The nutritional value of Biofuel co-products for poultry

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Premier Nutrition

Overview

- Cereal sources (fermentation)
- Oilseed sources
- Methods of production
- Nutritional value of co-products
- Variability in nutritional value and factors that influence this
- Disadvantageous compounds in the co-products

Substrates for biofuel production

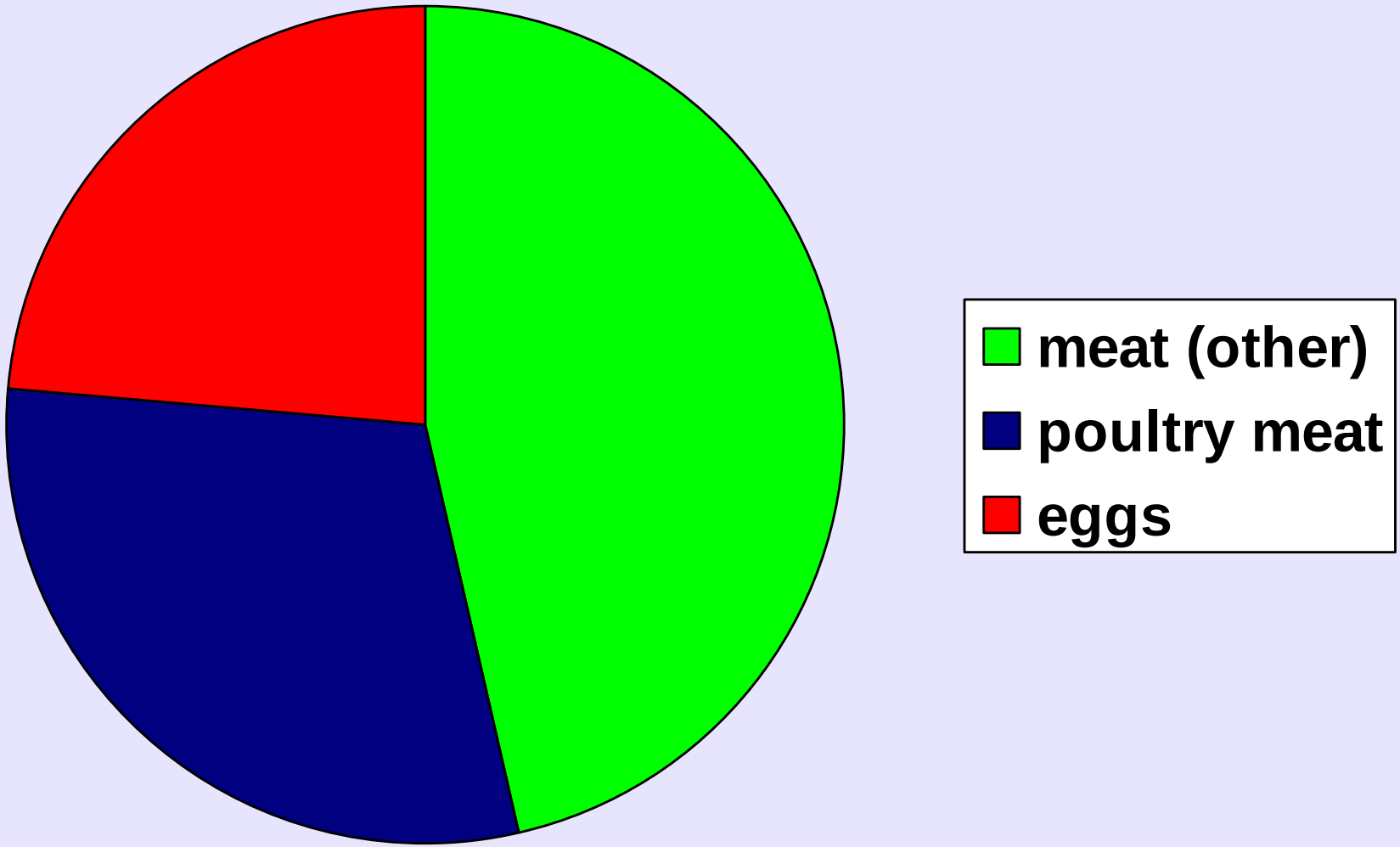
- Cellulosic and lignocellulosic materials
  - Used directly as a fuel
  - Pyrolysis
  - Biochemical/chemical conversion to substrates for fermentation
- No useable residue but potential for ruminant diets

Let’s set the scene: Poultry



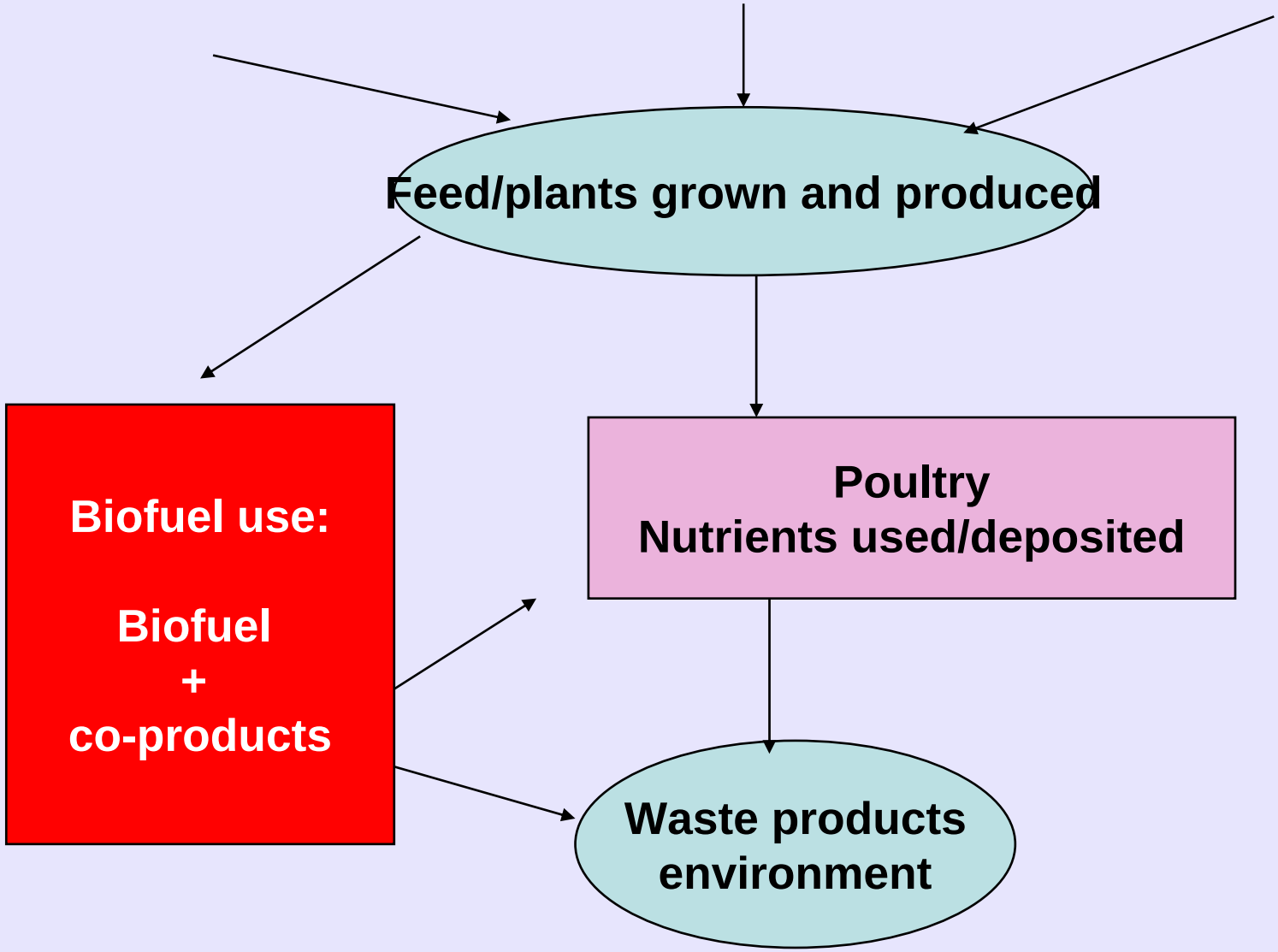

World poultry meat and egg production (2006)

FAO (2007)



Nutrient composition of some poultry diets.

