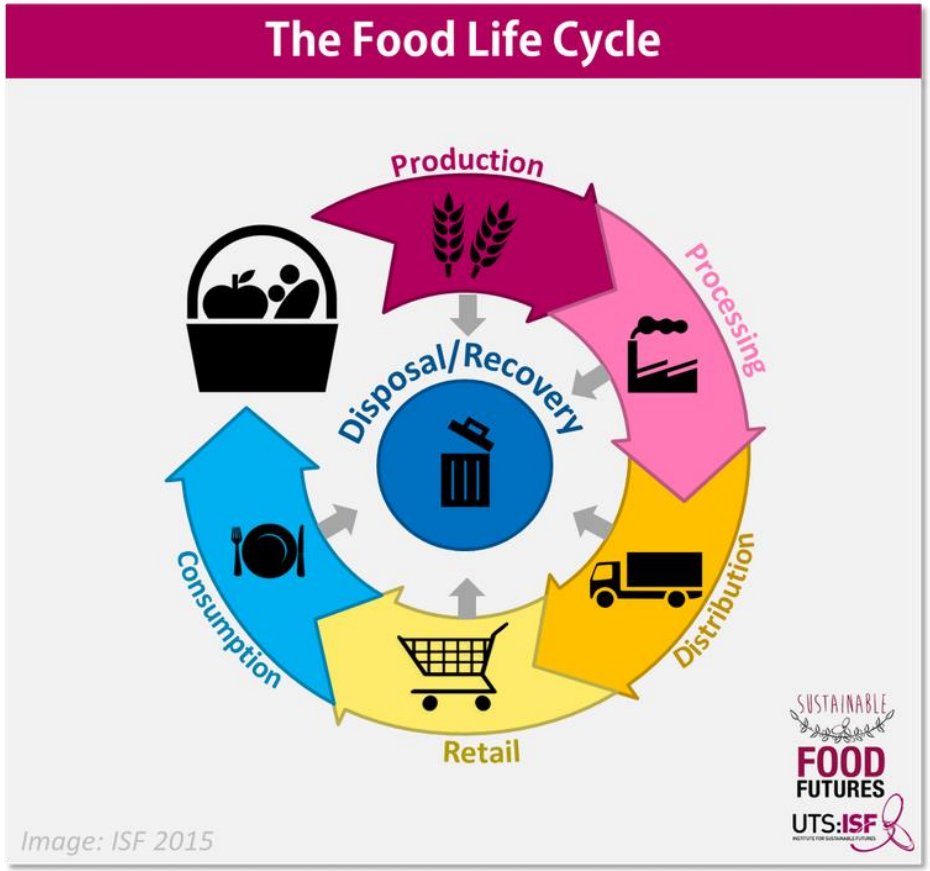
FOOD WASTE…. A BIG ISSUE

Food is lost in every step of the food "life cycle"



World wastes about 17 % of all the food produced (United Nations)

