SMIBIO Case Study in Germany - Green Biorefineries in the Bavarian region of Straubing-Bogen (a case study in progress)

SMIBIO Workshop
Small-scale Biorefineries for Rural Development in Latin America and Europe

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WIP Renewable Energies, Germany

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Green biorefineries – concept and classification

A green biorefinery processes fresh wet biomass, such as grass, clover, alfalfa or immature cereals. First processing of wet biomass involves dewatering (e.g. screw press) to obtain two separate intermediates:

A nutrient-rich juice "Organic Solutions" (press juice) and

a fibre-rich lignocellulosic press cake

Both intermediates are starting points for various valorization pathways.

(Source: IEA Bioenergy Task 42)

The organic solutions (press juice) contains valuable compounds, such as carbohydrates, proteins, free amino acids, organic acids, minerals, hormones and enzymes depending on the used feedstock (fresh biomass or silage).

Soluble carbohydrates and proteins can be used as fermentation medium or for generating feed products.

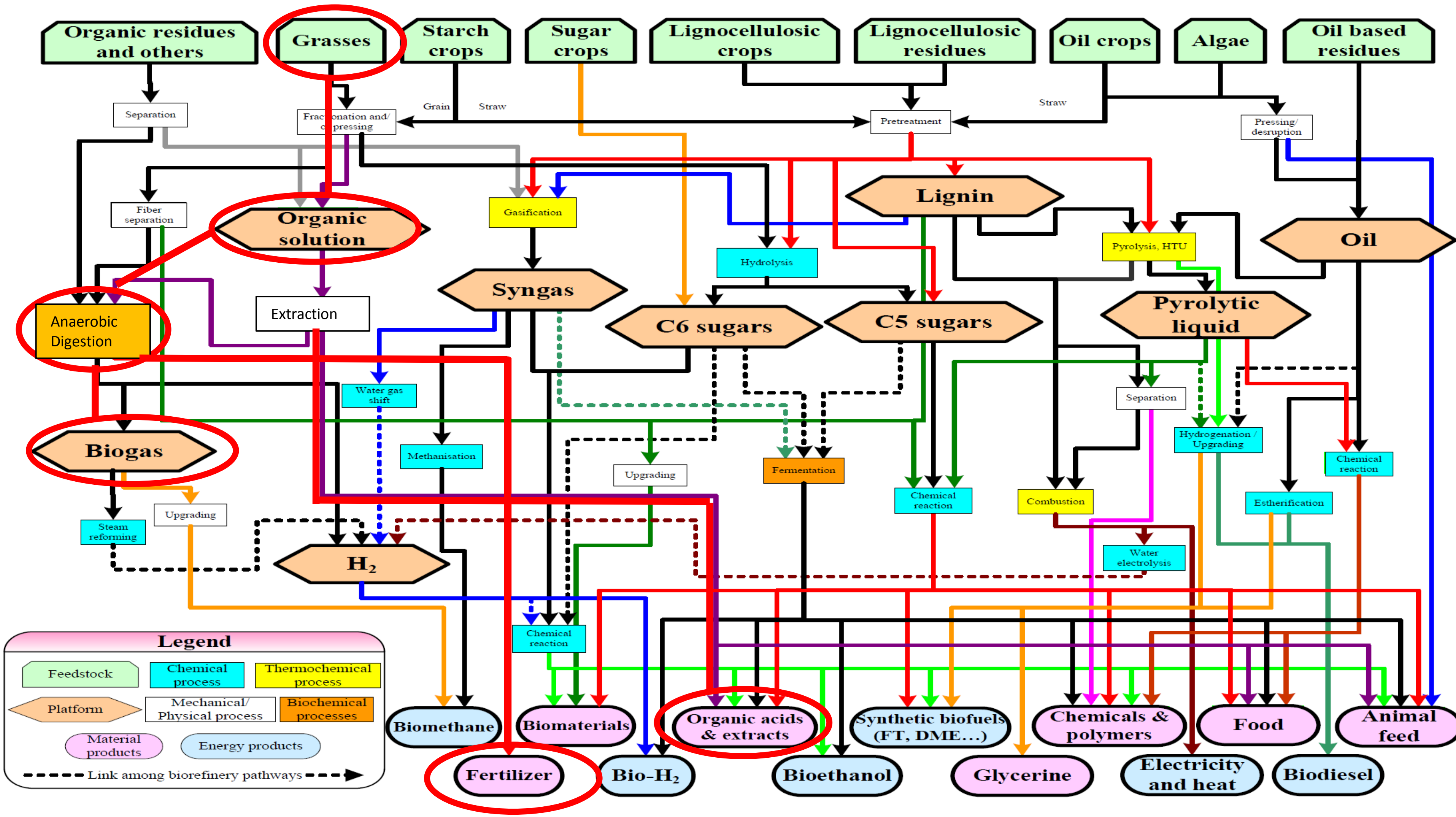
Silage juice has been demonstrated as feedstock for bio-chemicals and fuels production. Lactic acid and its derivatives as well as proteins, amino acids, bioethanol and energy via AD are the most favorable end-products.