ME (MJ/kg)	CP (g/kg)	Lysine (g/kg)	SAA (g/kg)	
12.7	230	14.0	10.0	broilers
11.8	280	18.4	12.5	turkeys
11.4	160	8.0	6.8	layers


Feed/plants grown and produced
Biofuel use:
Biofuel
+
co-products
Poultry
Nutrients used/deposited
Waste products
environment

The focus of producers (and growers?) is on biofuel production

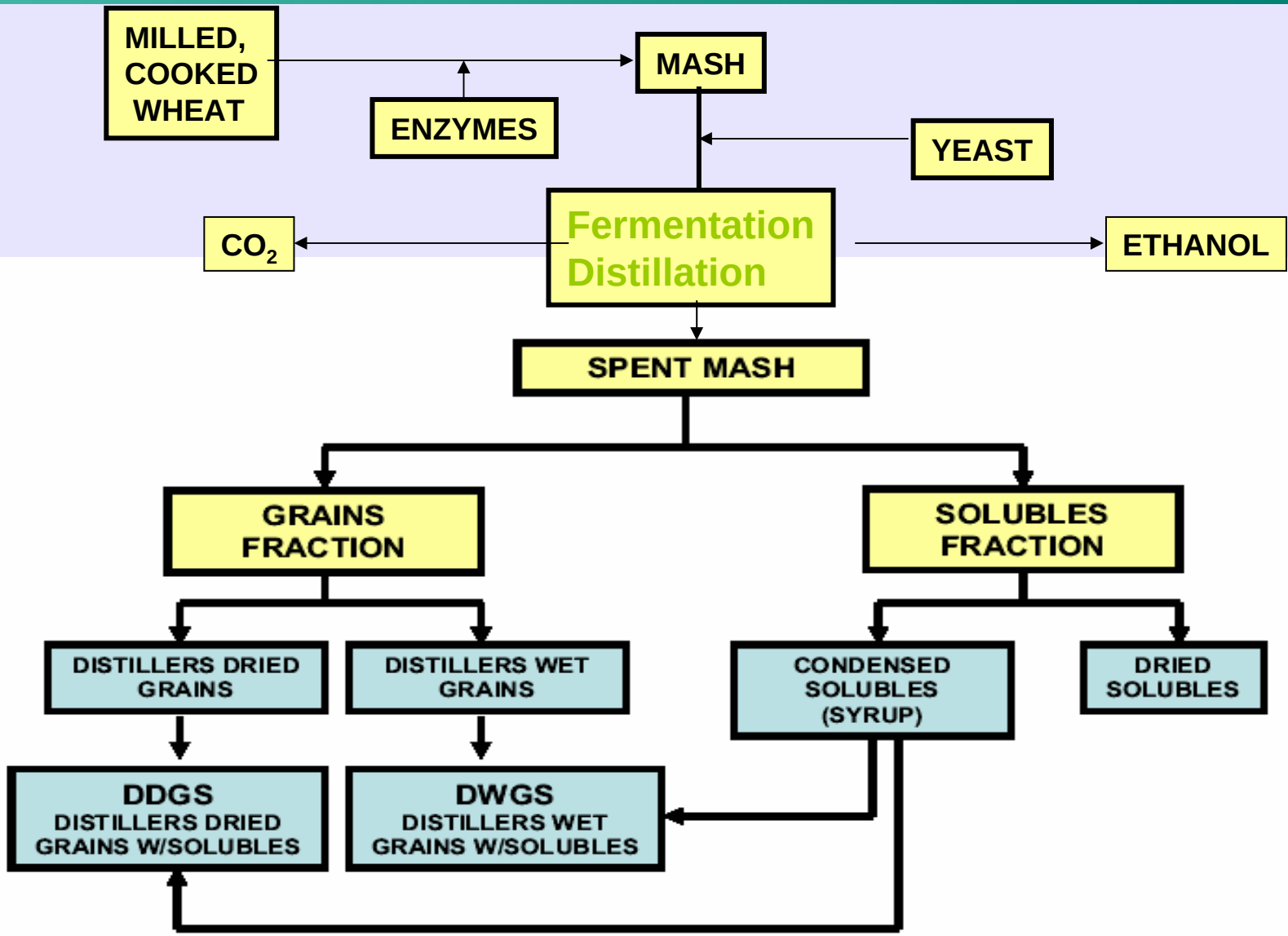
Co-products from biofuels

- Ethanol
  - Wheat distillers grains and solubles (DDGS)
- Biodiesel
  - Expeller rape
  - Glycerol

Substrates for bioethanol production

- Cereals
  - Maize*
  - Wheat
  - Sorghum
  - Others such as barley, oats, ??

Basic dry-milling bioethanol schematic



Composition of wheat (dry matter)

