By-products/Co-products

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EPSO Biofuels Workshop

The Royal Society, 28-29 May 2008

Co-products from biofuel production
The need for greater appreciation

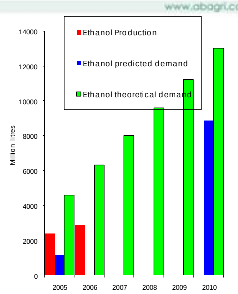
A call for more consideration to be given to improving the productivity and output of the existing EU grain based bioethanol industry

Use LCE technology to address pressing issues of the current generation of bioethanol plants

- Setting the scene; biofuel by-products/co - products
- Inclusion of co-products in feed – a nutritionists perspective
- Future requirements: Plant physiology and co-products

Drivers for Bio-fuels increase volumes of co-products

- 10% use in transport 2020
- Reduce greenhouse gases
- Reduce climate change
- Rural development
- Security of supply and energy diversification
- Depletion of mineral oils
- Air Quality
- Bridge to second generation



An emerging industry with established capacity: Major challenges and opportunities

EU 2010: 8 bill litres

+4 bill litres by 2010

Major feedstock wheat

+4.2MM T of co-products

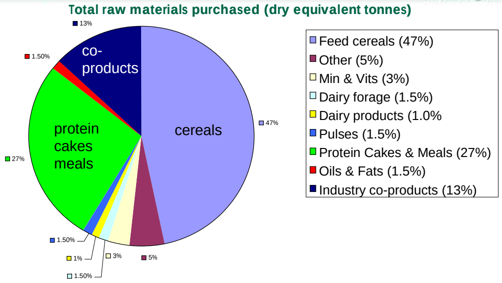
142 MM T EU feed market (approx 40% ruminant)

An additional 7.5% in all ruminant feed????

MS	Company	PC	Feedstock
Netherlands	Abengoa (Rotterdam)	480	Wheat
UK	Vivergo	420	Wheat
UK	Ensus plc (Teesside)	400	Wheat
France	Roquette (Beinheim)	200	Wheat
Spain	SNIACE II (Zamora)	150	Wheat
Germany	PROKON Nord (Stade)	100	Wheat
Belgium	Alco Bio Fuel (Gent)	100	Wheat
Slovenia	Slovnafta (Bratislava)	75	Wheat
Belgium	Amylum (Aalst)	35	Wheat
		1960	
Germany	Danisco (Anklam)	52	Suger beet (thick juice)
Greece	Helenic Sugar EBZ	150	Sugar beet, molasses,
France	Saint Louis Sucre / Ryssen (Dunkerque)	100	Sugar beet, molasses
Czech Republic	Agroetanol TTD (Dobrovice)	60	Sugar beet 720k tonnes
Germany	Nordzucker AG (Klein-Wanzleben)	130	Sugar beet
Germany	CropEnergies (Zeitz)	60	Sugar Beet
Belgium	BioWanze SA (Wanze)	300	Sugar and cereals
		852	
France	A B Bioenergy France (Lacq)	250	Maize, wine alcohol
Hungary	First Hungarian Bioethanol Kft (Elso	90	Maize 30 kt
Hungary	Hungrana Kft	175	Maize
Bulgaria	Euro Ethyl GmbH (Silistra)	30	Maize
Spain	Biocarburantes Castilla & Leon	5	Ligno-cellulose
Slovakia	Enviral	138	Corn
Czech Republic	Ethanol Energy (Vrdy)	70	Cereals, maize
Czech Republic	PLP (Trmice)	100	Cereals (possible sugar
Czech Republic	Korfil a.s. (Vrdy)	100	Cereals (possible sugar
Sweden	Agroetanol TTD (Dobrovice)	155	Cereals
Lithuania	Bioetan	100	Cereals
Spain	Alcoholes Biocarburantes de	110	
Germany	Bioethanol Emsland (Papenburg)	90	
Bulgaria	Crystal Chemicals	13	
Germany	Wabio Bioenergie (Bad Kostritz)	8.4	
Total		**1434**	
Total		**4246**	

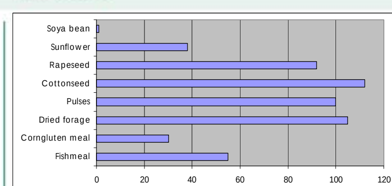
20 mill ton UK animal feed market dominated by 3 key raw materials

Total raw materials purchased (dry equivalent tonnes)



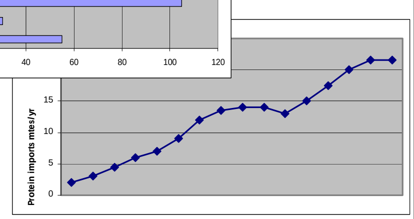
Grain (UK): Protein (soyameal etc): Co-products: Food, Drink, Biofuel

