Alternative Protein(s) for meat poultry: Challenges and Opportunities

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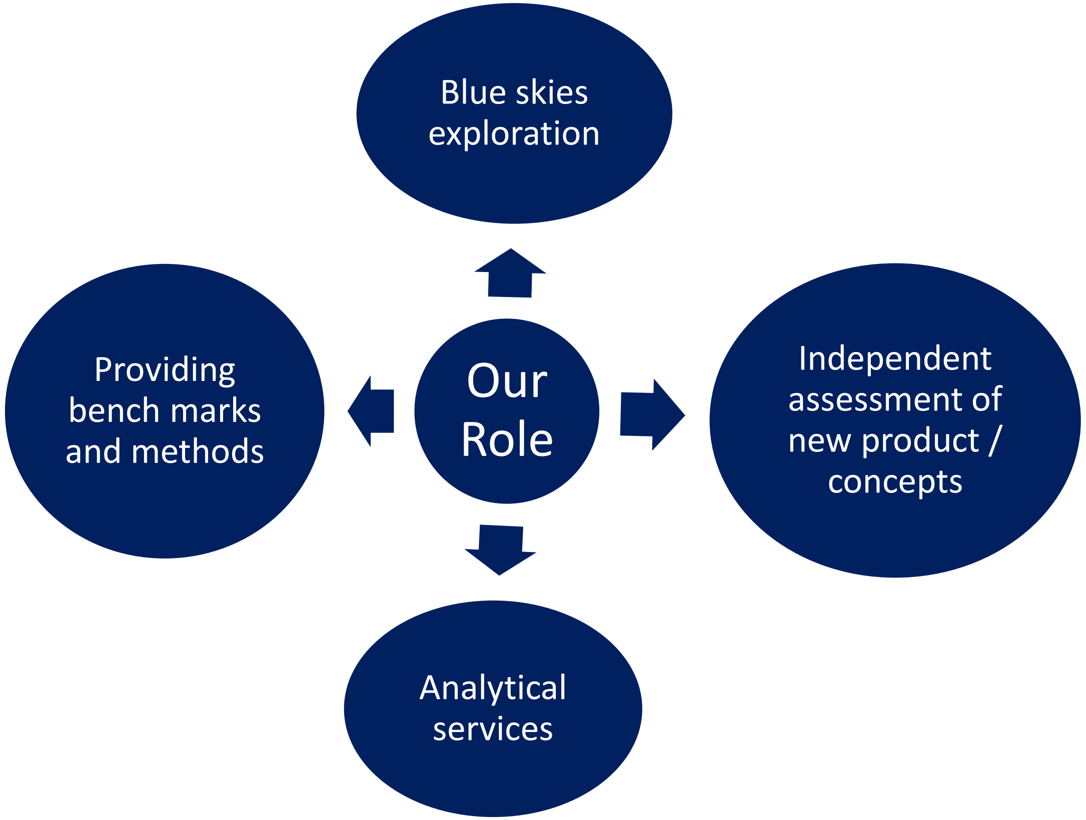
Structure for today

- Context to our current situation
- Challenges
- Candidates
- Case studies

Nottingham Trent University Poultry Research Unit

Focus:

Using nutrition as a tool to reduce environmental impact of poultry production and improve bird health



Role of nutrition in sustainable poultry production

- 60% of production costs are feed
- 2018 global requirement for poultry feed was 450 MMT:

  297 MMT meat sector + 153 MMT egg sector
- Diet mainly cereal (57%) and a protein source (40%), hence requirement for global poultry meat sector: ~118.8 MMT
- Protein most commonly supplied as defatted soya bean meal

Feed and Food; Corresponding Protein Requirements

The impact of the consumer on our business

9 Billion Mouths to Feed
30 Million Views to Consider

Policy Driving Forces	Consumer Opinion forces
Strategic Priorities	**Consumer Concerns**
Internationally competitive	GMO's/Biotechnology
GB Self sufficiency	Safety
Health and Nutrition	Welfare
Sustainable Intensification	Value and provenance
Regulatory compliant	Intensive agriculture
	Obesity/value; Red vs White

Why consumer concern?

13 feed-related food scares in 26 years alerted and sensitized public

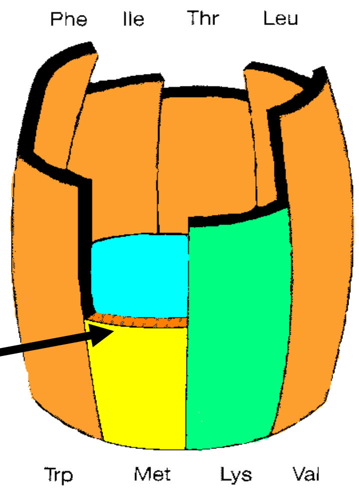
- **1987** BSE (from meat and bone)
- **1988** Salmonella in Eggs (feed materials)
- **1996 New Variant CJD (linked to BSE and beef)**
- **1997** GMOs (debateable but raised awareness!)
- **1998** Dioxins in Citrus Pulp ex Brazil
- **1999** Sewage Sludge in Feed (in Germany and France)
- **2000** Belgium Dioxin Crisis (fat contamination)
- **2002** Chloramphenicol in shrimp meal (China)
- **2005** Dioxins in pig bone fat (Belgium)
- **2008** Dioxins in bread meal (Ireland)
- **2009** Melamine in protein meals (China)
- **2011** Dioxins in blended fats (Germany)
- **2011** Arsenic in Palm Kernel Expeller (PKE) ex Malaysia

What does the poultry sector need from a protein source?