The press cake fibres can be used as green feed pellets, processed to fibre products (e.g. insulation material) or used as raw material for other platforms (e.g. C6 and C5, syngas and lignin).

Green biorefinery = Product driven biorefinery

- Target: production of chemicals, materials, food and feed; side-products are used for energy production (power/heat)
- Only few new facilities in operation yet
- Key technologies often still at R&D phase
- High potential (interested stakeholders, advanced properties)

Classification system - IEA Bioenergy Task 42



Source: IEA Bioenergy Task 42

Setting of the German case study

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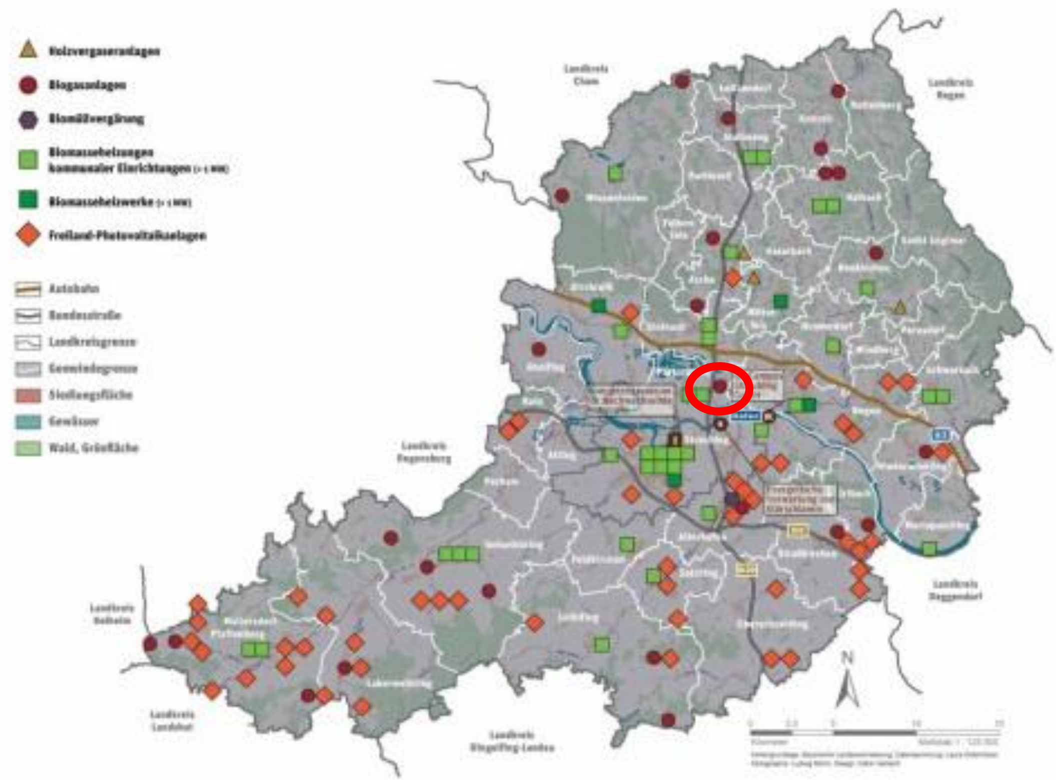
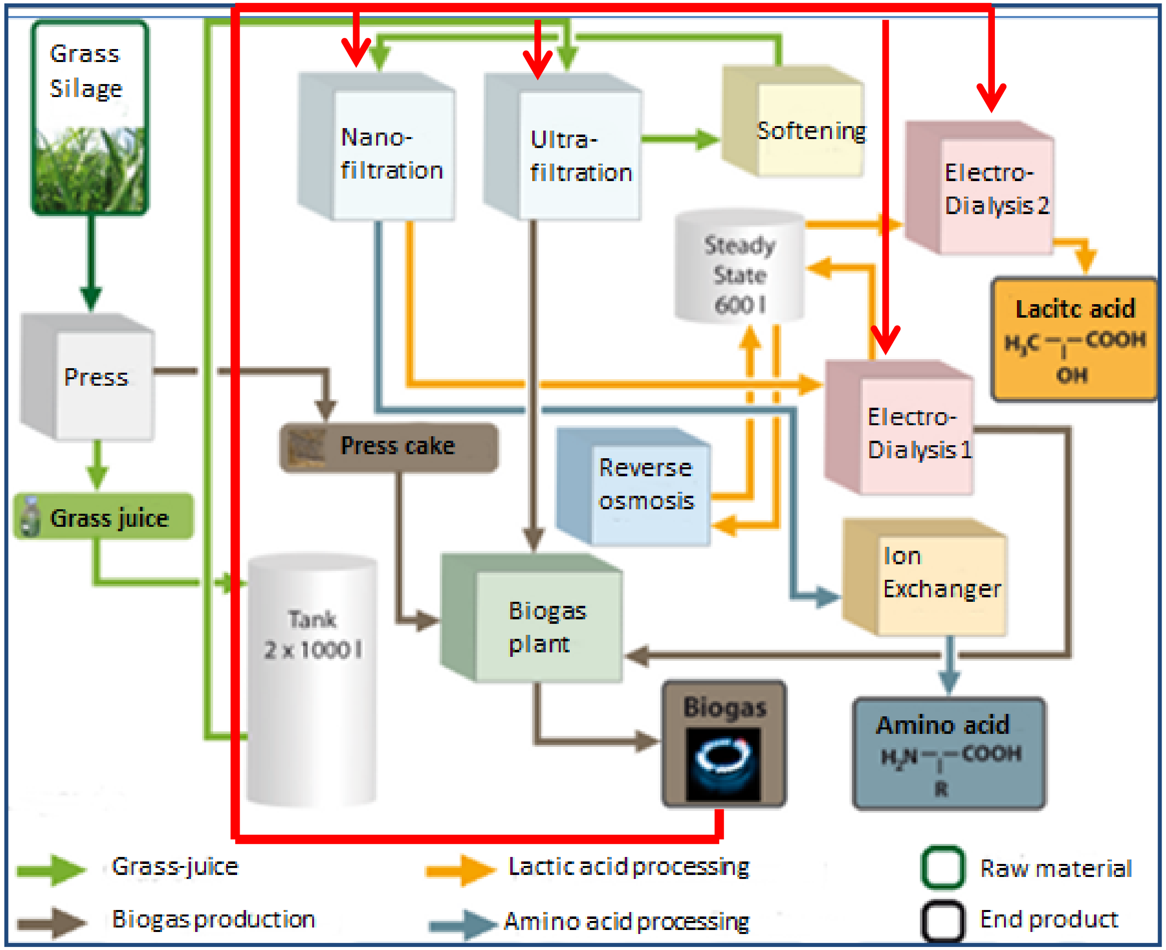
Setting of the German case study

Favored location next to an existing biogas plant close to Straubing, Bavaria

Logistics could be included in already existing scheme (optimisation of supply chain)



Overview of the process



Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

Technical concept – the feedstock

		g/mol	Formula	Content in silage juice, [g/L]
Anorg. ions				**26,09**
	Ammonium	18,039	NH4+	0,68
	Potassium	39,102	K+	11,66
	Magnesium	24,3	Mg++	0,55
	Calcium	40,08	Ca++	1,54
	Chloride	35,453	Cl-	4,13
	Nitrate	62,007	NO3-	1,70
	Phosphate	94,974	PO4--(-)	3,62
	Sulphate	96,064	SO4--	2,21
	Mol-Equ+			0,46
	Mol-Equ-			0,27
Carbohydrates				**26,59**
	Mannitol	182,178	C6H14O6	3,36
	Arabinose	150,1	C5H10O5	1,35
	Galactose	180,2	C6H12O6	2,12
	Glucose	180,2	C6H12O6	6,91
	Xylose	150,1	C5H10O5	0,51
	Fructose	180,2	C6H12O6	9,84
	Sucrose	342,3	C12H22O12	2,50
Organic acids				**34,30**
	Lactic acid	90,08	C3H6O3	**29,72**
	Acetic acid	60,05	C2H4O2	4,58
	Molequ. -			0,19