1 billion tonnes of food waste is generated per year

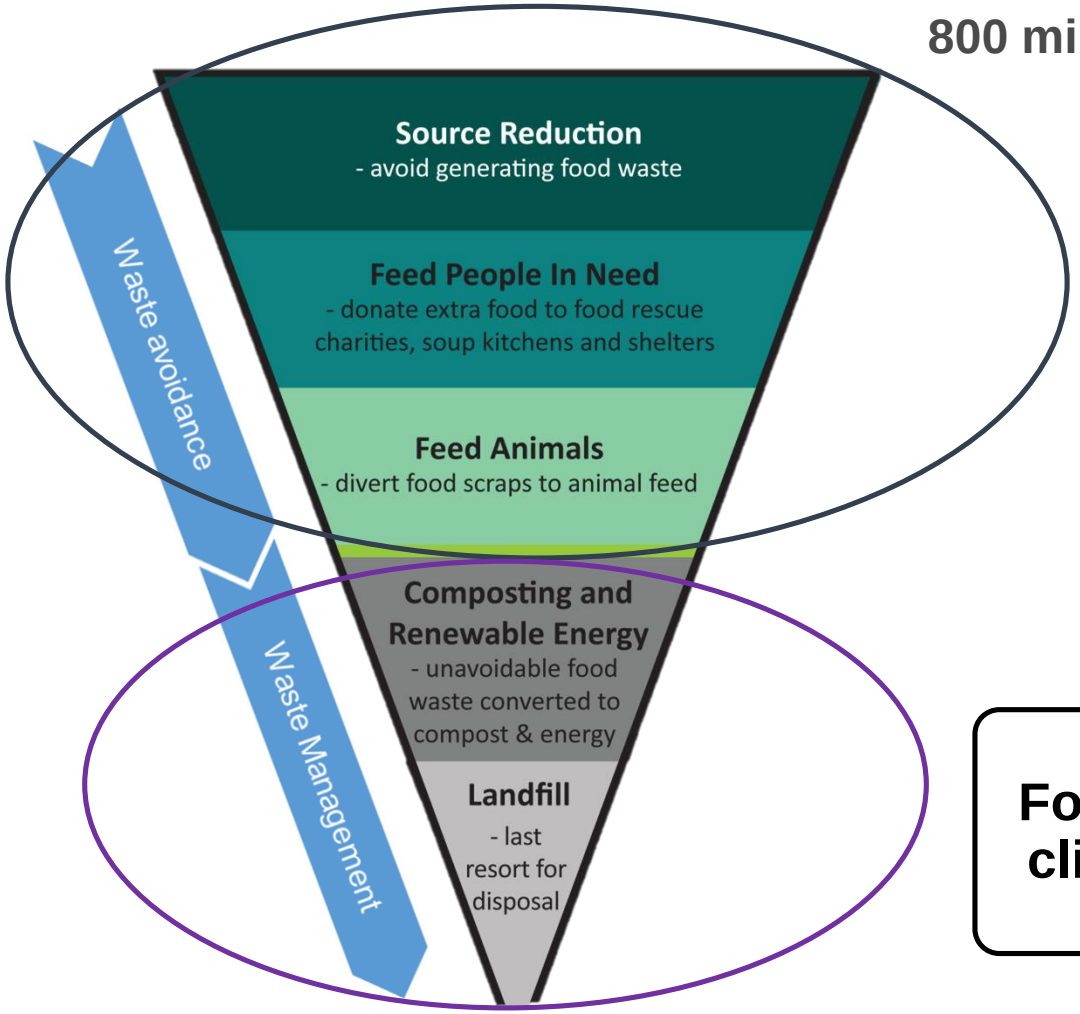
Production, processing and consumption are responsible for 75%

Fruits and vegetables wastes generated in the early stage of the food supply chain account for 30 % of annual food losses in Europe

FOOD WASTE…. A BIG ISSUE

RETHINK THE WAY THAT FOOD IS PRODUCED AND CONSUMED

800 million people suffer from hunger and undernourishment



Food waste and water resources

25% of the world's freshwater is used to grow food

Food waste and land

28% of the world's total agricultural area

Food waste and climate change

30% of greenhouse gas emissions

High management cost

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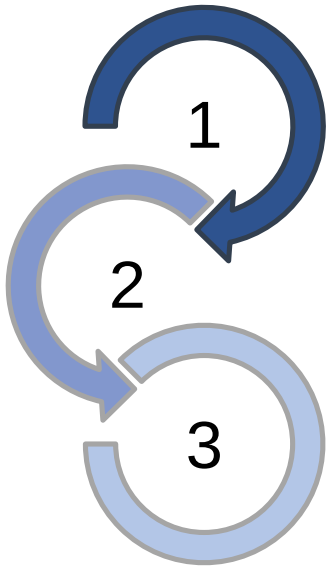
Biotechnological Processes Unit