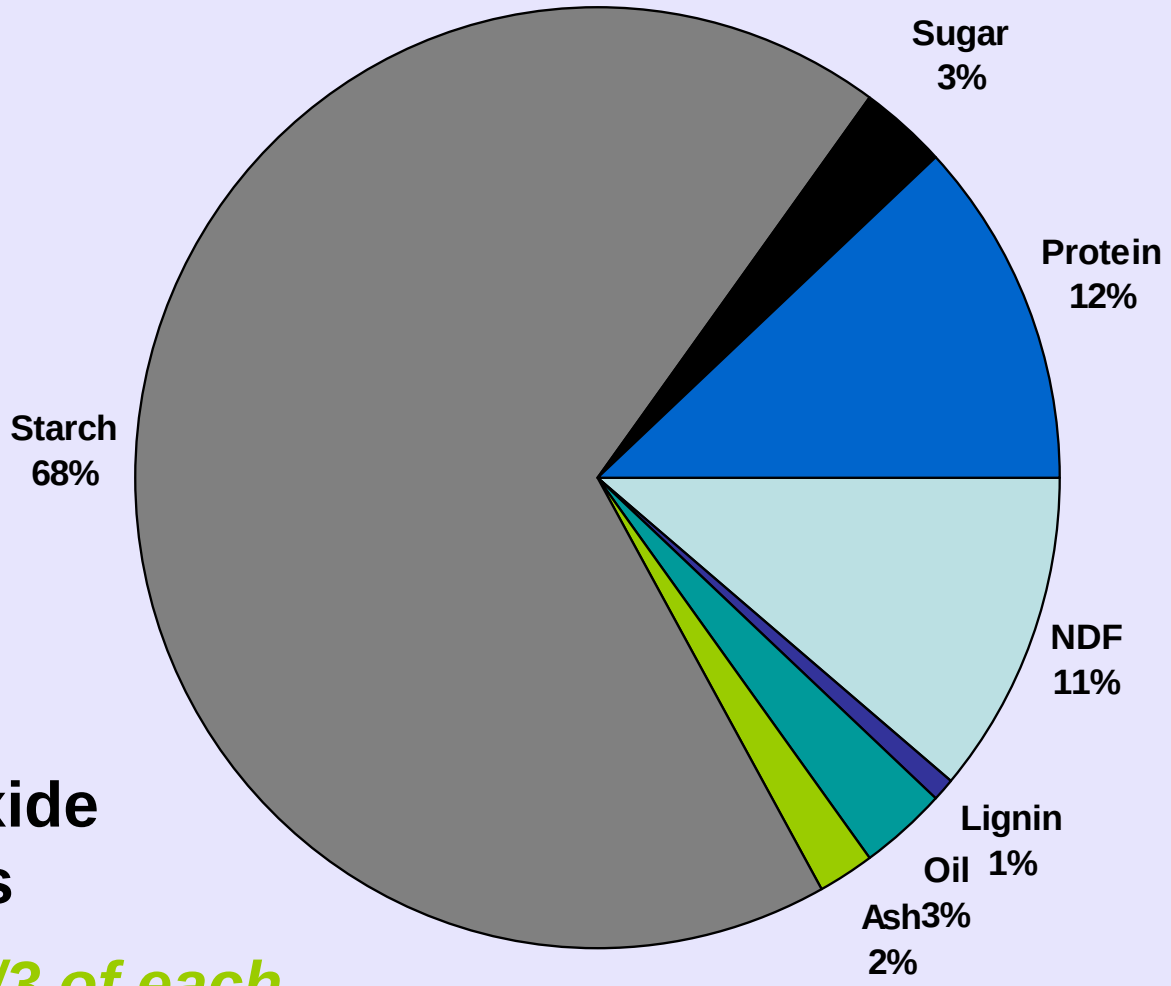
Starch + sugar

↓

Sugars

↓

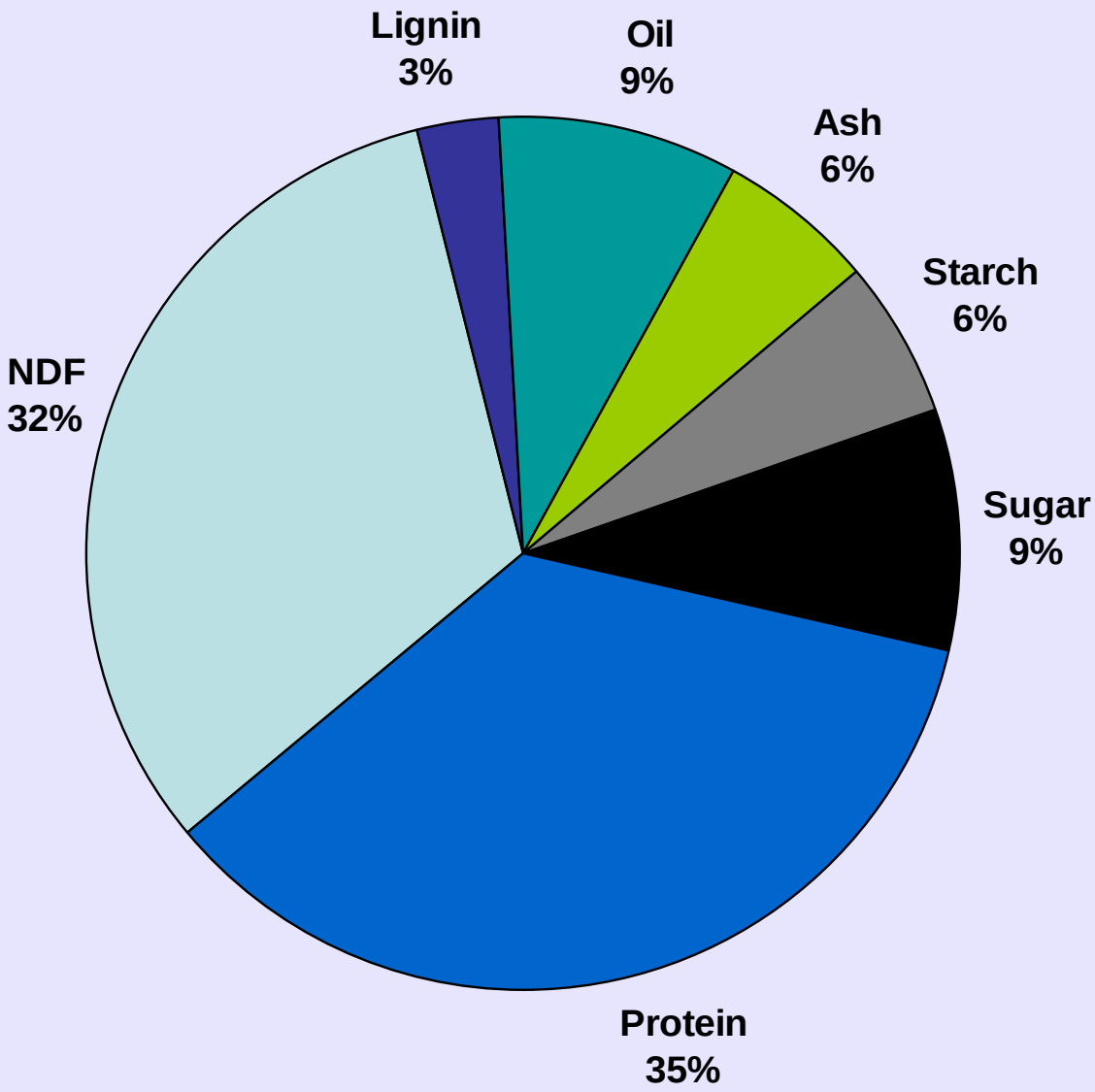
Ethanol
Carbon dioxide
Co-products



Approximately 1/3 of each

Composition of residue DDGS (dry matter)

Distillers co-products.
Nutrients about
3 times more
concentrated than
in wheat
De-starched wheat.



“Old” or “new” generation plants

- Old plants - the nutrient value of the DDGS was not a major consideration to the operators
- New plants
  - Better control of mash/fermentation
    - Greater conversion of starch/sugars to ethanol
    - Less residual starch and sugar in the DDGS
  - Better drying
    - Reduced thermal destruction of amino acids
    - Improved amino acid and protein (and therefore energy) digestibility
    - Improved P digestibility.

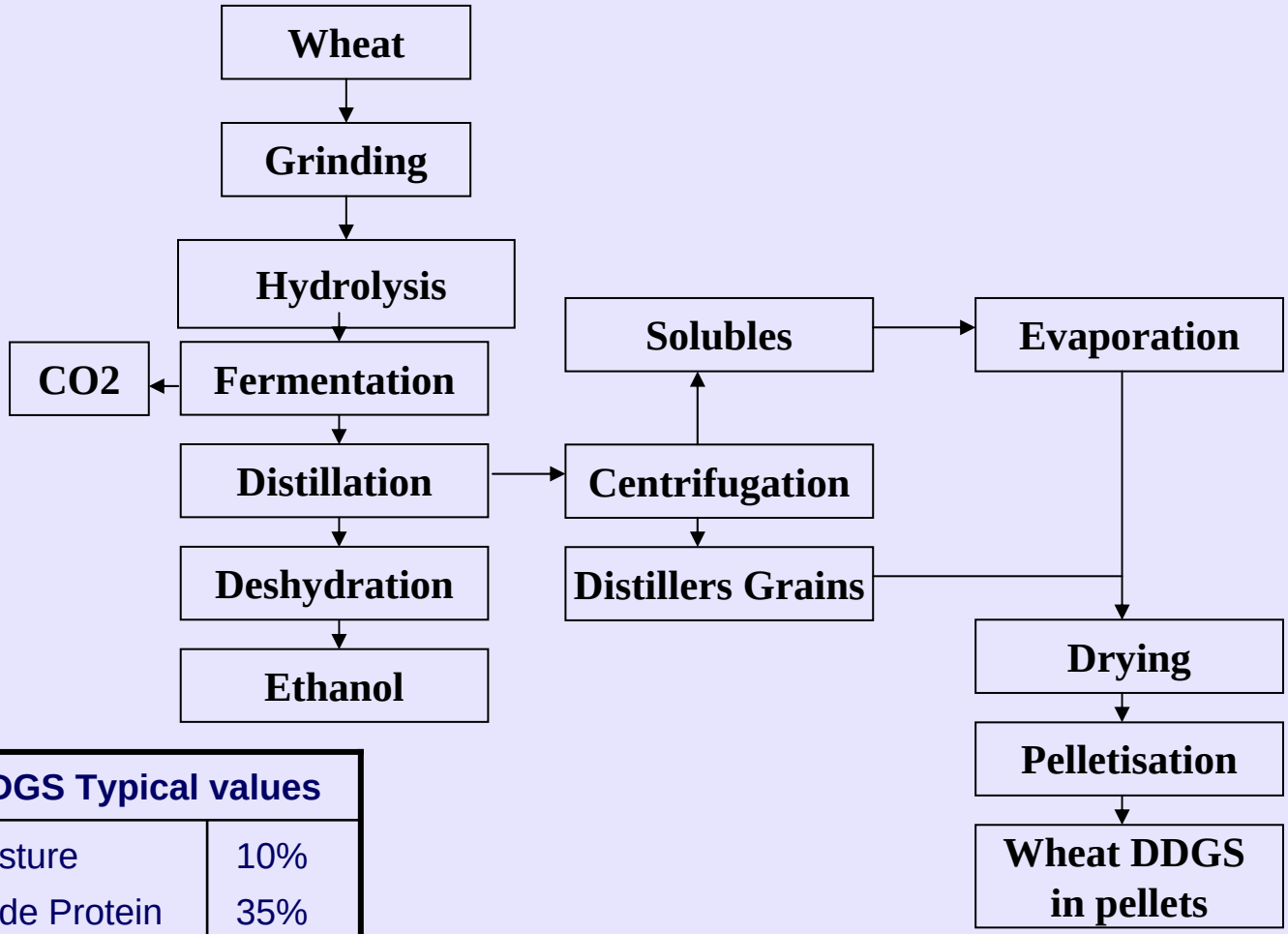
Factors influencing the nutrient composition of distillers co-products

