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it's all about innovation

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"Sustainable Development": From Bio to Business

Mark Lawther

Biobaserede restressource
- Fra bio til business!

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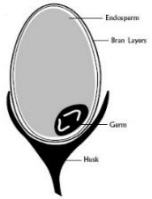

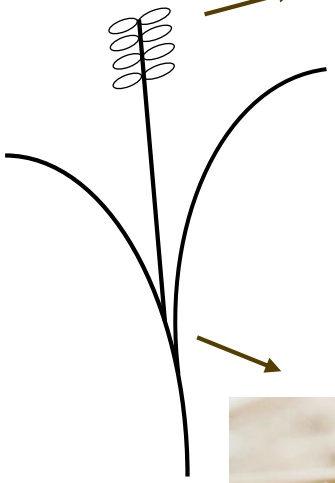

Tørfraktionering

Belimning
Presning

Emission og fysisk-mekaniske test

Mekanisk seperation

Analyse og karakterisering

Enzym hydrolyse seperation

Komposition
Masse balance

vådfraktionering

Building materials

Binders
Adhesives

Surface treatment

Food
Feeds

Medico cosmetic

Nutrients

Energy

Laboratorie og pilot skala

Laboratorier og pilotanlæg

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Laboratory

0,01 – 2 kg

Pilot scale

2 - 100 kg

Pilot production scale

0,1 - 10 ton

Process in full scale ??

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Overview:

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Wheat straw. (Winugroho 1981)

Component	Internode (%)	Sheath (%)	Blade (%)
Cellulose	50-53	47-49	42-45
Hemicell	30-31	32-36	22-30
Lignin	15-17	8-9	8-9
ash	2-3	7-12	15-28

Component	Content (%)
Protein	10-12
Beta Glucan	8-10
Insol Fibre	25 - 35
Starch / Malto dextrin	35 -45
Oil / Fat	6-9

Oat Bran

crude protein averaged at 36.1% and varied from 30.2% to 37.8% in dry matter. The content of crude fat varied in dry matter of expeller extracted rapeseed cake from 10.3% to 15.1% being 12.2% as an average. Minimum value of crude fibre content was 11.6% and maximum 16.8% in dry matter.

It was determined contrarily to the great variation in most of the nutrients that the content of metabolizable energy was relatively stable. The difference between minimum and maximum value was only 0.4 MJ/kg.

Table 2. Nutrient content and boundary values in dry matter of expeller extracted rapeseed cake (n=13)

Traits	Expeller extracted rapeseed cake			s
	mean	min	max	
Dry matter, %	95.3	89.6	98.2	2.6
Crude protein, %	36.1	30.2	37.8	2.2
Crude fat, %	12.2	10.3	15.1	1.5
Crude fibre, %	13.1	11.6	16.8	1.6
Crude ash, %	7.1	6.5	7.4	0.3
N-free extractives, %	32.2	30.6	34.2	1.2
Phosphorus, %	1.0	0.7	1.2	0.2
Calcium, %	0.7	0.7	0.9	0.1
Gross energy, MJ/kg	21.5	21.2	22.0	0.3
Metabolizable energy, MJ/kg	14.8	14.6	15.0	0.1

Wheat Straw:

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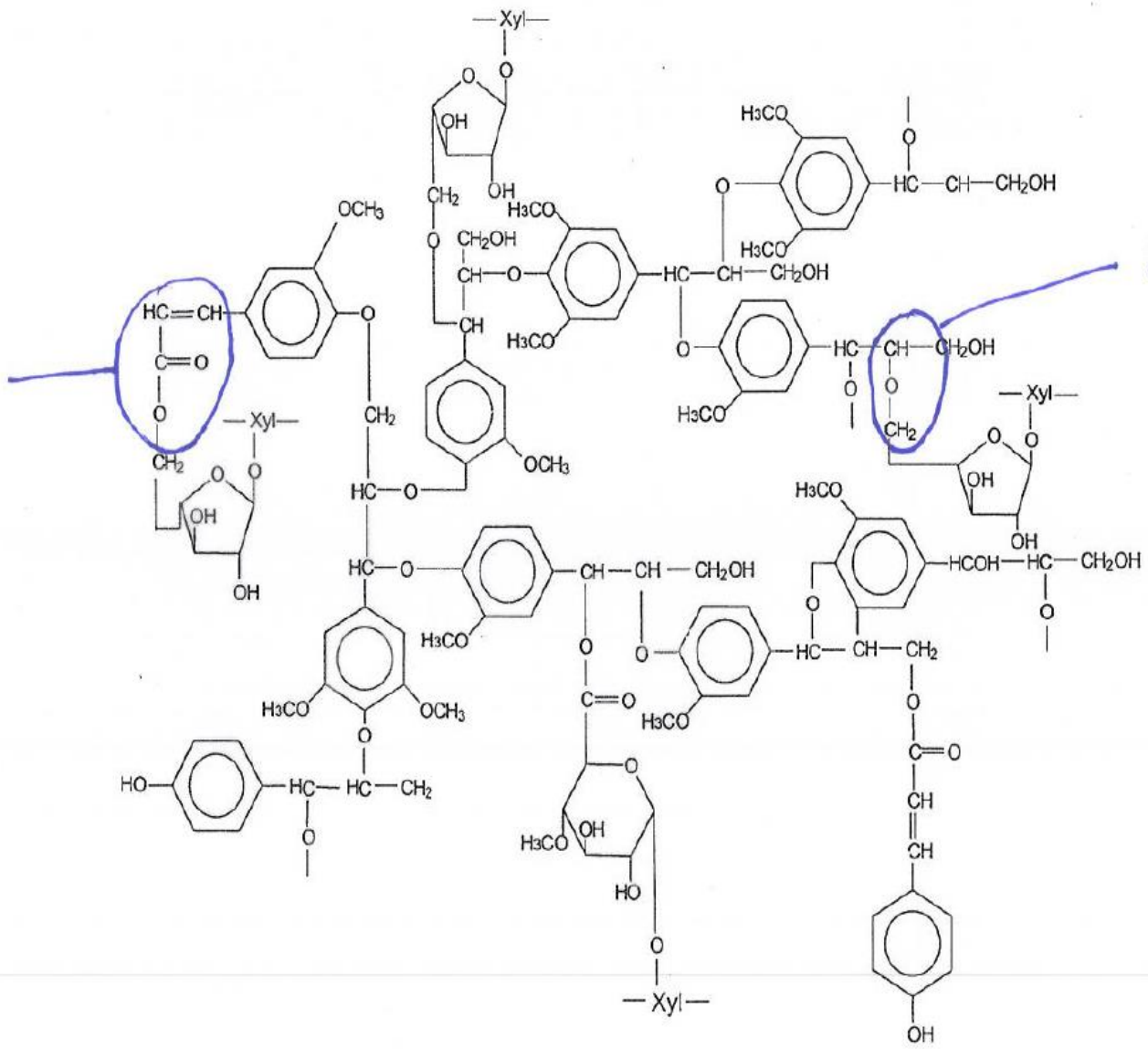
- 2-4 mio ton in DK
- Infrastructurefor collection in place
- Recycled fibre / paper price climbing
- Straw 500 Dkr per ton: 50 + % Cellulose fibre content.


ESTER BOND.
ETHER BOND
—Xyl—
OCH3
H3CO
CH2OH
HC=CH
C=O
CH2
OH
HC—O
CH—CH—CH2OH
HCOH
HO
HC—HC—CH2
—Xyl—

Tørfraktionering

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- Hammermølle
- Skivemølle
- Sigtekanal