Growth in meat consumption
EU relies on protein imports

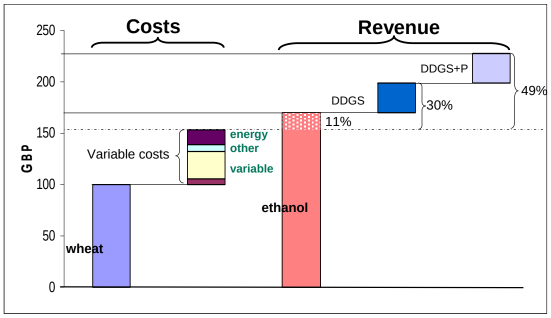


EU self sufficiency with protein feedstuffs

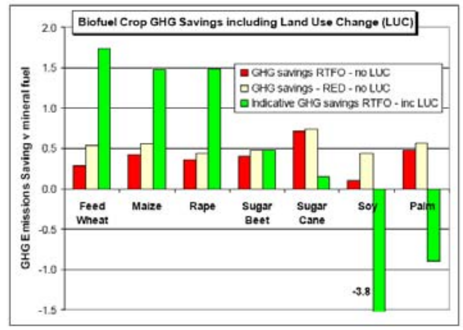
Annual protein imports mainly soya bean meal



In a wheat bioethanol plant the co-product stream is a major component of profitability



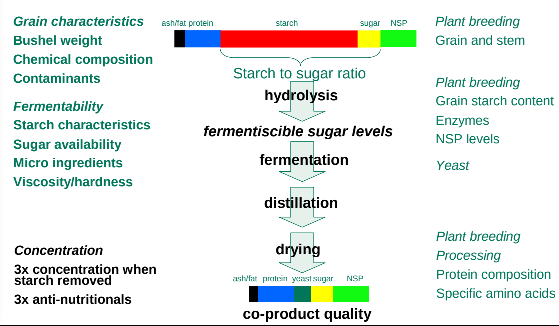
Credit for co-products significantly increases the effective biofuel yield



A range of co-products dependent on feedstock

- **Bio-ethanol**
  - Dried wheat distillers +/- solubles
  - Moist wheat distillers
  - Liquid syrups
  - Distillers dried grains + solubles (DDGS)
    - Maize (In UK unlikely)
    - Wheat (UK)
- **Bio-diesel**
  - Rape, palm or soya meal expeller and extract
  - Glycerol

Through out the process factors influence the final co-product quality



Co-products from biofuel production
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- Setting the scene; biofuel by-products/co -products
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Co-products are nutritionally important

Nutritional Quality (Fresh weight)

	Met Energy	Crude Protein %	Oil %	Starch %	Sugars %
Wheat	11.9	10	2	**58**	2
HiPro Soya bean meal	12.4	**48**	2.6	5	9
Wheat DDGS	**12.5**	**32**	4	2	2

Energy rich feeds are valued relative to the energy cost of cereals
Protein rich feeds are valued relative to the protein cost of Soyameal
DDGS is high energy and mid protein, palatable and easily processed
DDGS protein quality (Amino Acids) can limit its use in diets

Dietary inclusion rates differ for livestock species

Generally accepted corn DDGS dietary inclusion levels

Species		Maximum of ration (% DM)
Cattle		
	Lactating dairy cows	25
	Beef feeders	40
Swine		
	Weaned pigs	25
	Grow-Finish	20
	Gestation	50
	Lactation	20
Poultry		
	Broilers	15
	Layers	10

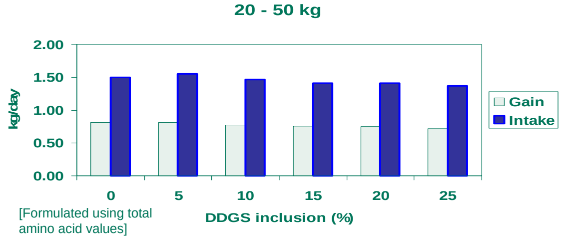
High variability in amino acid content and digestibility

Wheat distillers for poultry

	As % of Protein			Digestibility Poultry		
Amino Acid	**Mean**	**SD**	**CV%**	**Mean**	**SD**	**CV**
Lysine	1.93	0.36	18.4	38.2	10.4	27.1
Methionine	1.45	0.07	5.1	77.7	5.1	6.6
Cysteine	1.84	0.11	5.4	55.8	5.3	9.6
Threonine	3.32	0.57	17.1	67.9	7.0	10.4
Tryptophan	1.07	0.12	11.5	716	7.5	10.5

Source Adisseo

In pigs wheat DDGS reduced growth and intake (P<0.01)



[Formulated using total amino acid values]

11% reduction in intake and weight gain

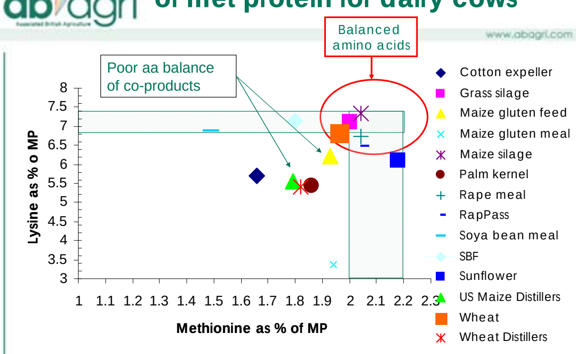
Response of cows to wet or dry corn DDGS