1. Critical volume (>100K tons/yr)
2. Resilience in the supply chain
   - Consistent supply
3. Established logistics
4. Regulatory Compliance
5. Highly consistent nutritional quality
   - Allowing cost-competitive diet formulation
6. Consumer acceptance

Nutritional quality

- Low in fibre
- Low in anti-nutritional factors
- Digestible amino acid supply matching needs of bird



Amino acids supplied in excess are not used

Limiting Amino Acid

Soy bean meal
– the bench mark

- Reference standard for all other proteins
- Global acceptance; economically priced
- 85% of the crop used in animal feed
- 44-49% crude protein
- Valuable amino acid composition high in lysine
- Oil is used for food and biodiesel
- Approx 90% of the crop is GM: Roundup Ready
- Presence of anti nutritional factors but consistent profile
- China a major draw on worldwide soybean meal

Why would the poultry sector change protein source?

1. Consumer questioning over ethics
2. Projected demand for soy outstripping production

Science News *from research organizations*

Global trade in soy has major implications for climate

Study examines carbon emissions from Brazilian soy exports with unprecedented accuracy

Date: May 7, 2020

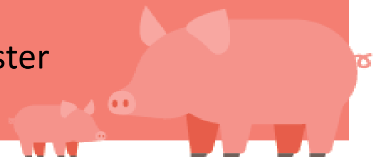
Source: University of Bonn

Summary: The extent to which Brazilian soy production and trade contribute to climate change depends largely on the location where soybeans are grown, according to a new study. In some municipalities, carbon dioxide emissions resulting from the export of soybean and derivatives are more than 200 times higher than in others.

Share:

Sustainable and ethical sourcing is increasingly of concern to the modern food shopper, with **85%** stating it's important or fairly important for supermarkets to source their produce **ethically.**

Lloyds Register 2019



Skretting, Cargill probe soy suppliers amid Amazon fires

Feed company said marked increase in deliberate forest fires could be devastating to the reputation of soy from Brazil in the aquaculture value chain.

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Why food companies have to get soy sorted

By Ben Cooper | 16 April 2020 Font size Email

Ben Cooper looks at the challenge food manufacturers face in putting their soy supply chains on a sustainable footing and why it is so important to them and the planet that they succeed.

Over recent decades, soy has become a hugely significant commodity for food manufacturers and will become only more significant over the coming years, particularly as consumption of plant-based protein increases.

At the heart of the challenge food companies face regarding soy is a paradox. Its high protein content makes it the staple ingredient in the majority of plant-based meat alternatives that will play a crucial

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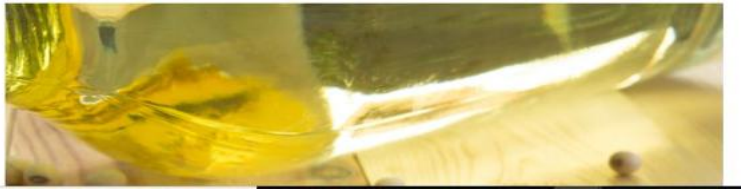
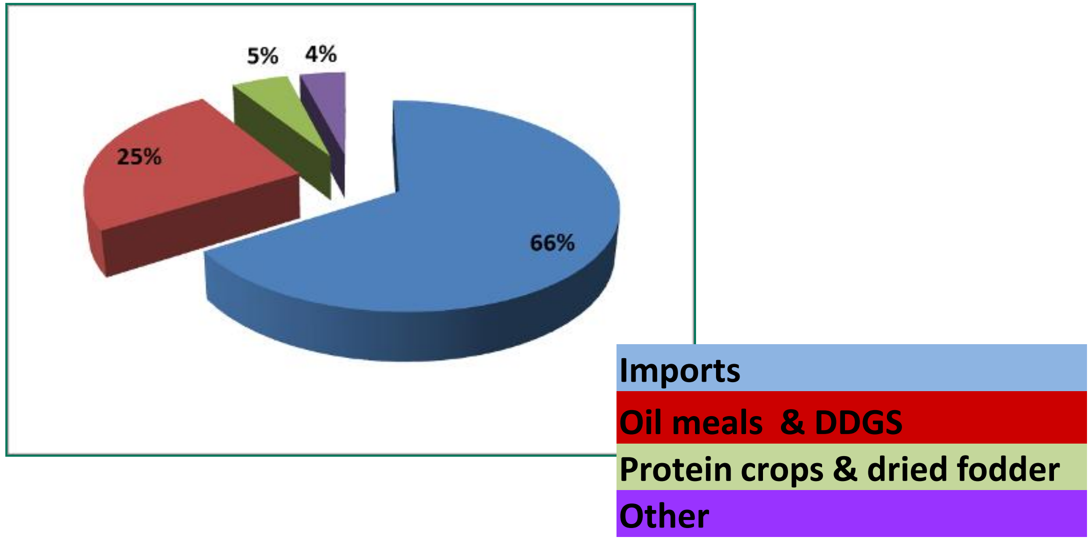
Report: Soybean global supply falling short of demand



