

Roetop værdiskabelse – protein raffinering – rejse 2015 til 2021

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Roetop – 20 % af tørstof pr ha findes i toppen





DANISH
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Subleem 2.0

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Teknologisk Institut.

Subleem 2.0 Food Grade

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Projekt Subleem 1.0 2016-2018

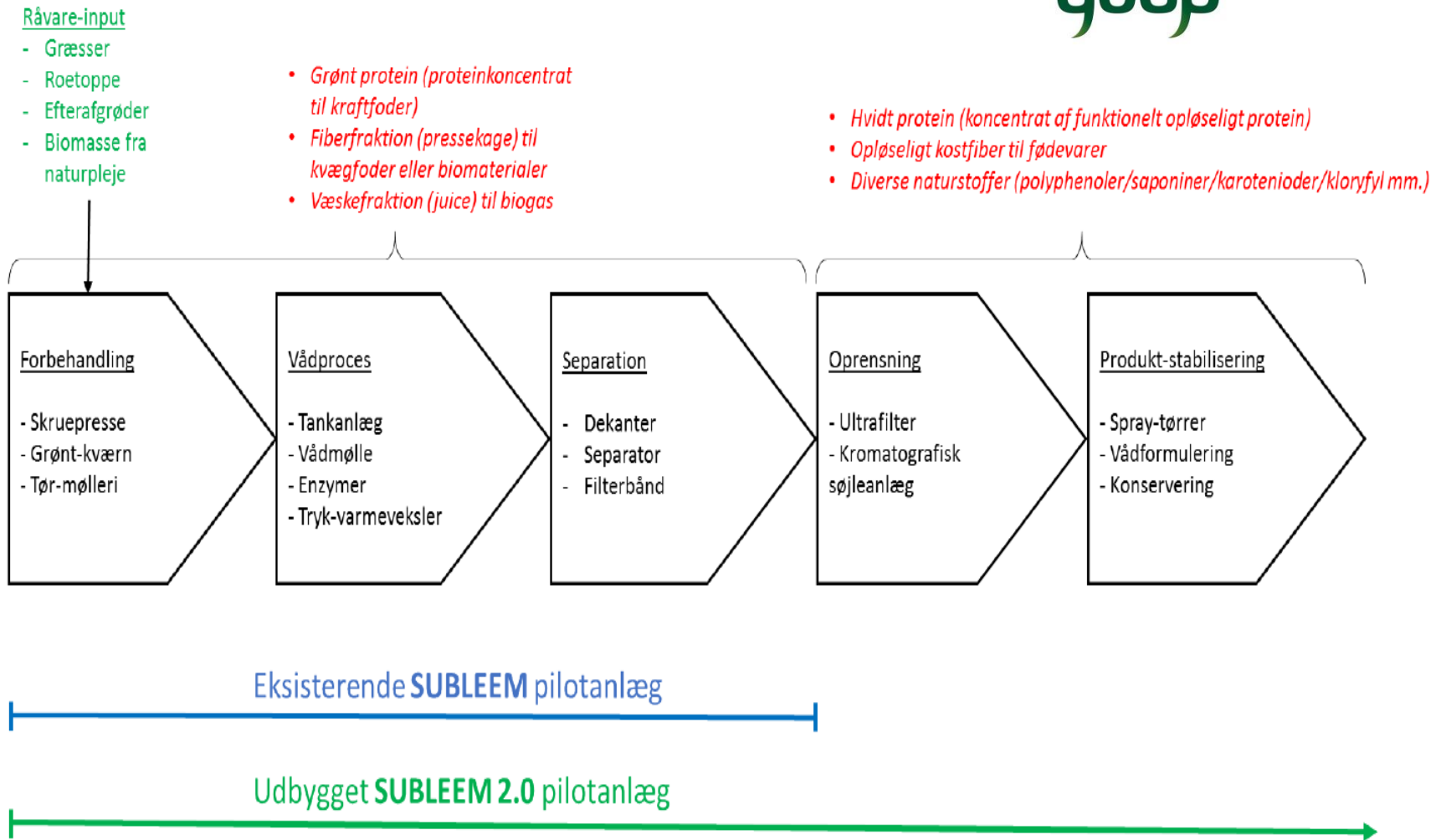
- Mølleri, vådformaling
- 2x800 l tanke, 2x200 L tanke
- Enzymatisk og kemiske reaktioner
- Pasteurisering, sigtning, decanter og separator
- Spray tørring

Anlæg suppleres 2018 med Projekt Subleem 2.0 Food Grade

- Ultrafiltrering
- Kolonne kromatografi



Pilot skala raffinering af grønne biomasser



Figur 1. Overblik over processen for raffinering af grønne biomasser i det eksisterende SUBLEEM pilotanlæg og det udvidede SUBLEEM 2.0 pilotanlæg

Techno-economic analysis - subleem 2.0

Biorefinering af roetoppe	% udbytte	ton/år	DKK/kg	t DKK
Hvidt opløseligt protein (53% protein)	10	520	35,00	18.200
Grønt fældetprotein (30% protein)	0,7	36,4	15,00	546
Kostfiber (14 % protein)	2	104	3,50	364
Omsætning i alt	13	660		19.110

Variable produktionsomkostninger	% udbytte	Ton	DKK/kg dm	t Dkk
Råvarer ³⁾ (Roetoppe/grønt)	100	5200	0,16	817
	kwh/Ton		DKK/kwh	
Energi, presning + UF + Spray tørring	240	5.200	0,75	936
Transport af roetoppe				3.934
Høst og indsamling af roetoppe				2.938
				10.485