Amino acids				**20,27**
	Aspartic acid	133,1	C4H7NO4	2,27
	Glutamic acid	147,1	C5H9NO4	1,04
	Asparagine	132,1	C4H8N2O3	0,98
	Serine	105	C3H7NO3	0,95
	Glutamine	146,1	C5H10N2O3	0,16
	Histidine	155,2	C6H9N3O2	0,39
	Glycine	75,07	C2H5NO2	0,81
	Threonine	119,1	C4H9NO3	1,05
	Arginine	174,2	C6H14N4O2	0,22
	Alanine	89,09	C3H7NO2	1,82
	Gaba	103,1	C4H9NO2	1,40
	Tyrosine	181,2	C9H11NO3	0,62
	Valine	117,1	C5H11NO2	1,35
	Methionine	149,2	C5H11NO2S	0,44
	Tryptophan	204,2	C11H12N2O2	0,30
	Phenylalanine	165,2	C9H11NO2	0,94
	Isoleucine	131,2	C6H13NO2	0,96
	Leucine	131,2	C6H13NO2	1,77
	Lysine	146,2	C6H14N2O2	1,39
	Proline	115,1	C5H9NO2	1,10
	Cysteine	121,2	C3H7NO2S	0,30
	Mol-Equ+			0,013
	Mol-Equ-			0,024
	Dry matter, DM	-		100
	Crude protein, CP	-		31,3
Peptide				**11,06**
	Vers. Subst. >300 D			2
	Vers. Subst. <300 D			2

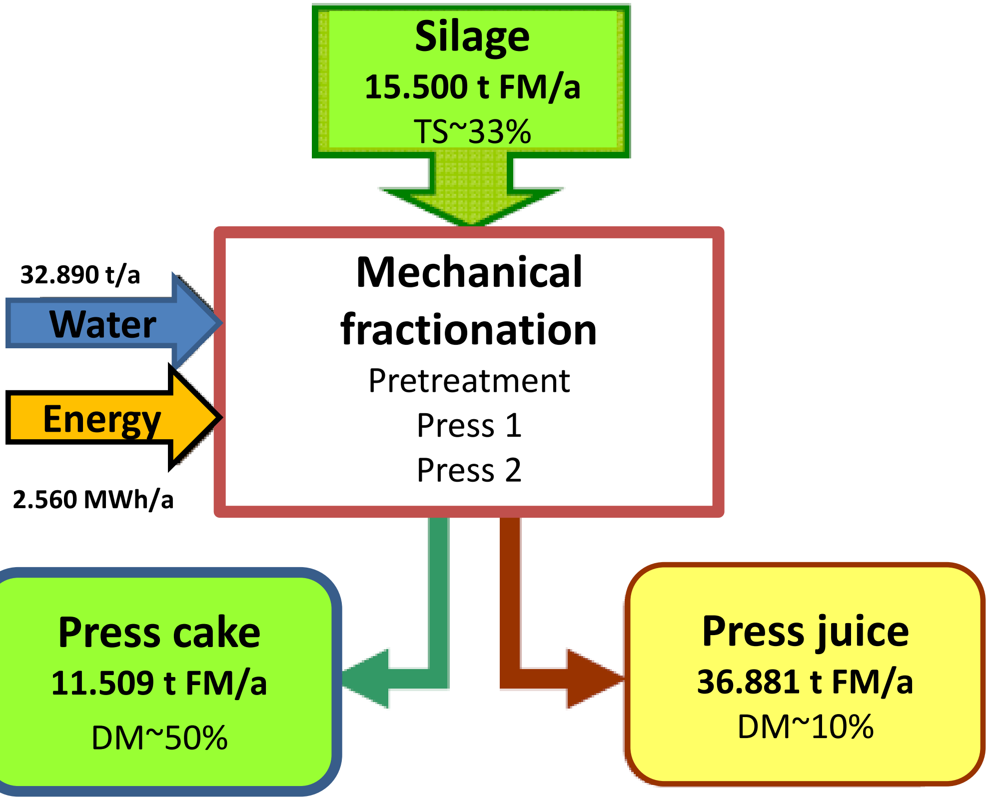
Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