Recover C (N & P) from wastes for energy and biochemicals production purposes



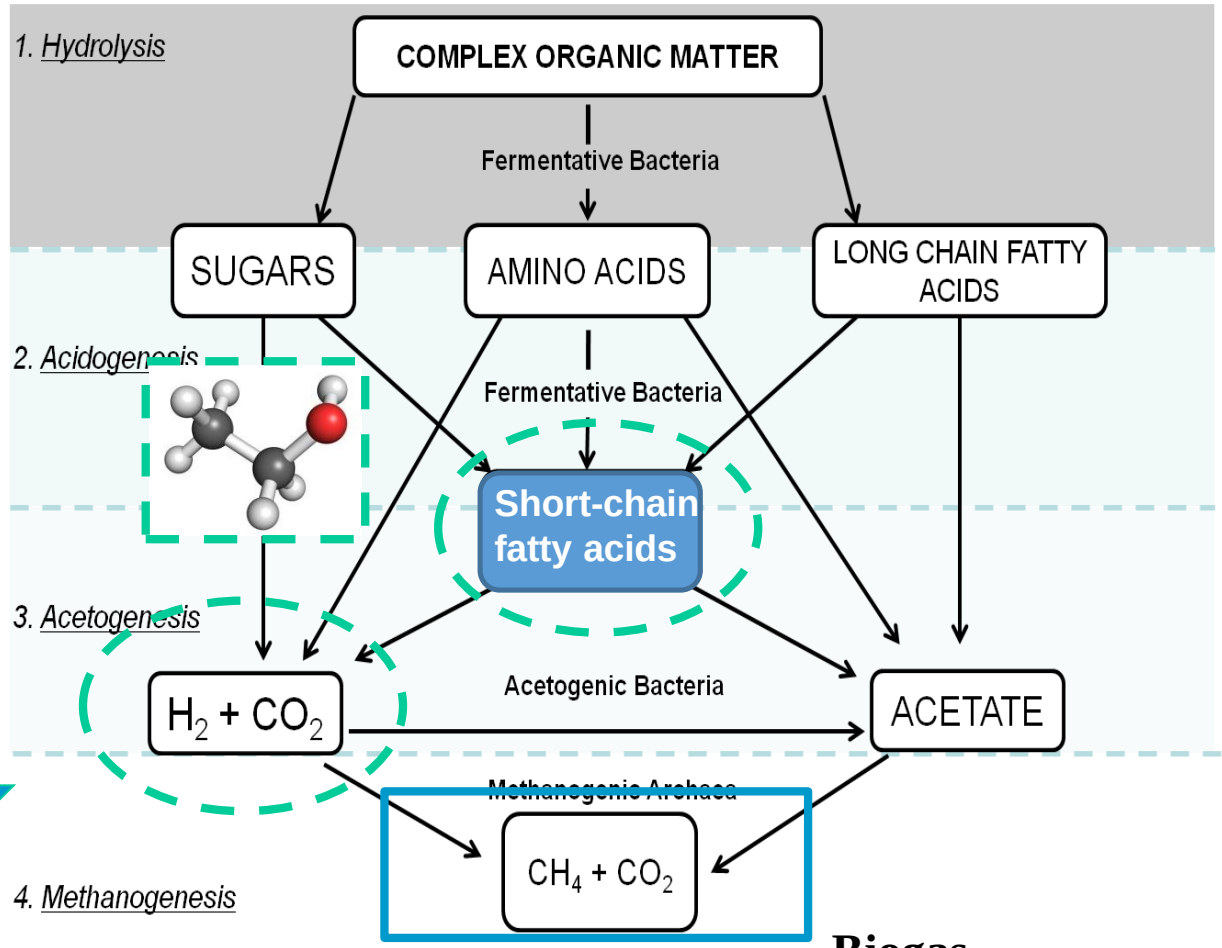
Develop bioprocesses that allows maximizing product portfolio (biorefinery)

Identification of microbial indicator of process efficiency

Improve the robustness of microbial systems (evolutionary engineering)

FOOD WASTE…. A RESOURCE

Anaerobic digestion



Biogas

Short-chain fatty acids (SCFAs):

- Acetic acid
- Propionic acid
- Butyric acid
- Valeric acid
- Hexanoic acid

Hydrogen (H_2)

Ethanol (EtOH)

Maximum organic wastes valorization

Cascade combination of bioprocesses

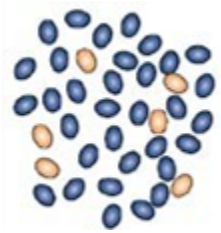
Organic waste

80% Carbohydrates
8% Proteins

Anaerobic Fermenter

1

T = 55 ºC
HRT = 21 d
OLR = 2.3 g SV/L d
pH = 5.8



Inoculum adapted to temperature

SCFAs rich effluent

Solid spent

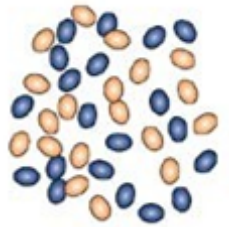
50% Carbohydrates
40% Proteins

Anaerobic Digester

2

Biogas

T = 35 ºC
HRT = 20 d
OLR = 1,4 g COD/L d
pH = 7



Inoculum adapted to temperature + pH

Bioproducts

+ Bioenergy

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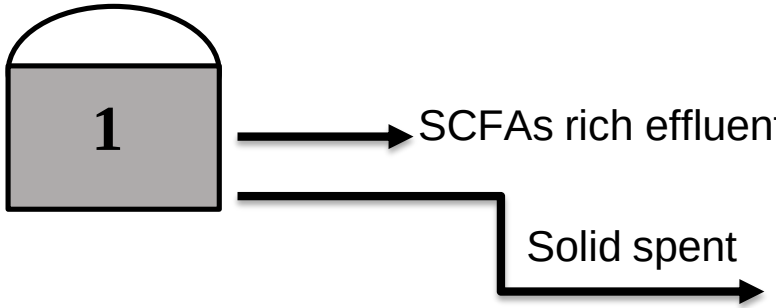
Cascade combination of bioprocesses