- Cirkulationskreds
- Varmepresse

Generisk pilotanlæg
- kaskadeudnyttelse af restressourcer

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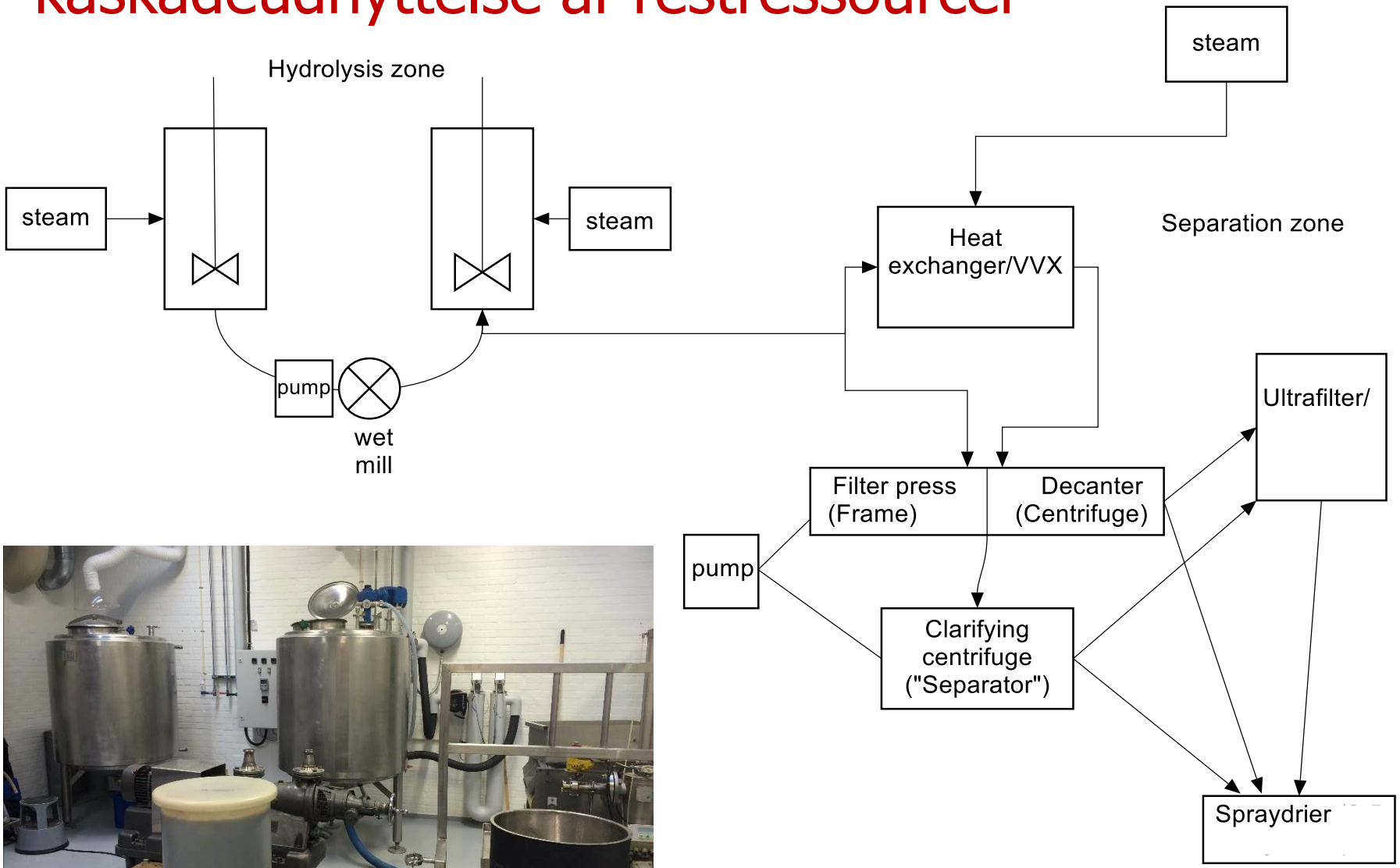

Fractionation

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MASS BALANCE !!

Is there a business case ??

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10,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	2.000	2.000	4.000.000
	Cellulose rich fibres	5.000	400	2.000.000
	Lignin	1.000	1.000	1.000.000
	oligomers	1.000	1.000	500.000
Total Revenues				**7.500.000**
Operating Costs				
	Wheat straw	10.000	50	500.000
	Fractionation - processing + labour			2.500.000
	Other Costs			650.000
Total Operating Costs				**3.650.000**
EBDITA				**3.850.000**

Investmen Around 5 - 6 mio euros based on N.European equipment costs
All operating costs based on local labour and energy costs.

Is there a business case ??