- substrate
- grind
- cooking
- amount of water
- amount of pre-malt
- temperature and time
- continuous or batch fermentation
- cooling time
- conversion
- quantity and quality of malt
- enzymes added
- time and temperature of ferment
- yeast type/quality/quantity
- cooling
- agitation
- acidity and production control
- distillation process
- type of screen
- centrifuges
- type of presses
- evaporators
- dryers
- amount of syrup mixed with grain

Derived from Olentine, 1986

BIOETHANOL FROM WHEAT

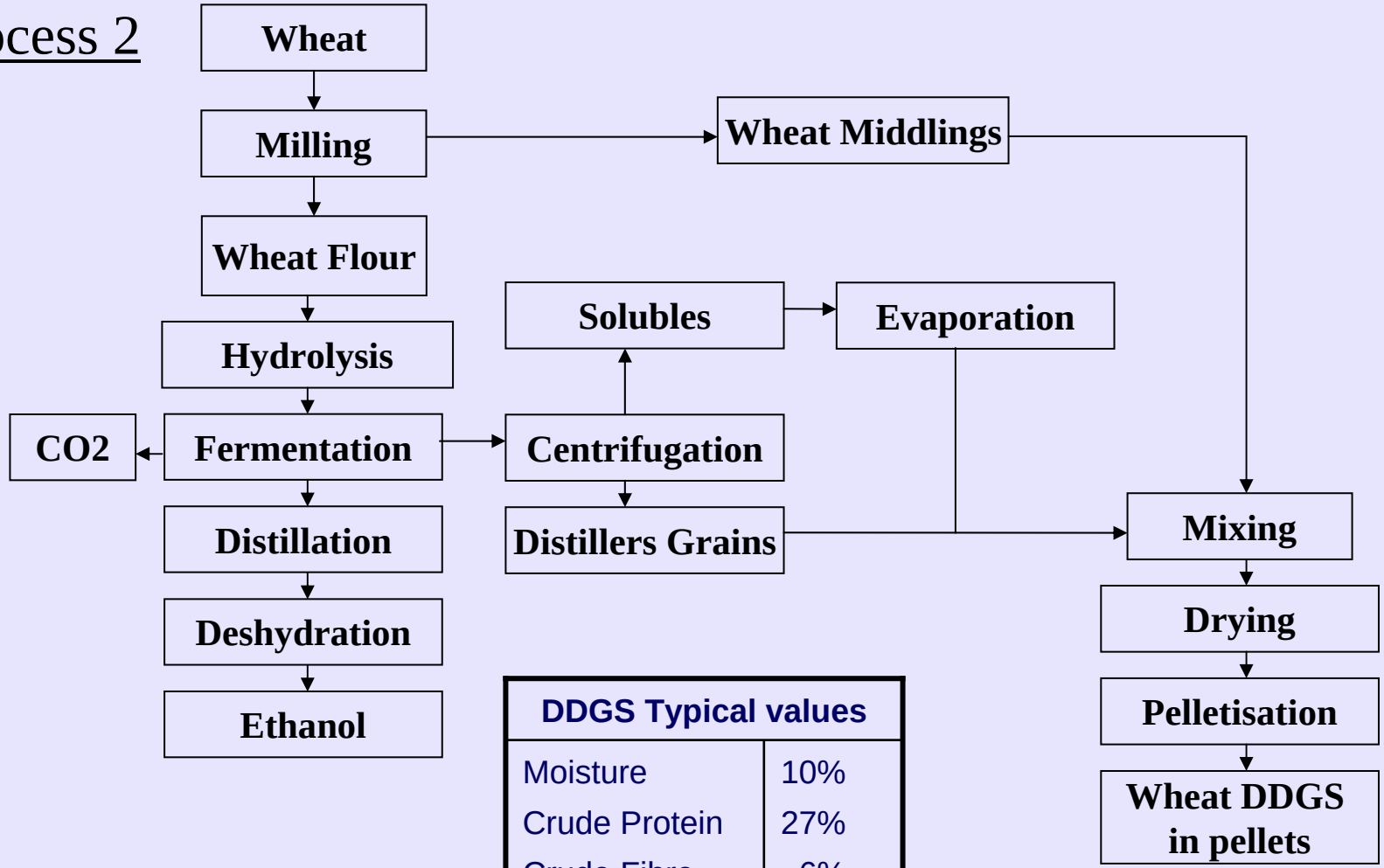
Process 1



DDGS Typical values	
Moisture	10%
Crude Protein	35%
Crude Fibre	8%
Starch + Sugar	<10%
Ash	6%
Crude Fat	4%

BIOETHANOL FROM WHEAT

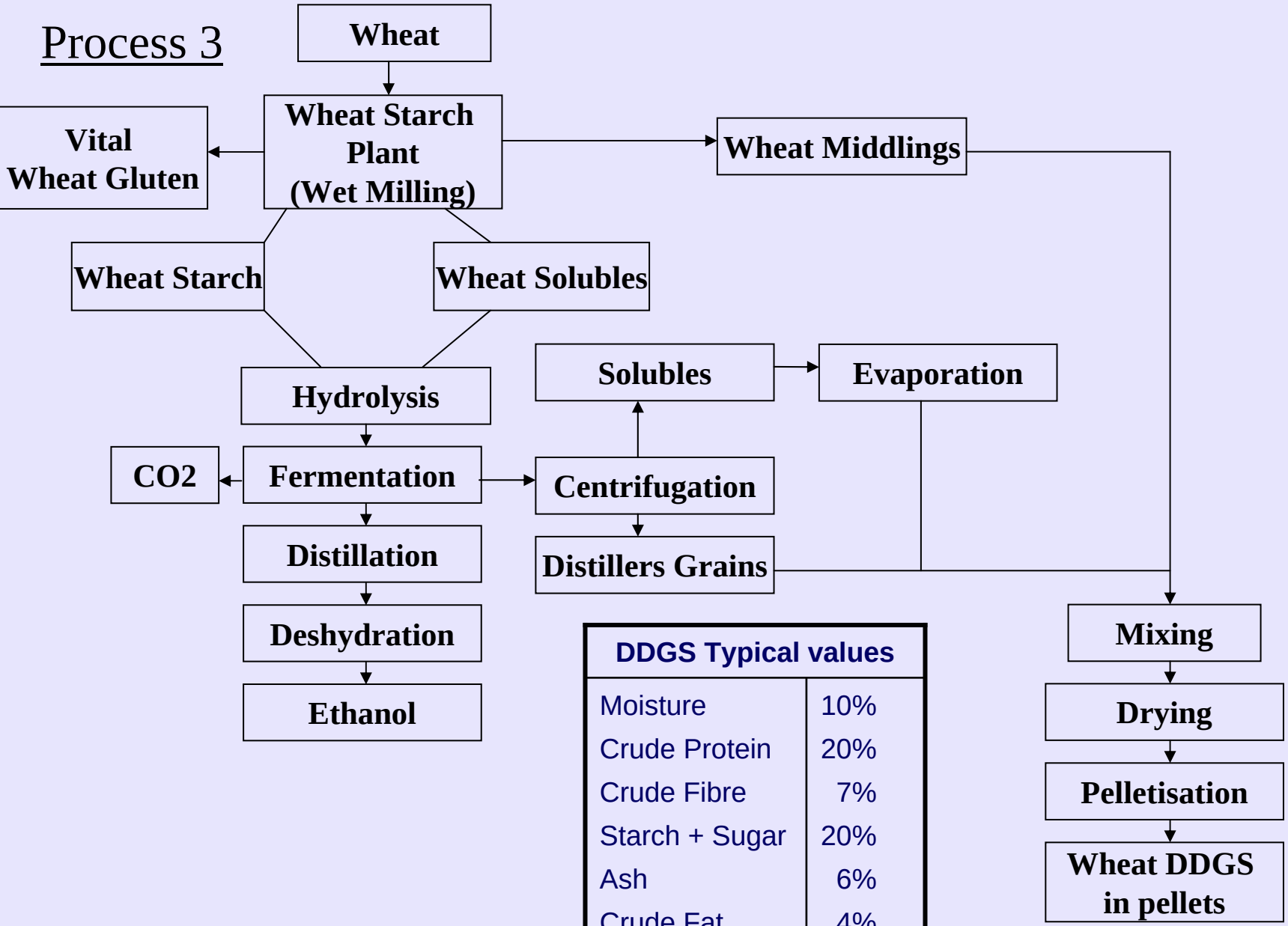
Process 2



DDGS Typical values	
Moisture	10%
Crude Protein	27%
Crude Fibre	6%
Starch + Sugar	15%
Ash	6%
Crude Fat	4%