Kontante kapacitetsomkostninger				t DKK/år
Lønninger				2.500,00
Husleje				350,00
Øvrige kontante kapacitetsomk.				100,00
Reparation og beligeholdelse			2%	600,00
	Invest t			
Annuitetslån	DKK	%	år	
Anlægsinvestering (Forretning + Afskrivning)	30.000	2	15	2.335
Fjernelse af næringsstoffer				817
				6.702,05
Indtjeningsbidrag				3.782,52

Umiddelbart :

- Der kan være et positivt indtjeningsbidrag
- Der er stort forbedringspotentiale i selve processen
 - Udbytte
 - Protein renhed
 - Sidestrømme udnyttelse

Green protein sugar beet leaves harvest and harvester



The Hack harvester designed for sugar beet leaves harvest is actually a modified spinach harvester.

Harvester cuts the leaves at least 10 cm above the beet, so as much stems as possible stays on the field.



Biggest challenge during harvest is ensuring that leaves are standing, not laying flat on the ground.

The leaves are collected in a way that ensures the minimum damage and juice loss.

Protein extraction LCA analysis



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RUBISCO PROTEIN PRODUCTION – LCA APPROACH

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JEL Category: **D15, O13**

- › The main conclusions of the research is that protein powder containing RuBisCo from sugar beet leaves affected the environment less than other analyzed plants with the exception of alfalfa.

Protein source	Environmental impact ²					
	GWP (kg CO ₂ eq)	OLD (mg CFC-11 eq)	ED (MJ)	EP (g PO ₄ P-lim)	AP (g SO ₂ eq)	LU (m ²)
Sugar beet leaves ³	15.64	1.12	194.54	4.57	586.12	0.15
Alfalfa	8.49	0.61	105.71	2.48	318.57	0.08
Yellow mustard	21.89	1.57	272.30	6.40	820.20	0.20
Ryegrass (mixture)	26.27	1.88	326.60	7.69	984.09	0.25
Italian ryegrass	29.86	2.14	371.30	8.74	1119.55	0.28
Brussels sprouts	33.64	2.41	419.00	9.85	1258.37	0.31
English ryegrass	37.19	2.66	462.40	10.87	1393.86	0.35
Carrot leaves	78.69	5.58	980.20	23.05	2950.20	0.74
Leaf radish	78.69	5.58	980.20	23.05	2950.20	0.74
Chicory	131.39	9.41	1635.10	38.41	4926.90	1.23

Table 1. Environmental impact comparison of different RuBisCo protein sources per 1kg of protein powder containing RuBisCo

Protein source	DM (%)	Protein (%)	Environmental impact				
			GWP (kg CO ₂ eq)	OLD (mg CFC-11 eq)	ED (MJ)	AP (g SO ₂ eq)	LU (m ²)
Sugar beet leaves protein powder	95	92.15 ^a	16.41	1.21	205.24	620.76	0.19
Soy protein	92 ^{1,spc}	87 ^{2,spi} 90 ^{3,spi}	5.14 ^{1,spc} 6 ^{2,spi,kp} 20.2 ^{3,spi}	0.02 ^{1,spc}	2.5 ^{3,spi} 19.3 ^{1,spc}	48.83 ^{1,spc}	4.6 ^{1,spc} 6 ^{2,spi,kp}
Whey concentrate	86-89 ⁴	60 ^{4,5} 80 ^{6,kp}	7.48 ⁵ 0.8-7.4 ¹ 12.1 ⁷ 28-43 ^{8,kp} 40.6 ^{6,kp}	0.01-0.06 ⁴ 3.33 ⁵ 3.8 ^{6,kp}	58.1 ⁷ 83.3 ⁵ 10.7-39.4 ¹	0.05-1.5 ¹ 56.6 ⁵	0.26- 8.27 ¹
Egg protein concentrate ⁴	85	80	23.4	1.01	183	4000	40.1
Microalgae ⁴	96	55	14.7-245.1	0.9-19.8	217.1- 4181.3	260.5- 1407.5	1.7-5.4

Table 2. Environmental impact comparison of different protein sources per 1 kg of product.⁴

Abbreviations in tables: **GWP**: Global Warming Potential, **OLD**: Ozone Layer Depletion, **ED**: Energy Demand, **EP**: Eutrophication Potential, **AP**: Acidification Potential, **LU**: Land Use

² Fine particulate matter formation is also important indicator, but sufficient data are not available.

³ Environmental impact results for sugar beet leaves in Table 2 are given without transport, since transport was not included in results of other crops.

⁴ Studies of protein sources in Table 3 include different production processes.

Nuværende vurdering af råvare og økonomi

- › Roetop skal høstes samtidigt med roerne (måske ikke optimal sammensætning)
- › Landmændene skal kompenseres for gødningsværdi og have incitament præmium
- › 300 kg høj renhed Rubisco pr ha
- › Ca 6 ugers grønne blade pr sæson

- › Ved 35 kr kg protein er der et positivt indtjeningsbidrag - MEN
- › Anlægget kan ikke afskrives ved kun 6 uger/år drift
 - Andre plante proteiner i levnedmiddel kvalitet er nødvendige i ligningen .. Fx lucerne mfl

- › NÆSTE skridt er skalerbart raffineringsanlæg med 1 ton protein/dag kapacitet. !!
 - Vise udbytte og renhed + verificere antagelser + bekræfte markedspris + andre råvarer valideres



Nordzucker

THE Sugar Company