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10,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	2.000	2.000	4.000.000
	Cellulose rich fibres	5.000	0	0
	Lignin	1.000	1.000	1.000.000
	oligomers	1.000	1.000	500.000
Total Revenues				**5.500.000**
Operating Costs				
	Wheat straw	10.000	50	500.000
	Fractionation - processing + labour			2.800.000
	Other Costs			650.000
Total Operating Costs				**3.950.000**
EBDITA				**1.550.000**

Investmen Around 5 - 6 mio euros based on N.European equipment costs
All operating costs based on local labour and energy costs.

Is there a business case ??

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50,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	10.000	1.500	15.000.000
	Cellulose rich fibres	27.000	400	10.800.000
	Lignin	6.500	1.000	6.500.000
	oligomers	6.500	2.000	13.000.000
Total Revenues				**45.300.000**
Operating Costs				
	Wheat straw	50.000	50	2.500.000
	Fractionation - processing + labour			15.400.000
	Other Costs			1.300.000
Total Operating Costs				**19.200.000**
EBDITA				**26.100.000**

Investment around 8-10 mio euros, based on N.European equipment costs
All operating costs based on local labour and energy costs.

Is there a business case ??

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50,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	10.000	1.500	15.000.000
	Cellulose rich fibres	27.000	0	0
	Lignin	6.500	1.000	6.500.000
	oligomers	6.500	2.000	13.000.000
Total Revenues				**34.500.000**
Operating Costs				
	Wheat straw	50.000	50	2.500.000
	Fractionation - processing + labour			15.400.000
	Other Costs			1.300.000
Total Operating Costs				**19.200.000**
EBDITA				**15.300.000**

Investment around 8-10 mio euros, based on N. European equipment costs
All operating costs based on local labour and energy costs.

Is there a business case ??

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250,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	50.000	1.500	75.000.000
	Cellulose rich fibres	125.000	400	50.000.000
	Lignin	30.000	750	22.500.000
	oligomers	25.000	1.000	500.000
Total Revenues				**148.000.000**
Operating Costs				
	Wheat straw	250.000	50	12.500.000
	Fractionation - processing + labour			61.000.000
	Other Costs			2.500.000
Total Operating Costs				**76.000.000**
EBDITA				**72.000.000**

Investment around 20 -25 mio euros based on N.European equipment costs
All operating costs based on local labour and energy rates

Is there a business case ??

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250,000 DM ton wheat straw plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Hemicellulose	50.000	1.500	75.000.000
	Cellulose rich fibres	125.000	0	0
	Lignin	30.000	750	22.500.000
	oligomers	25.000	1.000	500.000
Total Revenues				**98.000.000**
Operating Costs				
	Wheat straw	250.000	50	12.500.000
	Fractionation - processing + labour			61.000.000
	Other Costs			2.500.000
Total Operating Costs				**76.000.000**
EBDITA				**22.000.000**

Investment around 20-25 mio euros based on N.European equipment costs
All operating costs based on local labour and energy rates

Basis of process costs calculations (not including labour costs).

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1. For the cellulose rich fibres, hemicellulose, oligosaccharide and lignin fractions, the cost for the bulk wet-processing is around 100 euros per MT.

2. The fibres are separated via decantation from the liquid phase and are then bleached. We have assigned a bleaching cost of 50 euros per MT to the 27,000 MT of fibres. The fibres are not dried, but sent for pulp moulding as an approximately 35 % solids mass. Hence the process cost for the 27,000 MT of fibres is (@150 euros per MT): 4,050,000 euros.

3. The liquid phase from the decanting contains the hemicellulose, lignin and oligosaccharide materials. These need to be separated and then dried. The cost for this is average 350 euros per MT (mostly drying energy from 10% solids slurries). Hence the total process cost for 1 MT of each of these products is circa 450 euros.

Basic process cost calculations

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So:

The overall process cost for 10,000 MT hemicellulose is 4,500,000 euros

The overall process cost for 6,500 MT oligosaccharide is 2,925,000 euros

The overall process cost for 6,500 MT lignin is 2,925,000 euros.

Hence, the total overall cost for processing is: 4,050,000 + 4,500,000 + 2,925,000 + 2,925,000 = 14,400,000 euros.

Add another 1 mio euro on for production staff per year. That assumes 5 shift teams of 3-4 persons per team, and 24 hour 3 shift continuous production. This results in the **total of 15,400,000** on the spreadsheet.