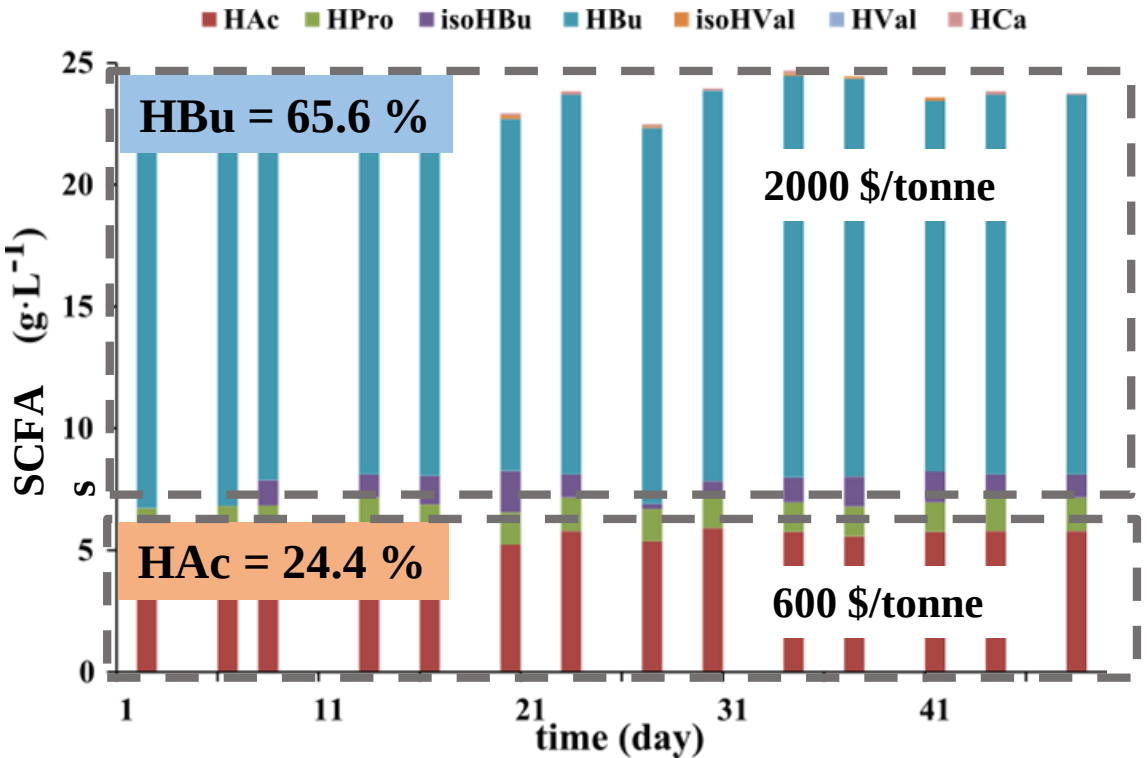
Anaerobic fermenter:
1. 50 % bioconversion into organic acids
2. **22 g EtOH / L**
3. **140 L H_2/kg organic matter**

Organic waste

80% Carbohydrates
8% Proteins

Anaerobic Fermenter



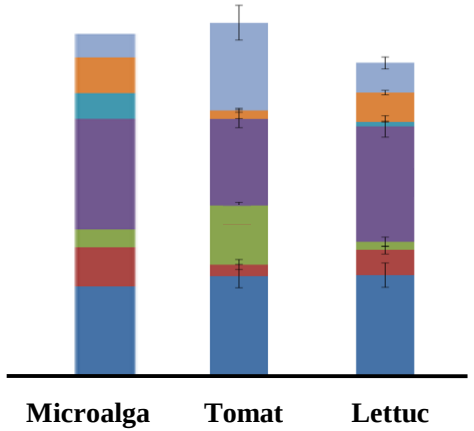


Total SCFAs = 24 g/L
Bioconversion = 50 %

vs.