EU feed protein is also a political issue

- EU imports 30 MMT soymeal/annum
- European Green Deal
  - Spot light on farming: accounts for 12-17% of annual greenhouse gas emissions
  - Amazon deforestation increases 28% over previous twelve months
    - EU a voracious consumer of Brazilian beef and soy
    - EU law to block import of commodities linked to deforestation

European protein feed requirements: Need and production



Key factors

- Concentration
- Amino acid composition
- Availability
- Antinutritional factors
- Quantity

Category	Novel protein sources
Oil seeds	Proteins of defatted soybeans, rapeseed and sunflower seed
Grain legumes	Peas, Vicia faba, lupines and concentrates, chick peas
Forage legumes	Lucerne (alfalfa)
Leaf proteins	Grass, sugar beet leaves
Aquatic proteins	Algae, both macro- (seaweed) and microalgae, duckweed
Cereals/pseudo cereals	Proteins from oat and quinoa
Insects	E.g. mealworm, housefly, house, black soldier fly

New sources of alternative proteins:

Insects; Algae; Single cell proteins; Designer Crops (Simm 2017)

What constitutes commercially viable to replace soya?

- Regulatory Compliant (safe and efficacious)
- Cost competitive taking into account all aspects
- Critical volume
- Resilience in the supply chain
- Consistent quality
- *Consumer acceptable*