Packaging, maintenance, labs, Q.C is included in the section “other costs” on the spreadsheet.

Economic Impact Example: Oats

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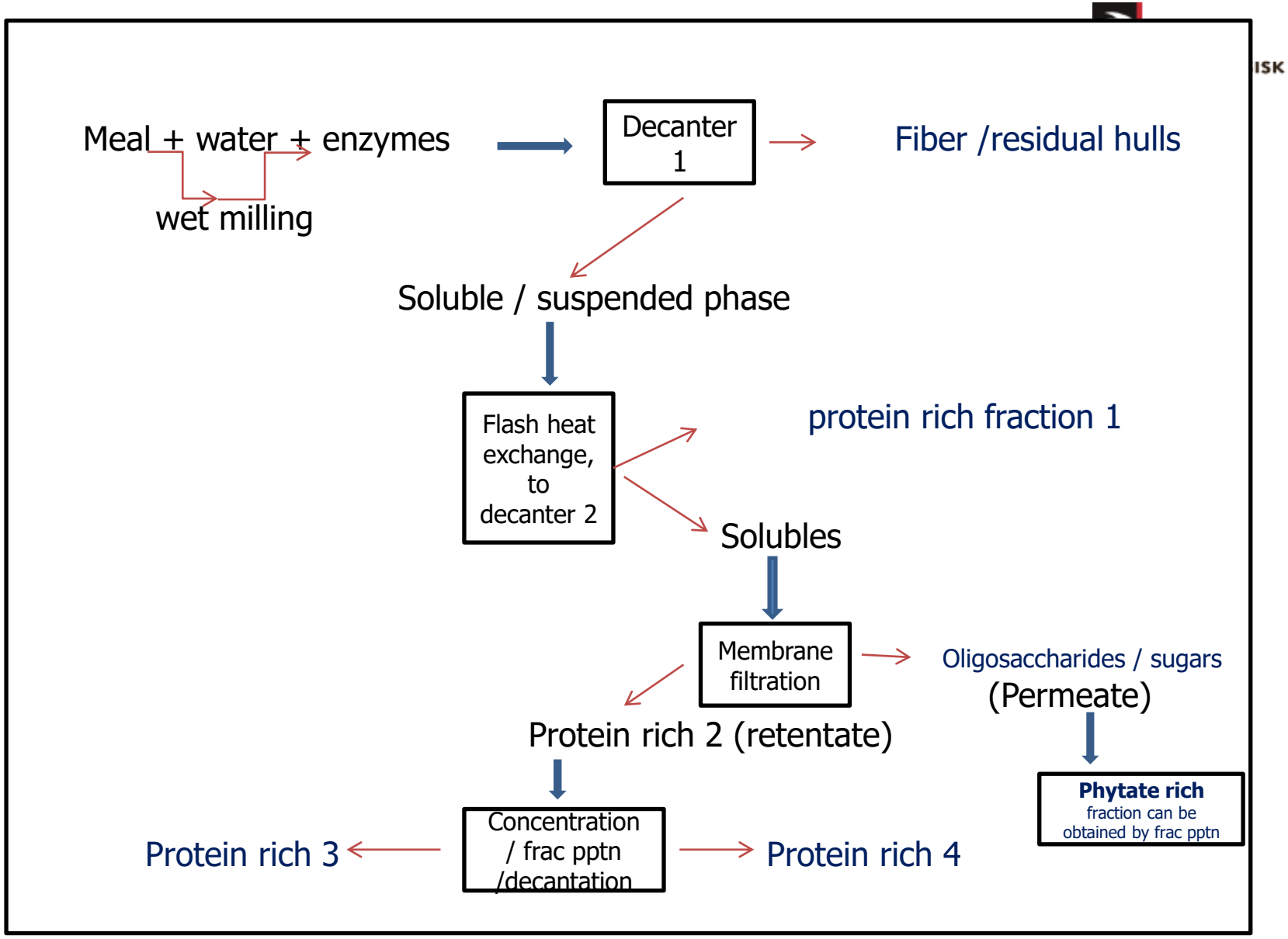
10,000 MT oat bran frac plant (27,500 MT oat grain input)		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Beta glucan rich	1.400	14.000	19.600.000
	Maltodextrins	3.670	0	0
	Oat protein rich	2.240	4.000	8.960.000
	Fibre	2.710	800	2.168.000
	Oat Flour (for extrusion etc)	10.000	300	3.000.000
	Oat husk (energy source)	6.800	0	0
Total Revenues				**33.728.000**
Operating Costs				
	Oat grain	27.500	250	6.875.000
	Fractionation - processing + labour			4.100.000
	Other Costs			750.000
Total Operating Costs				**11.725.000**
EBDITA				**22.003.000**