Common values in literature 18 – 35 %

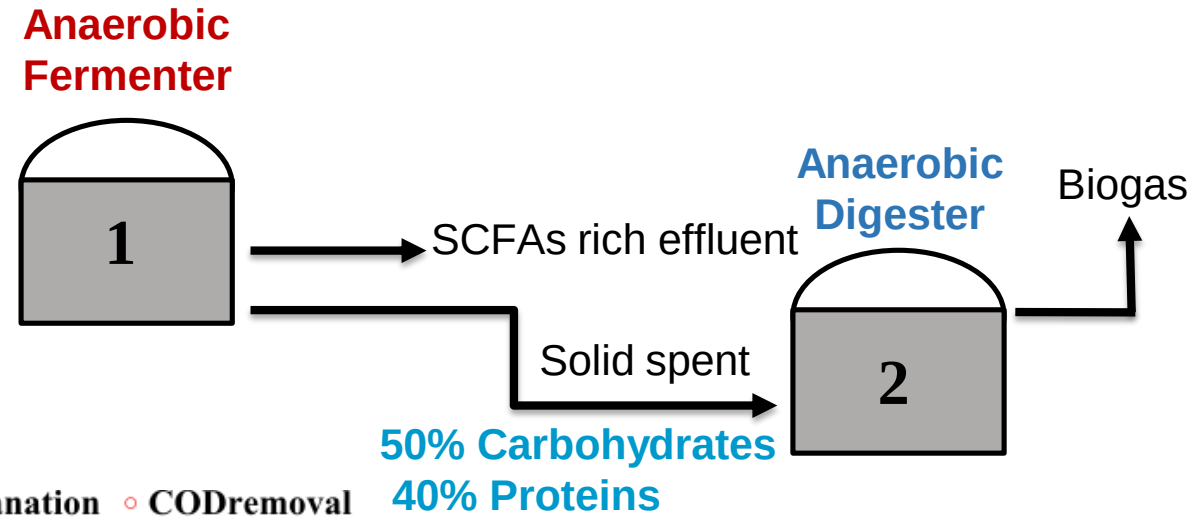
Previous studies



Greses et al., 2020. *Bioresource Technology*. https://doi.org/10.1016/j.biortech.2019.122486

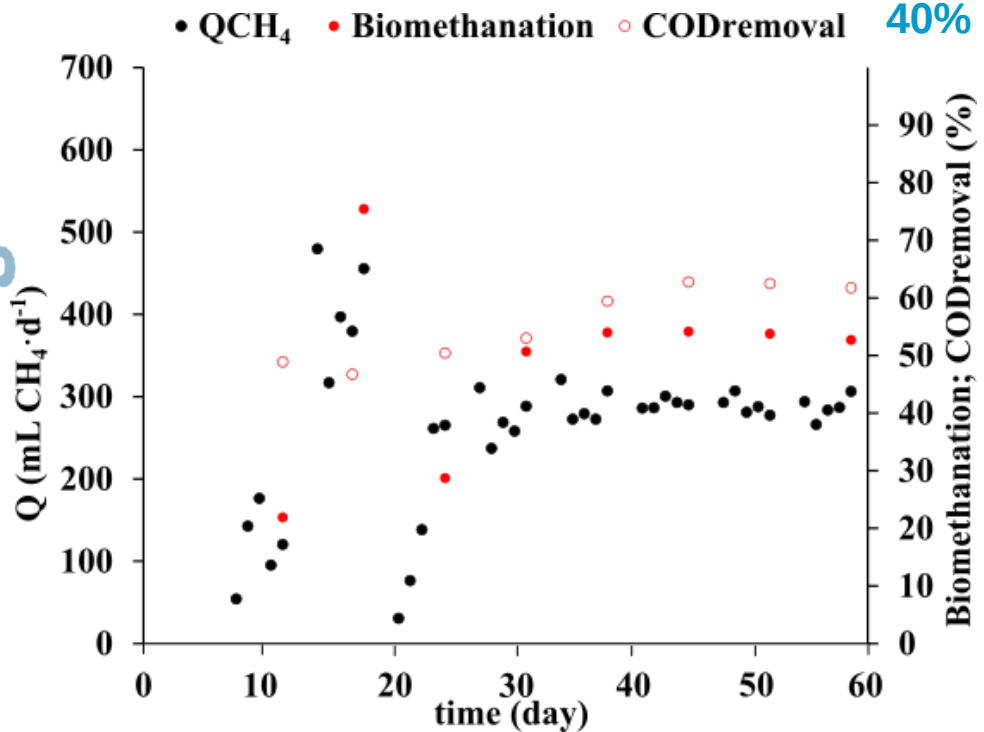
Cascade combination of bioprocesses

80% Carbohydrates
8% Proteins



Anaerobic fermenter:
1. 50 % bioconversion into organic acids
2. **22 g EtOH / L**
3. **140 L H_2/kg organic matter**