BIOETHANOL FROM WHEAT

Process 3



DDGS Typical values	
Moisture	10%
Crude Protein	20%
Crude Fibre	7%
Starch + Sugar	20%
Ash	6%
Crude Fat	4%

DDGS
Considerations – variability

- 37 samples CDS, South Dakota University
  - Lysine dig 62.0% (44-78%)
  - Methionine dig 81.9% (74-89%)
  - Cysteine dig 73.0% (66-81%)
  - Threonine dig 70.7% (61.9-83%)
  - Tryptophan dig 69.9% (54-80%)
- Variability reduces value (as nutritionists we formulate below the average) and inclusion rate, because of responses of animal to a bad batch.

Variability of Wheat DDGS (8 samples)

Amino Acid	% AA in Wheat DDGS (88% DM)			
	Mean	CV	Min	Max
Lysine	0.74	23.6	0.62	1.14
Methionine	0.51	15.9	0.47	0.71
Cystine	0.66	12.3	0.61	0.86
Threonine	1.00	5.8	0.96	1.14
Arginine	1.50	16.4	1.35	2.09

Source: Degussa

Variability of Wheat DDGS (8 samples)

Amino Acid	% AA in Crude Protein			
	Mean	CV	Min	Max
Lysine	2.20	16.7	1.83	2.94
Methionine	1.52	8.7	1.42	1.82
Cystine	1.98	6.3	1.86	2.22
Threonine	3.01	4.5	2.89	3.22
Arginine	4.46	9.2	3.99	5.39

Source: Degussa

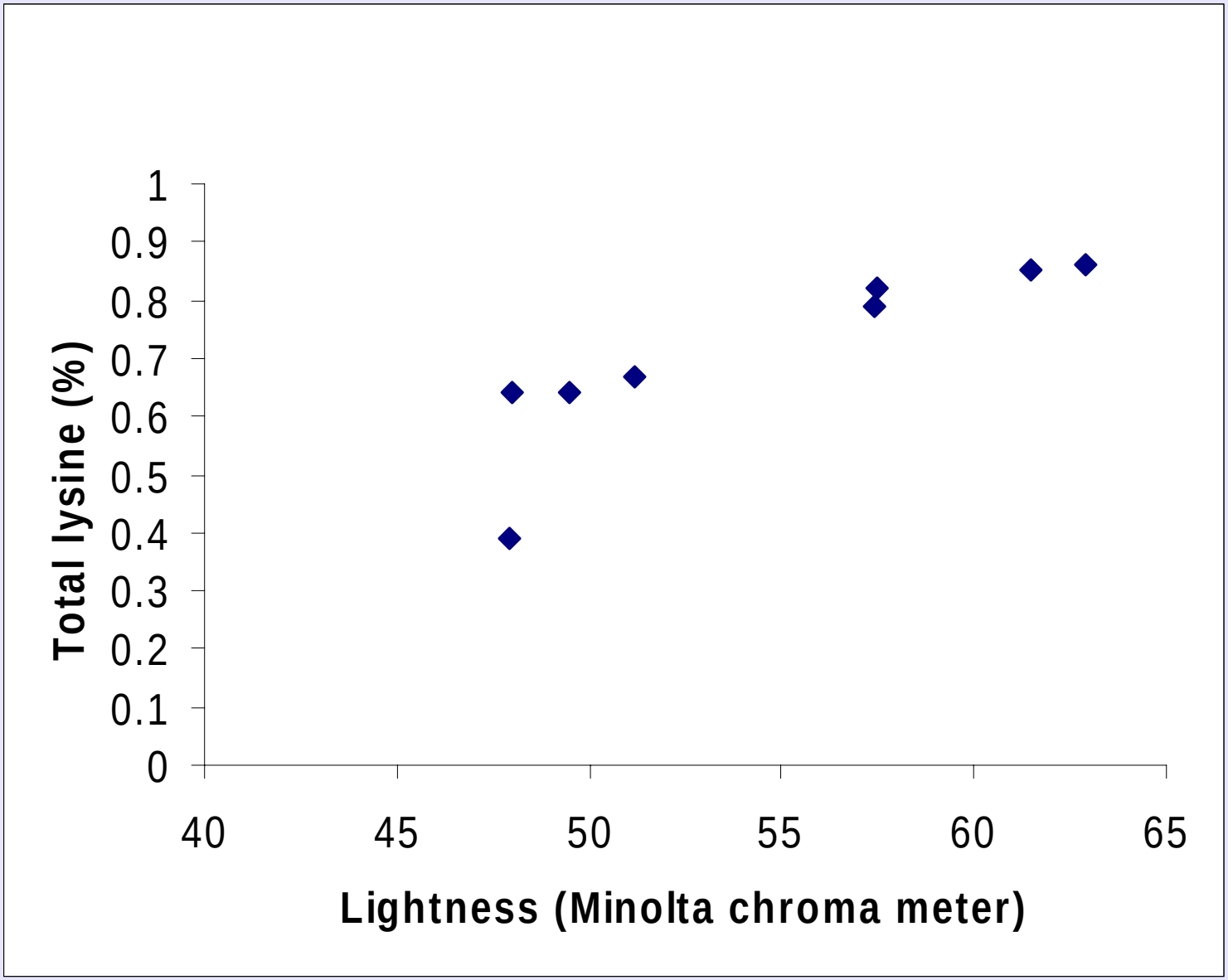
Amino Acid Variability Compared to Wheat

Amino Acid	% AA in Crude Protein			
	DDGS (n=8)		Wheat (n=415)	
	Mean	CV	Mean	CV
Lysine	2.20	16.7	2.76	9.0
Methionine	1.52	8.7	1.52	6.2
Cystine	1.98	6.3	2.23	6.4
Threonine	3.01	4.5	2.84	4.8
Arginine	4.46	9.2	4.77	5.9