Investment Around 8-10 mio euros based on N.European equipment costs
All operating costs based on local labour and energy costs.

NB: Husk, which can be 25 + % can be burnt to fuel driers

Rapeseed press-cake typical sequence



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RAPESEED PRESS-CAKE

Depending on the degree of processing used, we can achieve protein concentrates or isolates in different fractions.

4 different protein rich fractions

isolate

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RAPESEED PRESS-CAKE

Up to 90% of the available protein was located in these fractions, with 74% of that within the 2 concentrates and the isolate. These should be pooled if maximal protein extraction from the meal is the driver. Some final steps can be omitted, depending on needs for maximal protein return vs fractionation of types.

In addition, a fibre (insoluble fiber) fraction and an oligosaccharide rich fraction were obtained.

Plus a small fraction (approx 2 -2.5% of the input dry matter) in which the phytates were concentrated at around 60% concentration, the remainder being basic peptides and mineral.

Rapeseed Residual processing

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Starting with hexane-treated, defatted meal, yields are lower due to reduced protein solubility and mobility (partial denaturation due to heat exposure).

In such case, at most 30-45% of available protein can be isolated as concentrates.

Potential rapeseed refinery: including cold pressing of seeds

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10.000 tonne Rapeseed : scenario 2		Amount (ton)	Price (€/ton)	Amount (€)
Turnover				
	Oil: cold-pressed	3200	2000	6400000
	Protein Concentrate	1.700	2.000	3.400.000
	Protein Isolate	350	8.000	2.800.000
	Phytate	200	7.500	1.500.000
	Sugars	1.650	250	412.500
	Fibre	1.200	135	162.000
Total Turnover				**14.674.500**
Operating Costs				
	Rapeseed	10.000	350	3.500.000
	Chemicals, enzymes etc			200.000
	Energy: gas + electricity			2.000.000
	Lab + maintenance			50.000
	Personnel Plant + admin)			500.000
Total Operating Costs				**6.250.000**
Net Income before deprec., interest and taxes:				**8.424.500**

Very high value case: seaweed

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1,000 DM ton brown macroalgal plant		Amount (ton)	Price (€/ton)	Amount (€)
Renenues				
	Fucoidan 80% powder	175	15.000	2.625.000
	Fibrillar cellulose	125	2.000	250.000
	Protein Concentrate	100	4.500	450.000
	Laminaran beta Glucan	100	12.000	1.200.000
	Mannitol	75	500	37.500
	Algin oligomers	200	3.000	600.000
	Low MW specialties	5	10.000	50.000
Total Revenues				**5.212.500**
Operating Costs				
	Macroalgae	1.000	500	500.000
	Fractionation - processing + labour			1.500.000
	Other Costs			250.000
Total Operating Costs				**2.250.000**
EBDITA				**2.962.500**

All operating costs based on Swedish costs.

Biobaserede restressource
- Fra bio til business!

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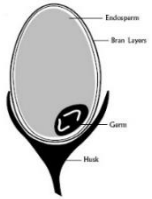

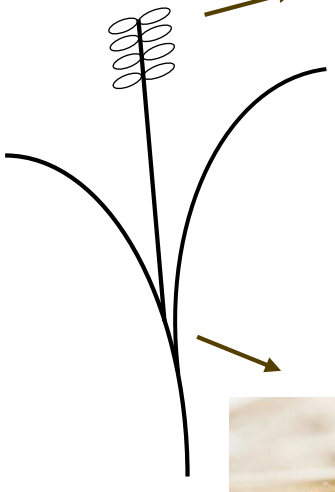

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Thank you for staying Awake !!