Anaerobic digester:
4. 190 L CH_4/kg organic matter
5. **Digestate → biofertilizer**



CH_4 = 190 L CH_4/kg COD_{FW}
300 L CH_4/kg VS_{FW}

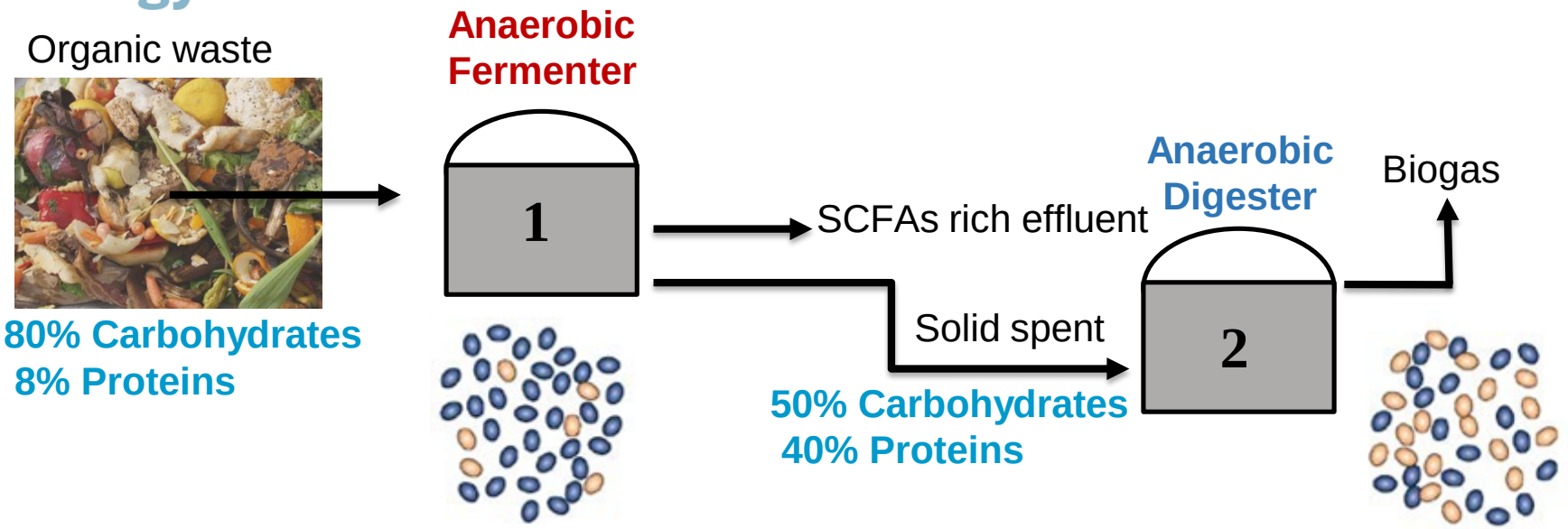
54% Biodegradibility

vs.