DDGS as % of dry matter	DM Intake (kg/day)	Milk Yield (kg/day)	Milk Fat %	Milk Protein %
0	22.1b	33.1ab	3.39	2.95a
4-10	23.7a	33.5a	3.43	2.96a
10-20	23.5ab	33.3ab	3.41	2.94a
20-30	22.9ab	33.6a	3.33	2.97a
➢30	20.9c	32.3b	3.47	2.82b

Values with different letter differ by P<0.05 – adapted from Kalscheur 2005

A limitation to dietary inclusion of DDGS in dairy cows

Unbalanced amino acid quality of met protein for dairy cows



Additional limitations on use

Nutrient variation & antinutritional factors

Variation:-

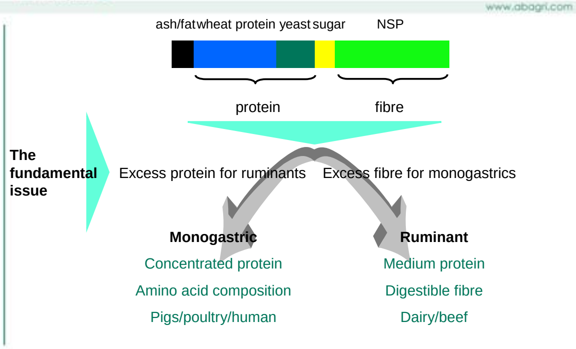
- Incoming raw material
- Addition of condensed distillers solubles
- Quantity of starch removed
- Quantity of non starch polysaccharides
- Temperature and duration of drying process

Antinutritional:-

- Toxins

(Shurson *et al.*, 2004)

The fundamental issue: 3x the value 3x the problems



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An important role for wheat as a bioethanol feedstock

- EU 8 bill litres: 70% cereals ethanol
- Wheat well adapted to European agronomics
- Versatile: evolved as a source of feed, food, biomass and biofuel
- A self ripening crop
- Convenient to store and transport
- Valuable co-products; feed, bedding and biomass

What is the impact of differences between corn and wheat DDGS ?

- Wheat DDGS ~ 10 X more soluble xylose then corn DDGS
- Wheat DDGS ~ 4 X more non starch polysaccharides (NSPs)
  - Greater potential to form Maillard's that reduce digestibility
  - Greater heat susceptibility?
  - More substrate for hind gut fermentation in pigs

Several constraints on the use of wheat DDGS

- Increased concentration of monosaccharides
- Poor digestible amino acid content
- Residual monosaccharides highly susceptible to Maillard reactions – particularly lysine
- Non starch polysaccharides likely increase viscosity
- Viscosity is a processing and nutritional constraint
- Challenge of drying with high viscosity and high Maillard

Where should effort be expended?

Short term important to work with existing plant design

Developments in the bioethanol / co-product process		
Agronomics	Bioethanol plants	Operation/Formulation
7 year development	US&EU 630 sites	1-2 year development
Technology acceptance (GM/MAB)	10 year write off	Limited CAPEX
Identity preservation	High CAPEX	
Crop specific	Operation assurance	
Little integration – limited grower processor relationships		
	Integrated development – good integration in fuels, poor in co-products	

Opportunities to improve the value of co-products in feed

Agronomics – traits (7-10 years)

- **The crop**
  - High yield
  - High starch
- **Protein**
  - Protein content
  - Zero protein (germ free)
  - Amino acid composition
- **Characteristics of fibre**
  - Stem and grain
  - Lignification (targetting)
  - NSP content
- **Enzymes**
  - *In planta*
- **Anti nutritional components**
  - Mycotoxins

Processing (2 years)

- Combined lignocellulosic and starch
- Efficiency of starch extraction
- Reduced saccharification time
- Increased ethanol
- Reduced monosaccharides
- Reduced viscosity
- Available phosphorus
- Extraction of valuable nutrients
- High protein
- Reliable fermentation/consistency
- Efficient dehydration
- Available protein

Opportunities to improve the value of co-products in food

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- Wheat is a valuable source of nutrients
  - Wheat DDGS is suitable for dairy cows
  - Currently wheat DDGS is not suitable for pigs and poultry
  - Wheat protein suitable for humans
- Challenge the traditional paradigm of yield improvement
  - Volume x value
- Crop functionality and productivity are cornerstones

Functionality in terms of ethanol and the co-products

A biofuel plant or a bio-refinery?

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- High value animal feed additives are produced by fermentation
  - Enzymes
  - Vitamins
  - Colorants
  - Antibiotics
- Yeast cell wall material represents approximately 10 percent of the biomass in DDGS
- Optimising fermentation is paramount

Conclusions

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- A bioethanol plant – NO. ***It is a biorefinery***
- Co-products play a key role in sustainability and profitability but have been neglected
- Cereals will be custom designed for individual markets
- Short term added value from processing improvements
- Ligno-cellulosic technology is highly relevant
- Has appropriate attention been given to the current generation – significant gains and impact now in a sustainable system?

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Thank you