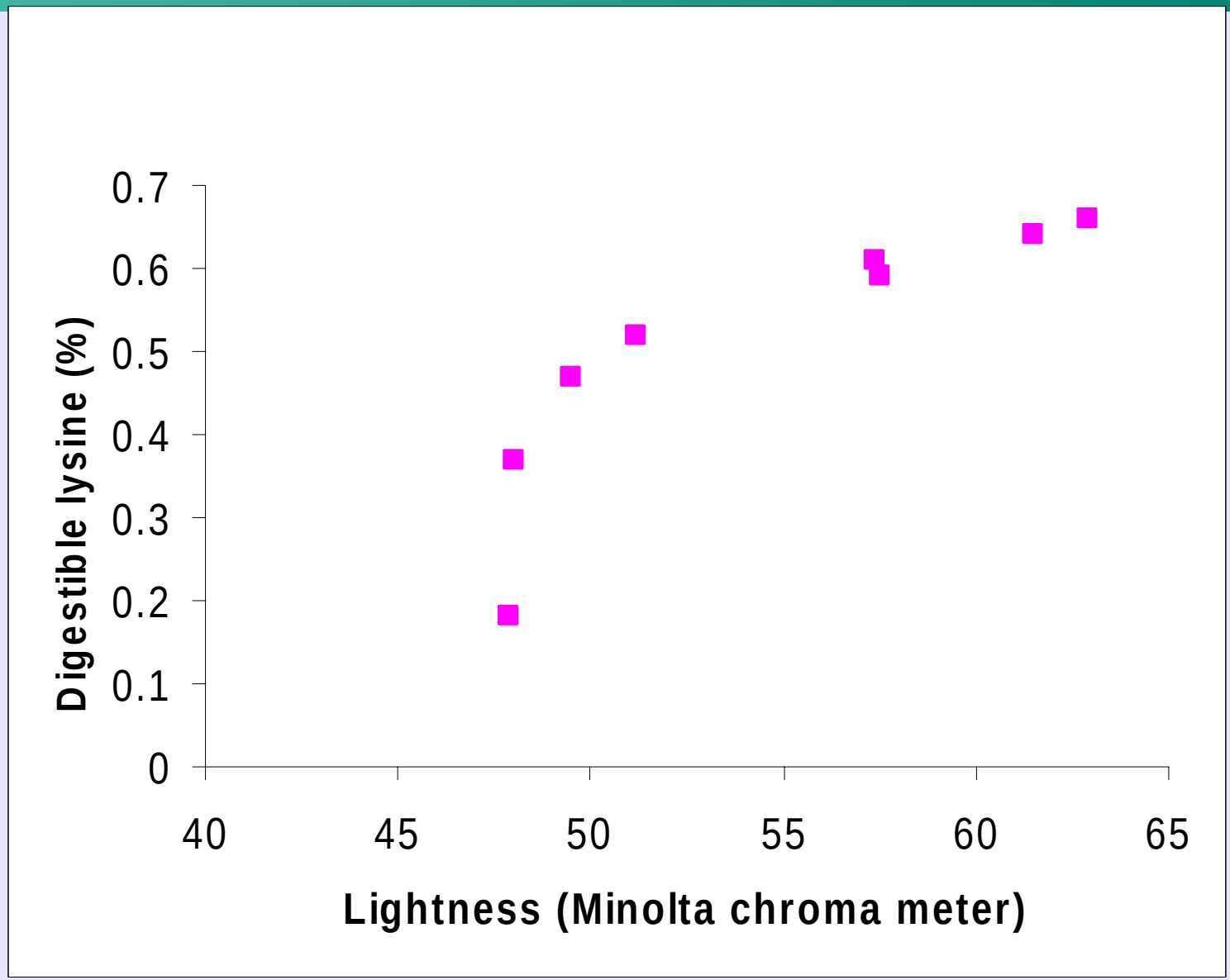
Source: Degussa

Colours of samples of DDGS (Corzo, 2007; MSU)

Colour of maize DDGS and lysine concentration



Colour of maize DDGS and digestible lysine (%)



Calculated analysis of wheat DDGS

Example of “new” generation

		Wheat		DDGS
Dry matter	%	87	87	92
Oil B	%	2.3	6.1	6.4
Protein	%	11	29.0	30.7
C. Fibre	%	2.3	6.1	6.4
NDF	%	10.5	27.7	29.3
Starch	%	60.5	1	1.1
Sugar	%	2.6	0	0.0
Ash	%	1.7	4.5	4.7
Lys	%	0.31	0.82	0.78
Dig Lys	%	0.26	0.69	0.58
ME	MJ/kg	13		11.2

2.8x

Good fermentation

10% destruction

10% digestibility reduction

Wheat DDGS
Summary

- Accurate definition of nutrient content essential
  - Variability (colour, NIR, plant specific)
  - Energy/digestible amino acids/ digestible P.
- If accurately defined, and heat damage limited, can be fed to reasonable levels
  - e.g 20% in turkey finishing feeds.
- Amino acid concentration poor
  - 10% DDGS increases CP by 1% in pig/poultry feeds
- Fibre source
  - Potential in Layer diets
  - May improve gut health
- Other components increase in concentration compared to original wheat
  - Mycotoxins
  - Antinutrients and other toxins

Biodiesel (rapeseed methyl ester, RME)

- Rapeseed expelled
  - Expeller rape meal
  - Rape oil
- Glycerol
- Above also is relevant for other oilseeds

Substrates for biofuel production

- Oilseeds
  - Soyabeans
  - Oilseed rape
  - Palm kernals
  - Jatropha
  - Others; sunflower, linseed, groundnut
  - Used vegetable oils
- Co-products: seed meals and glycerol

Extraction of oil

- Oilseeds

  Pressed at various pressure

  Pressed at various temperatures

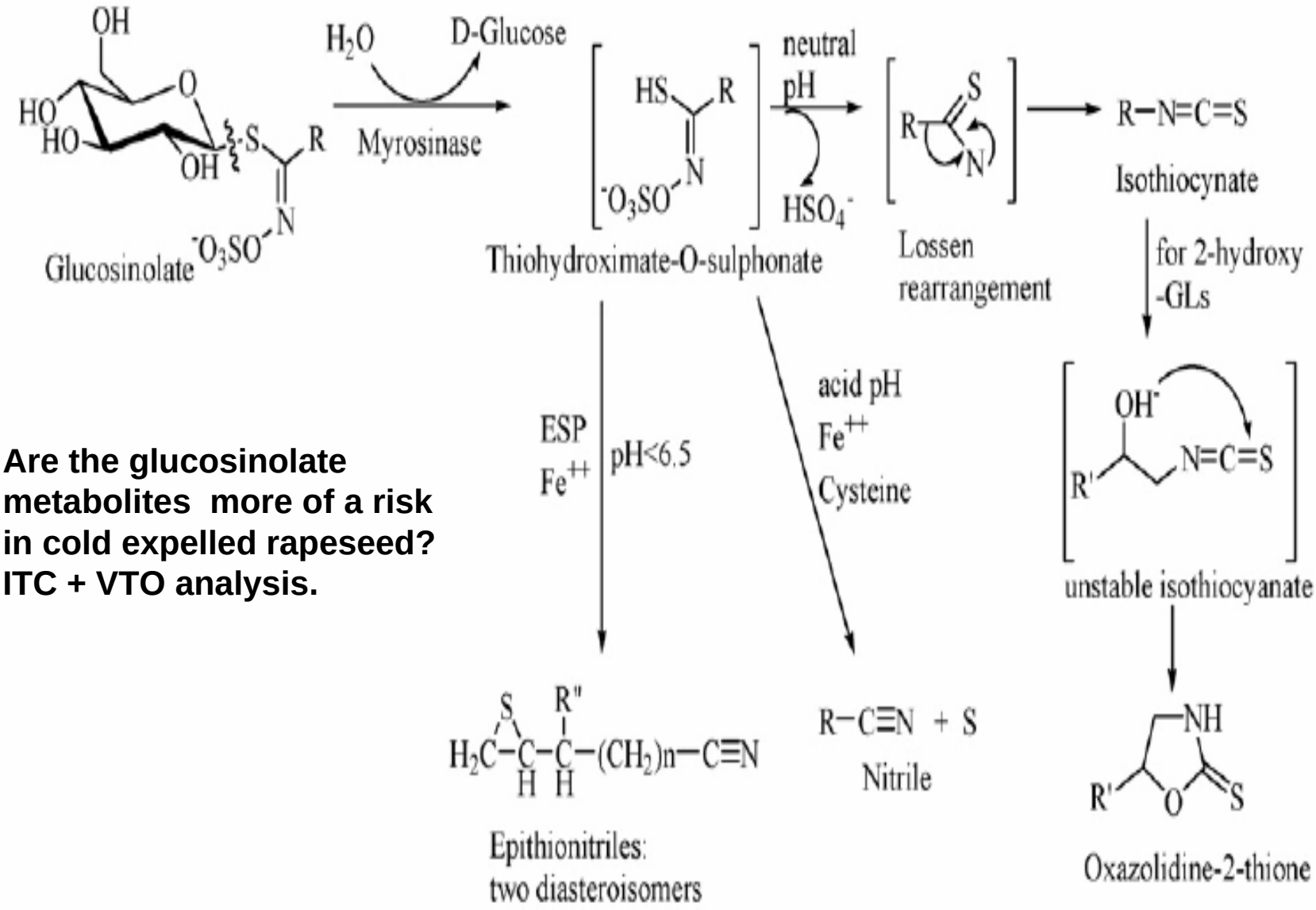
  Thus the processing can influence the quality of the residual meal (Malliard products and oil content).

  Oil content influences ME

  Maillard products influence the availability of amino acids and the toxicity of the material

Rapeseed

- Extracted rape
  - Seed flaked at cooked at 85-105C for 15-20mins (China up to 120C)
  - 60-70% of oil removed by expelling
  - Hexane removes most of residual oil
  - Desolventising/toasting, 103-107C for 20 mins
  - Gums may be added back (Canola)
- Expeller rape
  - The expelling process varies.
  - It may be cold-pressing, or involve flaking and heating (eg 100°C for 20-25 minutes). Cold-press involves some friction and so temperatures of 50-60°C may be encountered.
  - Variable oil (7-20%)



Are the glucosinolate metabolites more of a risk in cold expelled rapeseed? ITC + VTO analysis.