There is no single alternative to soya

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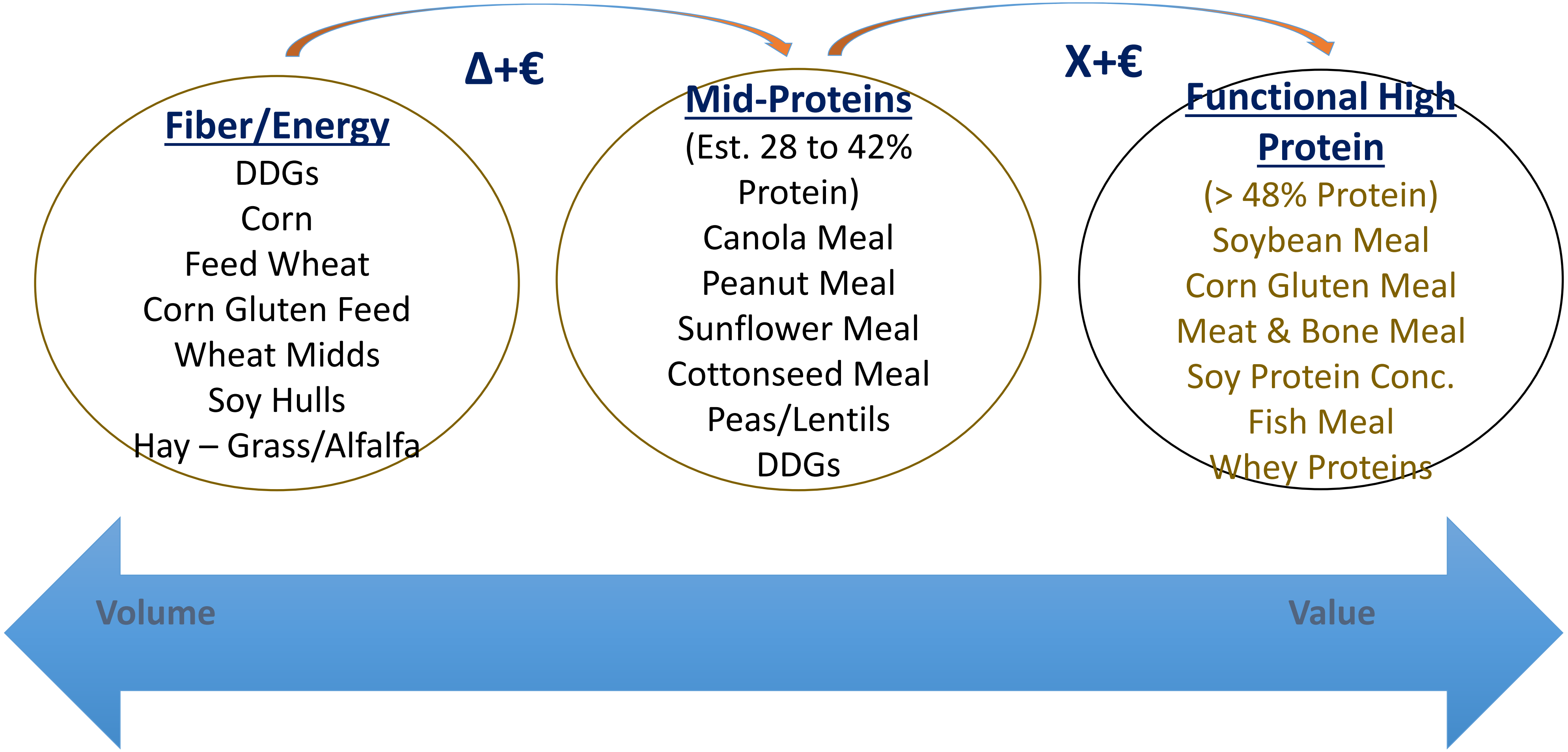
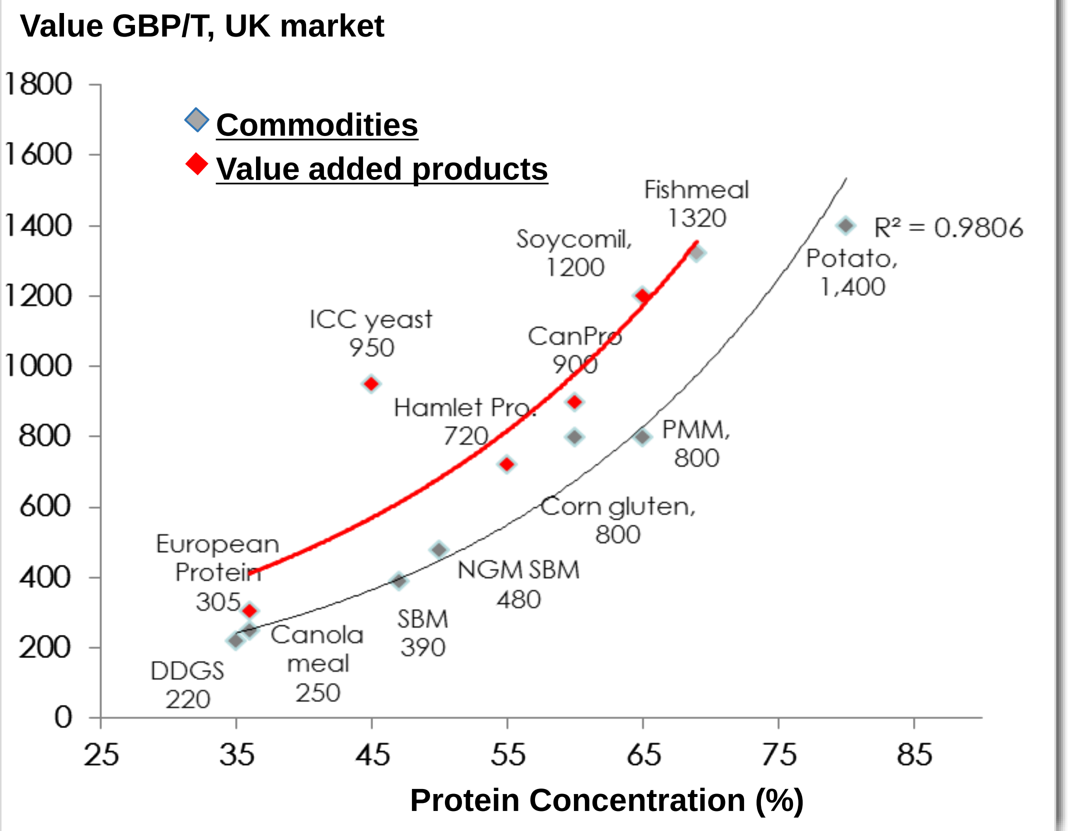
Candidates

Not all Protein is Equal



Most current alternatives need to obtain price premiums for functionality

Proteins supplement prices correlated to protein concentration



Added value allows to charge premium

Commodities tend to be **priced according** to their **protein concentration**, as shown when plotted against the commodity price line

Value added products deviate from the line due to following benefits:

- Yeast effects (palatability, source of nucleotides, mannans, glucans, Vitamin B etc.)
- Removed anti-nutritional factors and high digestibility
- Improved gut health

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Single cell proteins

Fungi, Yeast, Algae and Bacteria

Efficiently converting inedible materials into protein sources

Waste carbohydrates; Cellulose, Hemicellulose, Lignocellulosic

- Light energy
- Fixating C02

Currently very limited commercial scale

- Not cost competitive with traditional protein sources

Significant challenges and advances in feed formulation

- Bacteria – 70% protein
- Yeast/fungi – nucleotides, cell wall materials
- Algae - **ώ-3 oils**