Technical concept - extraction

Extraction

Feedstock for free:

- **1.000 t/a grass clippings**
- **14.500 t/a grass-like garden waste**



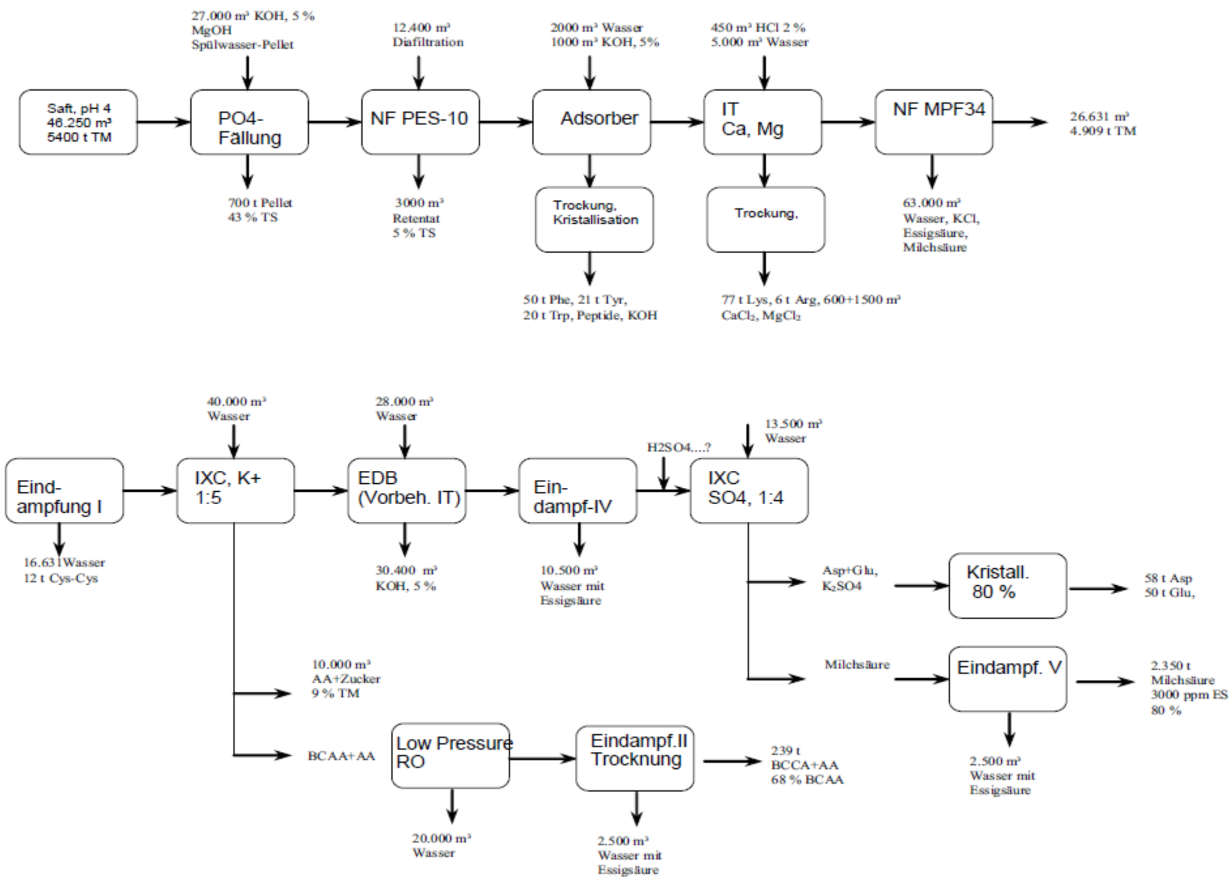
Technical concept - feedstock after extraction