Common values
in literature for RAW organic waste
350-400 L CH_4/kg VS_{FW}*

*Renewable and Sustainable Energy Reviews 133, (2020) 110138

Microbial community analysis



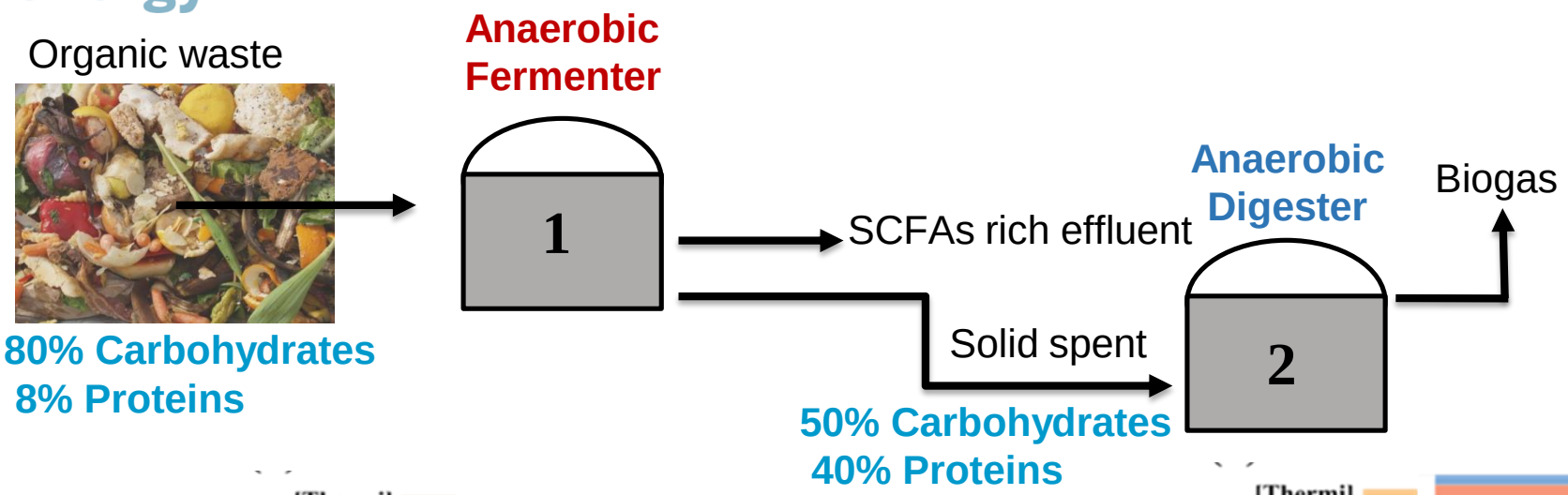
BIODIVERSITY

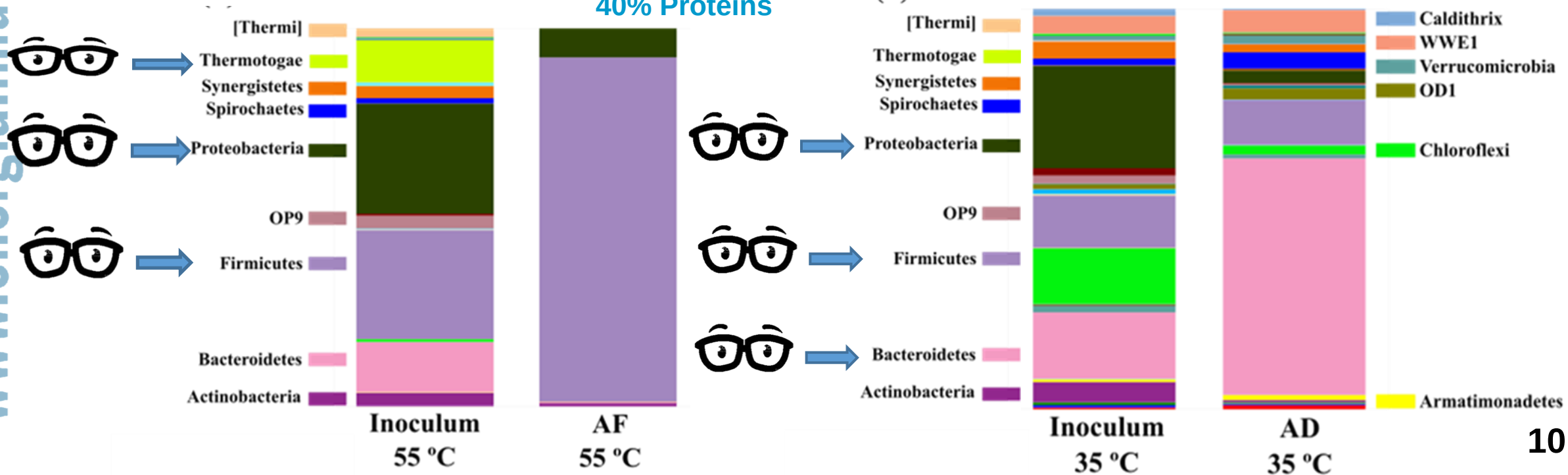
Inoculum 55 ºC	AF 55ºC	Index	Inoculum 35 ºC	AD 35 ºC
1098	119	Observed OTUs	895	544
6.736	2.500	Shannon	6.975	5.148