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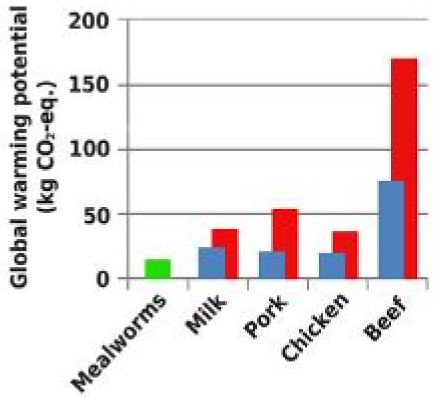
Insect protein

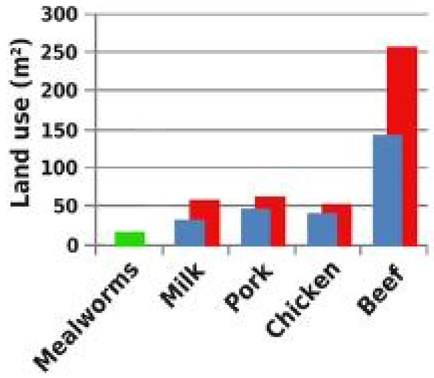
Role may grow if meat poultry reposition as waste recyclers / nutrient up cyclers

- *Musca Domestica* larvae
- Protein (%) 45-60
- Fat (%) 20-35

- Current legislation a barrier
- Chemical safety
- Microbiological Safety
- Potential allergens

- Supply difficulties
- Consumer attitudes

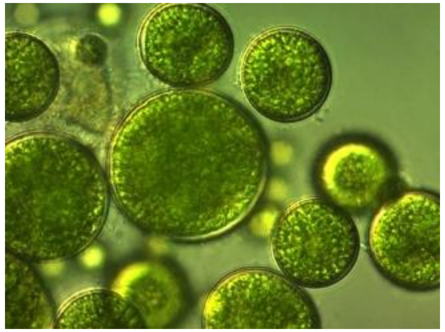




PROteINSECT
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN
www.proteinsect.eu

MicroAlgae

- Unicellular, photosynthetic aquatic plants.
- Currently applied as source of n-3 long chain PUFAs plus vitamin and antioxidants source, for egg yolks.
- Mainly Spirulina and Chlorella sourced as a defatted biomass from biofuel production
- Positive performance indices and immune function when used to replace AGPs
- sources.
- 60-70% protein content with excellent amino acid profile



Why haven't we given up on algae?

Algae production is a potential co-product from ethanol production

Co-location

- Free waste streams
  - CO_2 utilization
  - Waste heat
  - Nutrients
  - Water reuse