		g/mol	Formula	Content in silage juice, [g/L]
Anorg. ions				**21,06**
	Ammonium	18,039	NH4+	1,23
	Potassium	39,102	K+	9,60
	Magnesium	24,3	Mg++	0,25
	Calcium	40,08	Ca++	0,78
	Chloride	35,453	Cl-	2,22
	Nitrate	62,007	NO3-	2,74
	Phosphate	94,974	PO4--(-)	2,93
	Sulphate	96,064	SO4--	1,31
	Mol-Equ+			0,37
	Mol-Equ-			0,20
Carbohydrates				**11,00**
	Mannitol	182,178	C6H14O6	4,24
	Arabinose	150,1	C5H10O5	0,13
	Galactose	180,2	C6H12O6	0,74
	Glucose	180,2	C6H12O6	1,21
	Xylose	150,1	C5H10O5	0,00
	Fructose	180,2	C6H12O6	2,07
	Sucrose	342,3	C12H22O12	2,62
Organic acids				**56,92**
	Lactic acid	90,08	C3H6O3	**46,92**
	Acetic acid	60,05	C2H4O2	10,00
	Molequ. -			0,32

Amino acids				**23,56**
	Aspartic acid	133,1	C4H7NO4	1,70
	Glutamic acid	147,1	C5H9NO4	1,52
	Asparagine	132,1	C4H8N2O3	1,47
	Serine	105	C3H7NO3	1,10
	Glutamine	146,1	C5H10N2O3	0,26
	Histidine	155,2	C6H9N3O2	0,74
	Glycine	75,07	C2H5NO2	0,95
	Threonine	119,1	C4H9NO3	1,29
	Arginine	174,2	C6H14N4O2	0,16
	Alanine	89,09	C3H7NO2	2,01
	Gaba	103,1	C4H9NO2	1,93
	Tyrosine	181,2	C9H11NO3	0,50
	Valine	117,1	C5H11NO2	1,38
	Methionine	149,2	C5H11NO2S	0,57
	Tryptophan	204,2	C11H12N2O2	0,45
	Phenylalanine	165,2	C9H11NO2	1,14
	Isoleucine	131,2	C6H13NO2	1,04
	Leucine	131,2	C6H13NO2	2,07
	Lysine	146,2	C6H14N2O2	1,88
	Proline	115,1	C5H9NO2	1,10
	Cysteine	121,2	C3H7NO2S	0,30
	Mol-Equ+			0,019
	Mol-Equ-			0,023
	Dry matter, DM	-		117
	Crude protein, CP	-		31,3
Peptide				**3,00**
	Vers. Subst. >300 D			2
	Vers. Subst. <300 D			2

Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

Main process steps: Nanofiltration and chromatography



Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

Economic possibilities

Production assumption based on Austrian study:

Example out of study:				
	Input:	silage	150.000	t
	After extraction:	press cake	100.000	t
		press juice	50.000	t
	Out of press juice:	lactic acid	15.000	t
		proteins	12.000	t

The 100.000 t of press cake are used in AD: 150 GWh thermal energy and 100 GWh electrical energy .

Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

Economic possibilities

Price assumption:

AA-acids category 30 €/kg, Tyr	30.000 €/ton
AA-acids category 10 €/kg, Phe	10.000 €/ton
AA-acids category 10 €/kg-AA, Produkt mit 40 % BCAA	10.000 €/ton
AA-acids category 10 €/kg, Cys²	10.000 €/ton
AA-acids category 5 €/kg, Asp	5.000 €/ton
Aminoacids category 1 €/kg-AA unter 25 % AA	1.000 €/ton
Aminoacids category 2 €/kg-AA über 40 % AA	2.000 €/ton
Lactic acid, 0,6 €/kg	600 €/ton