Rapeseed

	Whole Rape	Rape meal	Rape expeller
Crude Protein (%)	20-22	32-35	31-34
Fat (%)	42-44	2.5-3.5	7-13
Crude Fibre (%)	7-10	11-13	10-15
Lysine digestibility (%)	70-78	72-80	72-79

Schothorst

Glucosinolates

- Sulphur-containing glycosides found in many species of Brassica, giving them the characteristic bitter flavour (e.g. mustard, radishes, horseradish).
- Plants use glucosinolates as natural pesticides, and as a defence against herbivores, as they are very unpalatable (or more correctly their breakdown products are).
- Plant breeders have developed varieties of rapeseed with lower levels of glucosinolate (referred to as 0-rape, 00-rape or canola).
  - 0 rapeseed meal 120-150umol/g total glucosinolates
  - UK 00 about 8umol/g total glucosinolates
- Glucosinolates are relatively harmless until they are broken down. This breakdown can either occur following crushing of the seed, resulting in the release of the enzyme myrosinase, or by gut microflora.
- The main breakdown products of glucosinolates
  - thiocyanates, which are very bitter tasting and goitrogenic
  - isothiocyanates, nitriles and oxazolidinethione (goitrin).

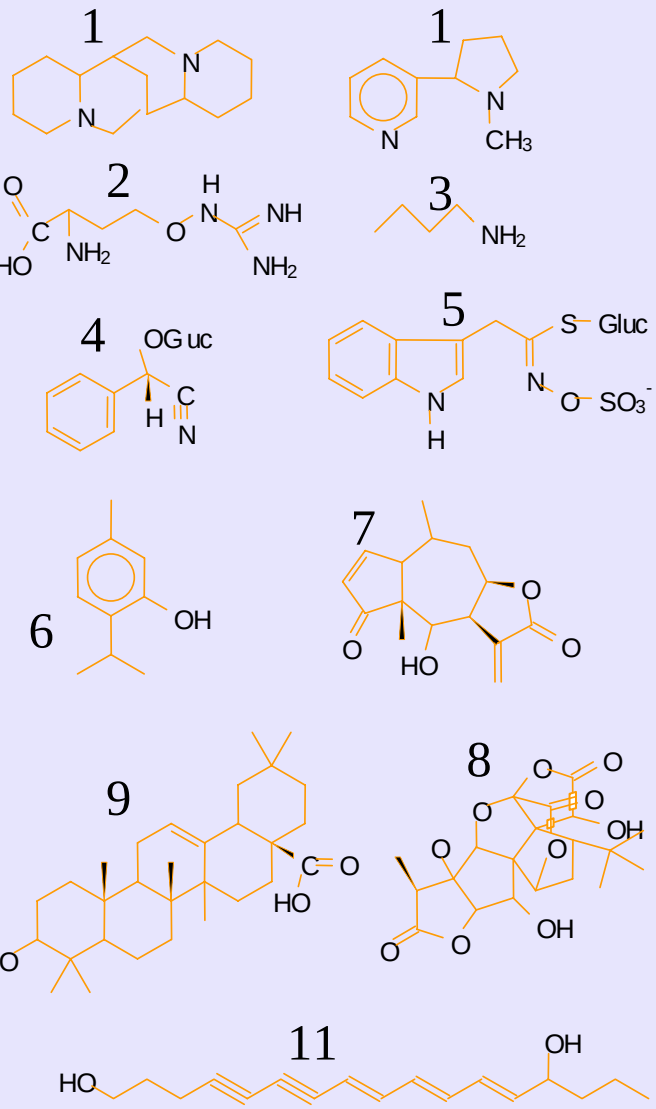
Jatropha

- Seeds contain 300-400g oil/kg
- Extract oil: fats, glycerol
- Residual proteinaceous meal
- Contains increased content of phorbol esters ca 0.5g/kg (cytotoxic)
- Cannot be used as a feedstuff in the EU

Range of plant secondary metabolites in feedstuffs (Natural products)

Number of natural products

With nitrogen	
• Alkaloids (1)	12,000
• Non-protein amino acids (2)	600
• Amines (3)	100
• Cyanogenic glycosides (4)	100
Glucosinolates (5)	100
Without nitrogen	
• Monoterpenes (6)	1,000
• Sesquiterpenes (7)	3,000
Diterpenes (8)	2,000
• Triterpenes, Saponins, Steroids (9)	4,000
• Tetraterpenes	350
• Flavonoids (10)	2,000
• Polyacetylenes (11)	1,000
• Polyketides (12)	750
• Phenylpropanes	1,000



(ca 80,000) (from: Wink; in Acamovic et al, 2004)

Glycerol

- Also known as glycerin or glycerine
- Colourless odourless liquid
- Sugar alcohol, 60% as sweet as sucrose
- Soluble in water, hygroscopic
- Widely used in food and beverages, personal care and pharmaceutical products
- Potentially a very useful feed ingredient

Glycerol analysis

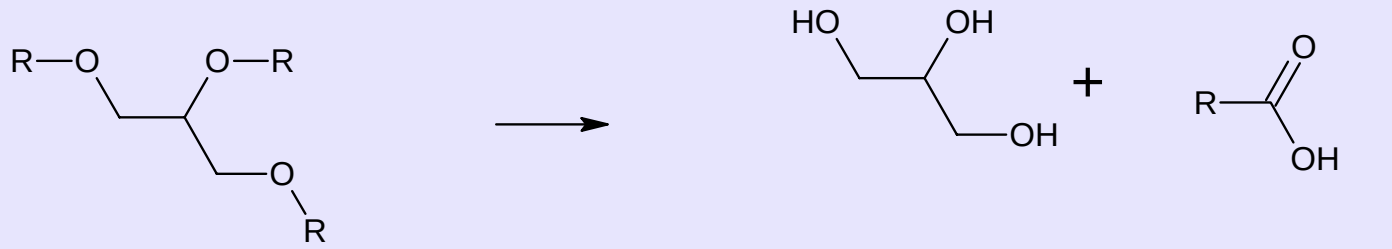
	Pure	Crude	ADM Cocerine
Glycerol	99% min	80% min	80% min
Water	0.5-1.0%	10-15%	14% max
Ash	Max 0.1%	Max 10%	Max 10%
Methanol	0	Max 0.5%	Max 0.5% Typical 0.05%
Other	GE =18 MJ/kg	Na 0.09% P 2.4% K 2.3% Fat 0.4%	Na 2.5% Cl 3.6%

Glycerol – metabolisable energy value (MJ/kg)

Glycerol (Gross energy= 18.0 MJ/kg) is an unusual feedstuff in that it is highly utilised until a particular level is used but beyond this point it is excreted

Inclusion rate (%)	Layers	Broilers	Pigs
5	17.6	17.7	17.5
10	16.8	17.0	14.4
15	15.4	15.4	10.6