Autotrophic

- No sugar costs
  - Heterotrophic face sugar costs & produce CO_2

Light Utilization

- High productivity

Harvest Density

- Low cost dewatering

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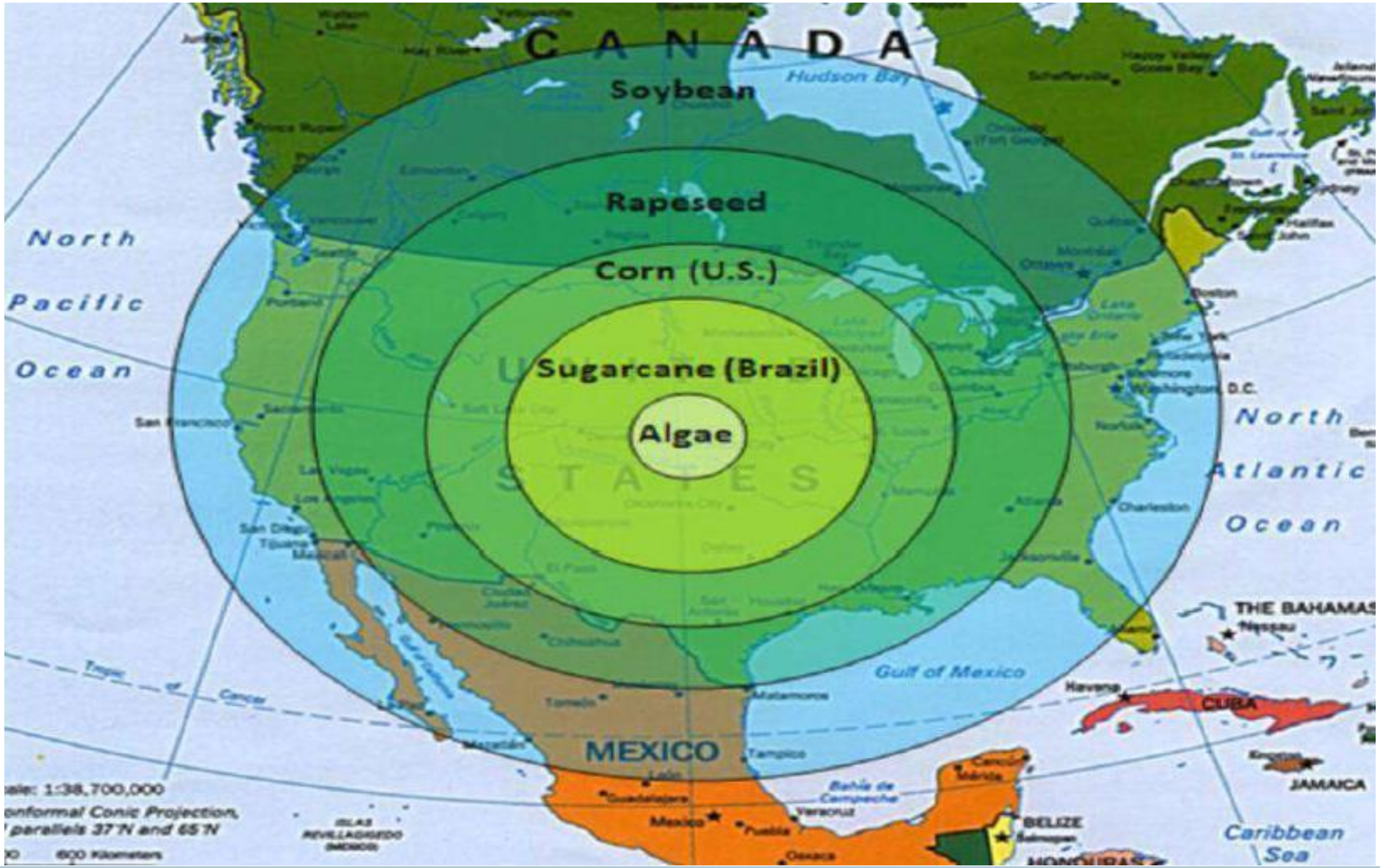
Algae has the lowest land use of any biofuel crop

How much land mass would it take for the US to grow its own fuel



High protein beet-top meal replicating alfalfa
Leaf Protein – a model that did not work

8.2 ton fresh leaf at (12% DM) provide 1 ton DM @ 15% protein

Process recovers 50% of the protein:

A product: 52% protein; 20% CHO/fibre; 10% lipid

Residual cake and liquor (90% OM) to AD

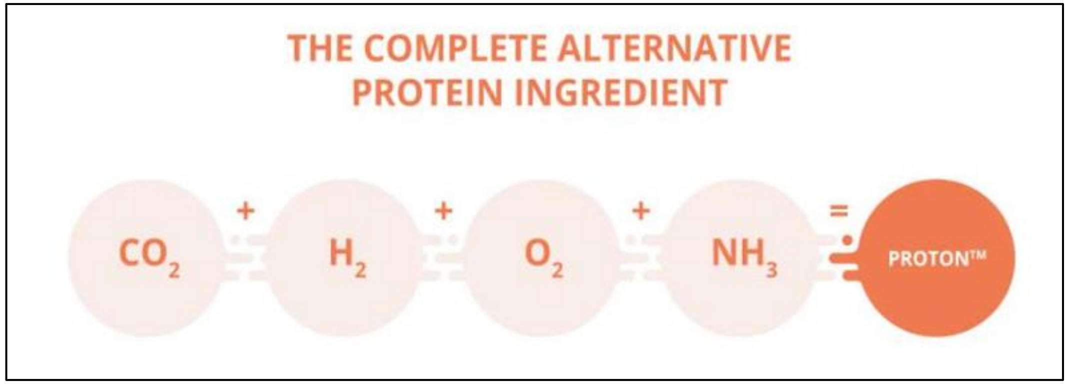
But

110 tonnes of leaves for 1 tonne of pure protein.