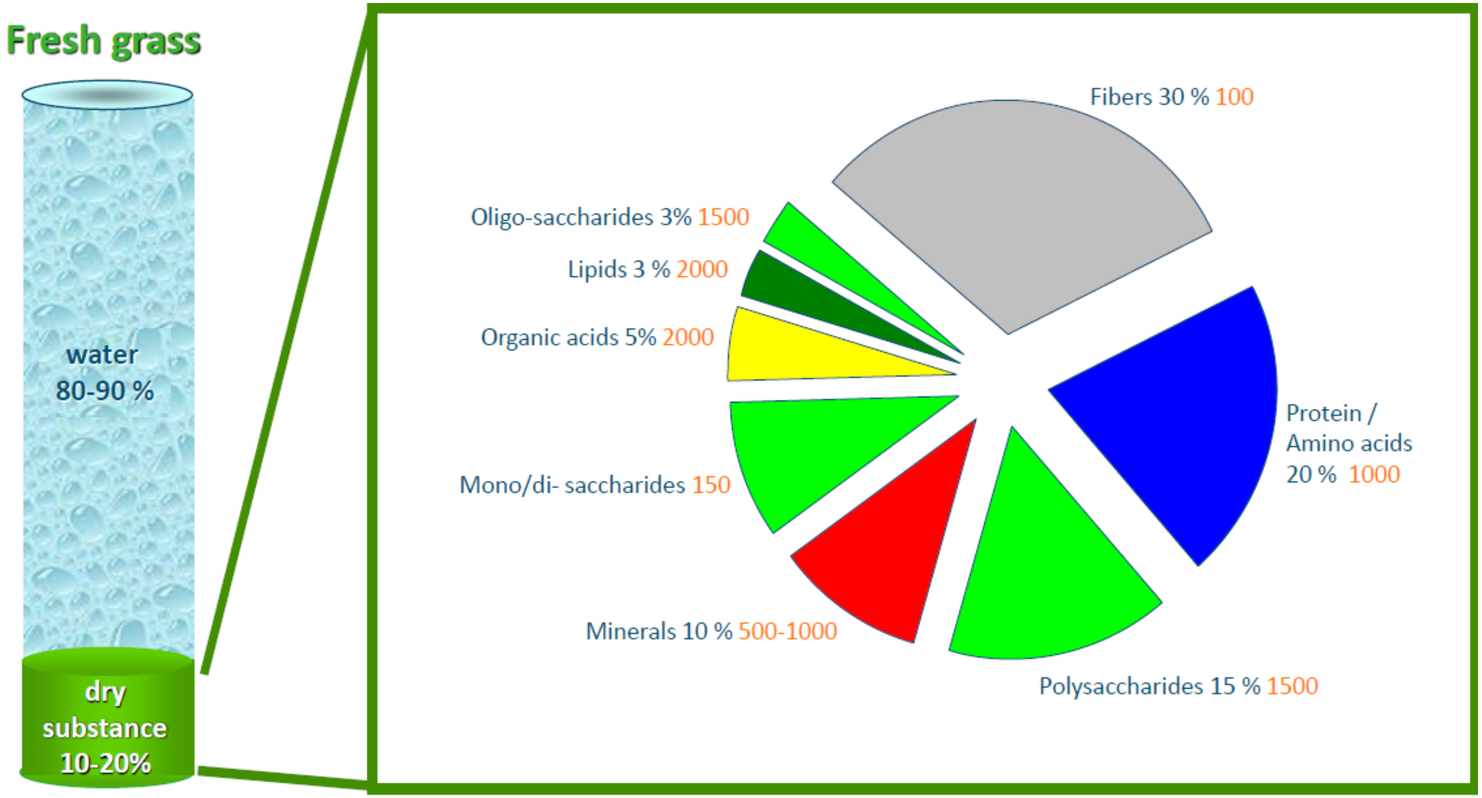
Source: S. Novalin et Al., Grüne Bioraffinerie, 2005

NB: All assumptions will be verified and updated in the coming months.

Challenges

- **Real value data for all steps**
  - **To be assessed in the next months**
- **Filtration processes are very energy intensive**
  - **Sustainable energy to be provided by AD / CHP**
- **Cooperation partner**
  - **Agricultural companies (feed & AD)**
- **Find markets for production**
- **LCA**
  - **To be done in next months**
- **Etc.**

Separated components of grass value 700-800 EUR/ton, compared to 60 EUR/ton costs of raw material



Source: J. Sanders, Wageningen UR, Status of the Bioeconomy, Oslo, 2-3 Sept. 2015

Conclusions

- Grass as feedstock can be found almost everywhere
- Realisation of a small green biorefinery concept would be a chance for rural regions
- First realisations are on the market
- Economic feasibility needs to proven on the long run
- Potential for many more small green biorefineries worldwide

Gracias por su atención

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