Adapted to temperature but not to pH

Adapted to temperature but not to substrate

Microbial community analysis





Microbial community analysis

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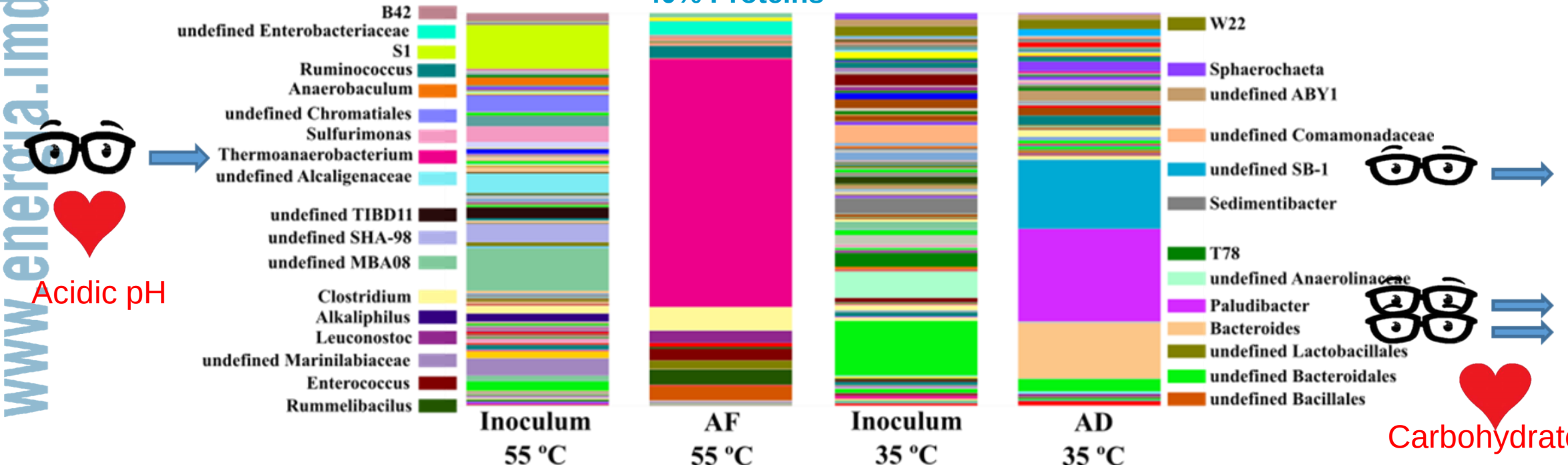
GENUS

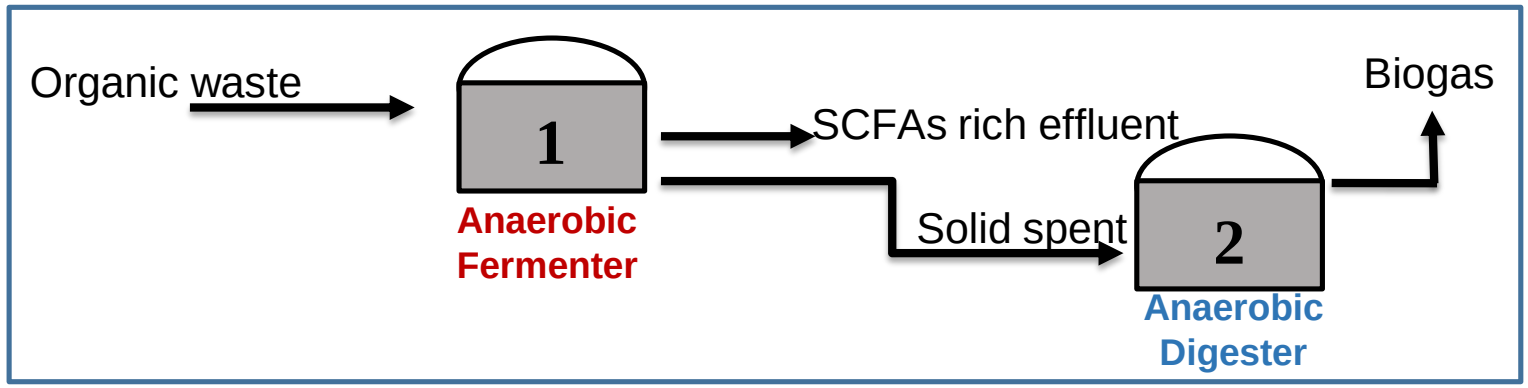


Acidic pH

Carbohydrates

FINAL REMARKS

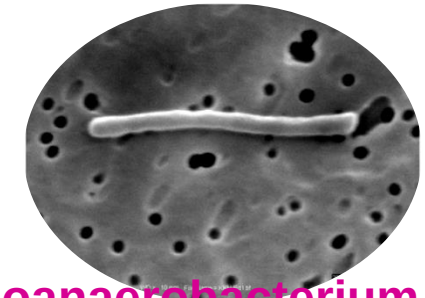
- **Cascade combination of bioprocesses**



5

- SCFAs
- Ethanol
- H_2
- Biogas
- Biofertilizer

- **pH tuning can mediate product selection by promoting specific microorganims with high industrial interest**



Thermoanaerobacterium

Think about AD as a multiproduct technology

Thanks for your attention

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Acknowledgements

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