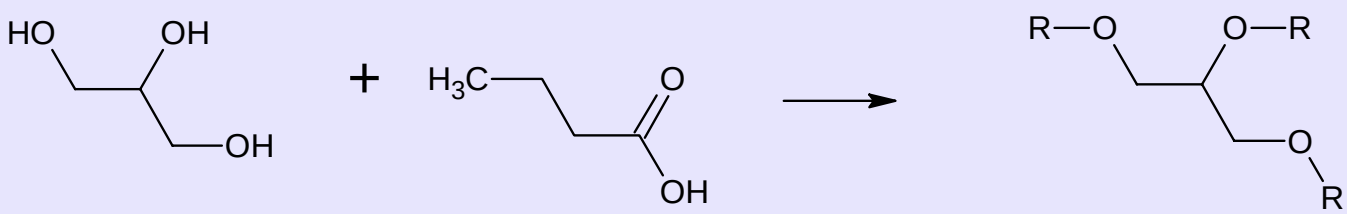
Fatty acid triglycerides



triglyceride

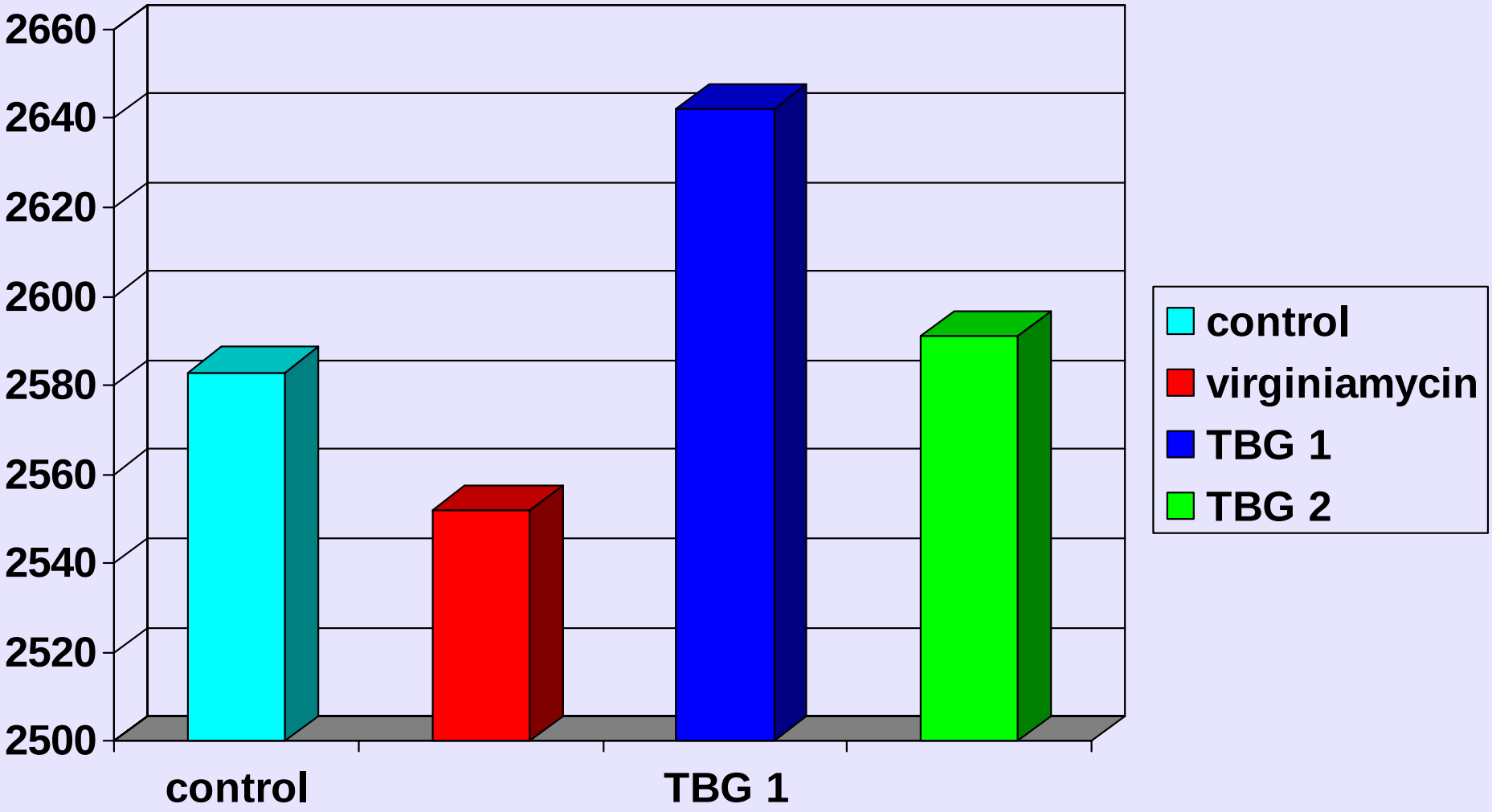
glycerol

fatty acids

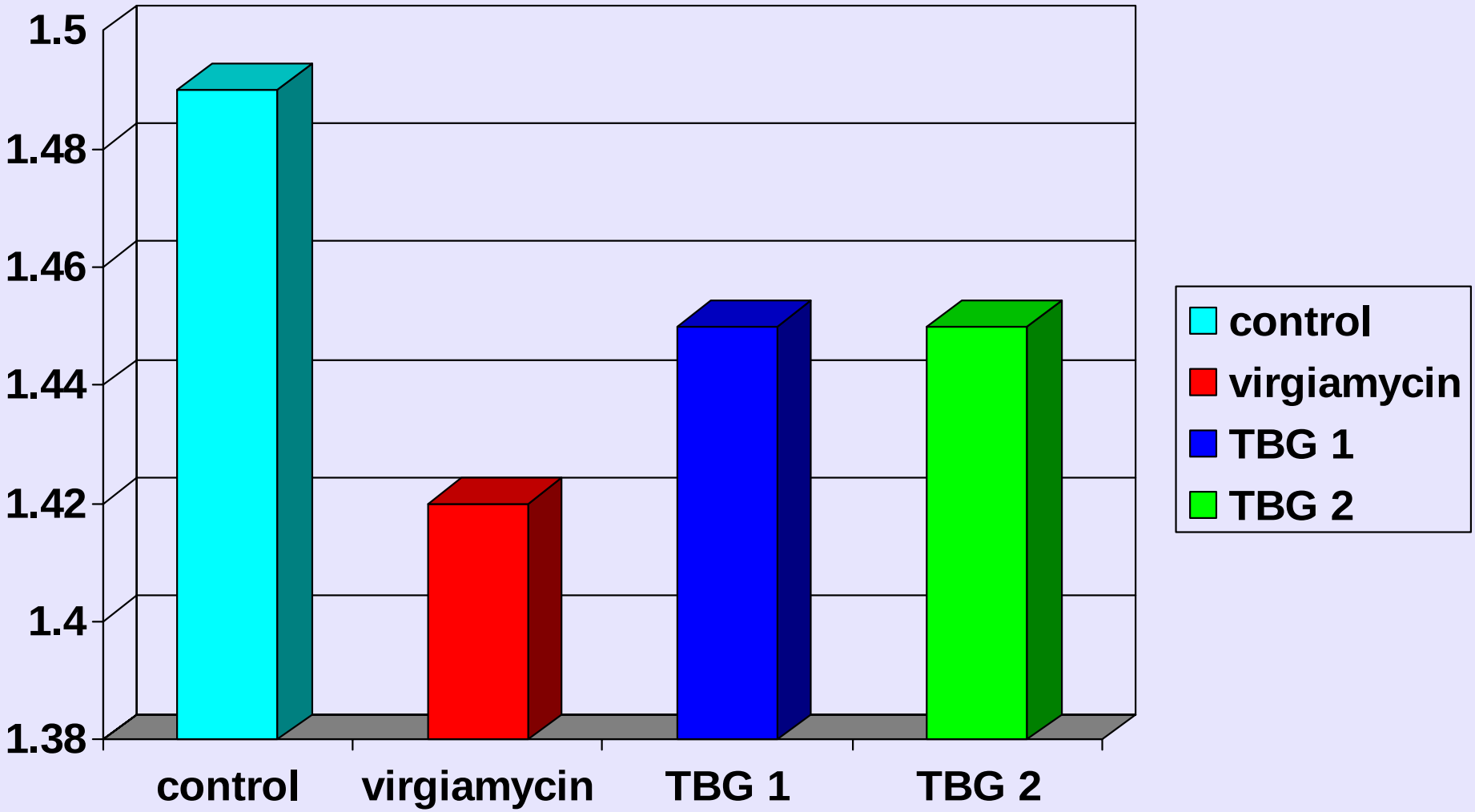


(R)

Weight at 42d glycerine tri butyrate [TBG] (Leeson)



FCR at 0-20d glycerine tri butyrate [TBG] (Leeson)



Biodiesel co-products Summary

- Expeller rape
  - Ensure 00 seed used
  - Oil is variable (and thus protein); availability/seed rupture?
  - Conservative inclusion rates on cold pressed until ITC+VTO known
  - Handling?

- Glycerol
  - Good ingredient but note maximum inclusion rates.
  - Check methanol, moisture, minerals.
  - Limited supply as yet, mainly used as a molasses replacer.
  - Derivatives may be useful.

Overall Summary

- Biofuel Co-products are variable
- Anti-nutritional concentration needs further assessment
- Opportunities to add value

Courtesy: "The Other Coast" August 17, 2006

The end

SAC receives financial support from the Scottish Government

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