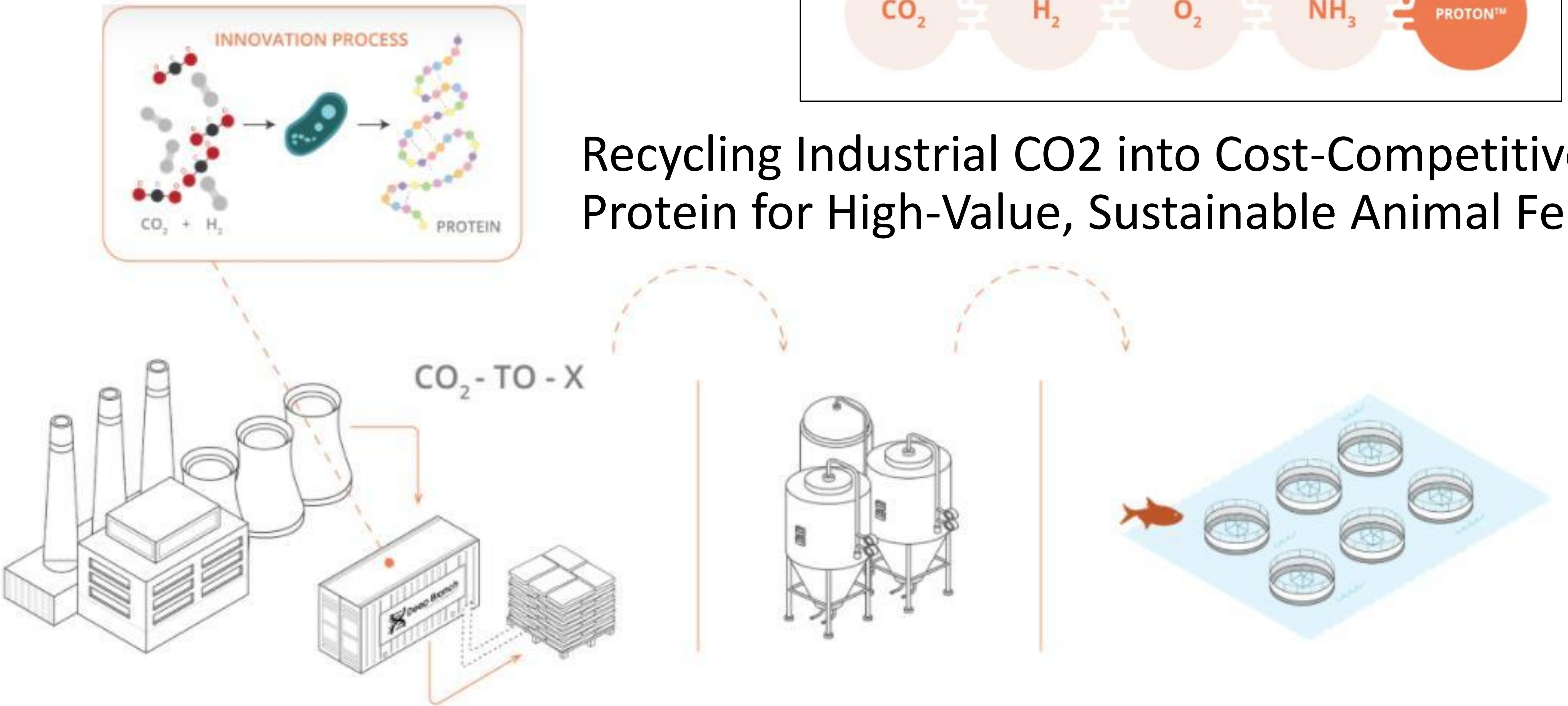
56 tonnes of leaves to make one tonne of feed protein (130 Ktons/wk)

Economics only work when the fresh leaves are already in the factory

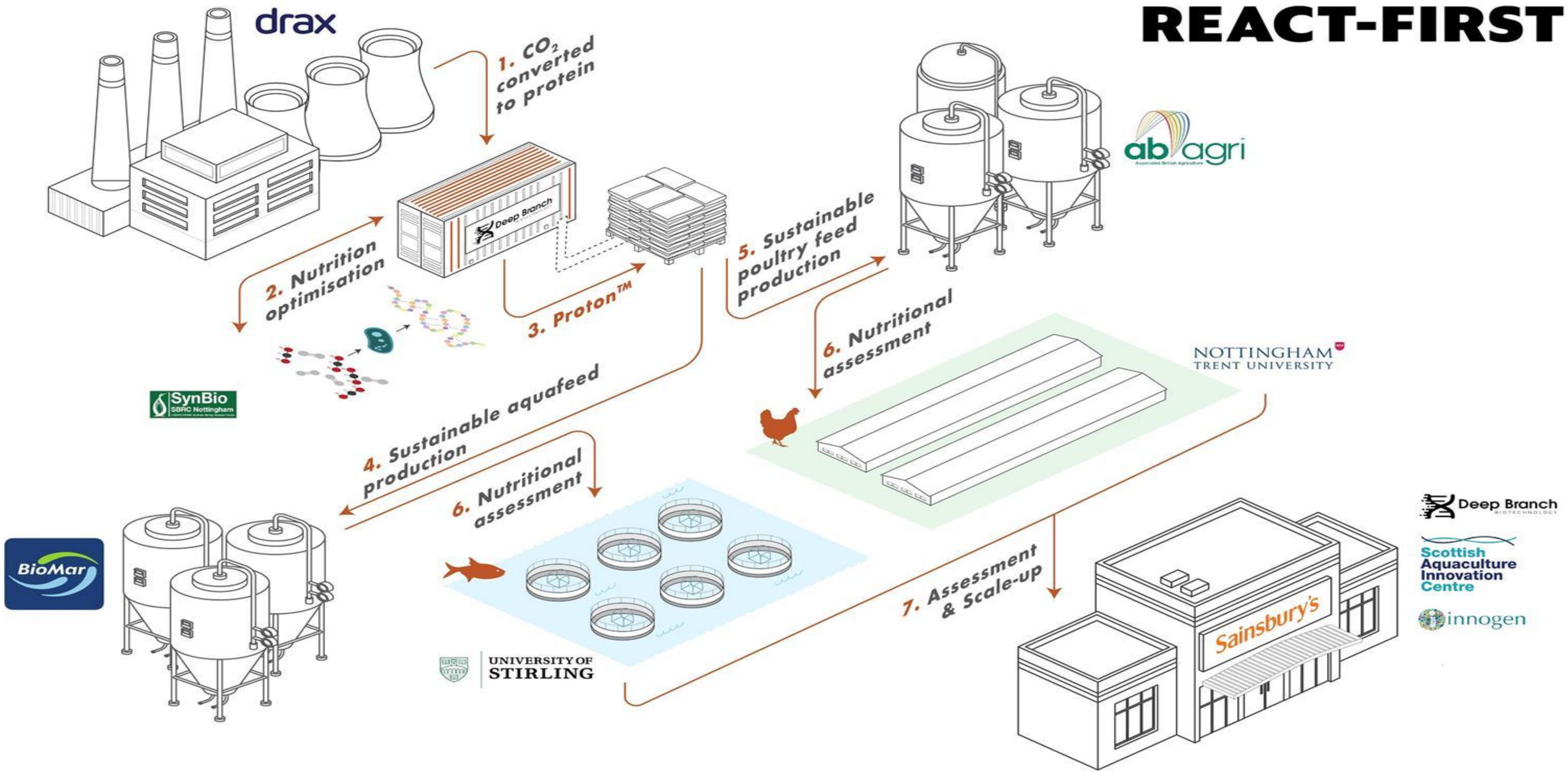
REACT-FIRST Project:



Recycling Industrial CO2 into Cost-Competitive Protein for High-Value, Sustainable Animal Feed.



Vision:


REACT-FIRST
drax
1. CO2 converted to protein
2. Nutrition optimisation
3. Proton™
4. Sustainable aquafeed production
5. Sustainable poultry feed production
6. Nutritional assessment
6. Nutritional assessment
7. Assessment & Scale-up
Deep Branch
SynBio SBRC Nottingham
ab agri
NOTTINGHAM TRENT UNIVERSITY
BioMar
UNIVERSITY OF STIRLING
Sainsbury's
Deep Branch BIOTECHNOLOGY
Scottish Aquaculture Innovation Centre
innogen

Deep Branch BIOTECHNOLOGY Process

Step 1

Captured CO_2 into Proton™, a single-cell protein optimised for animal feed via proprietary gas fermentation process

Step 2

Co-develop Proton™-based feeds with market leading feed producers

Step 3

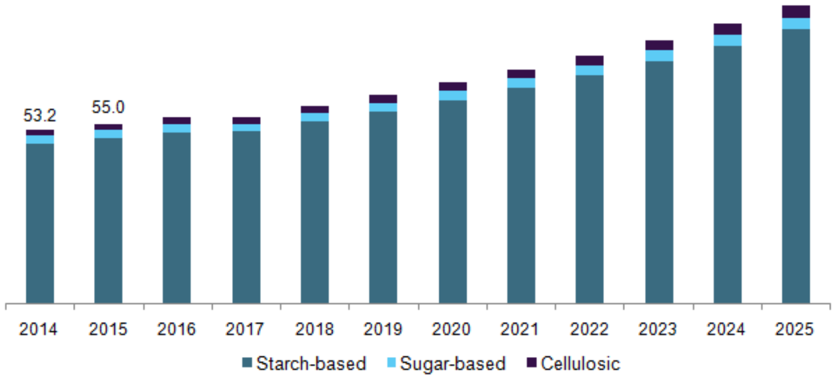
Produce sustainable animal products with up to 60% less greenhouse gas emissions (throughout total value chain)

- Currently: scaling up Step 1
- Optimising drying process
- First poultry trial due Oct 2021, early 2022, now June 2022…

Biethanol Protein Concentrate Project

World Bioethanol

- World ethanol margins have narrowed
- Plants are motivated to find the next technologies to improve margins
- Co-product technology sound but dated (1790)
- Food vs. Fuel debate



Bioethanol generations: bridging the gap

First Generation Bioethanol – produced from starch crops

- Fuel versus Feed/Food issues
- Competing demands for feedstock

Second Generation Bioethanol – lignocellulosic

- Uses residues from agriculture
- Poor yield
- Advanced tech investment needed

Generation 1.5: starch crop feedstock with bio-refining for multiple co-product streams

The 4 F's

A new factor in demand, the emergence of biofuel initiatives

The current F factors of demand will remain strong over the coming years and support a base shift in commodity price (Rabobank 2008)

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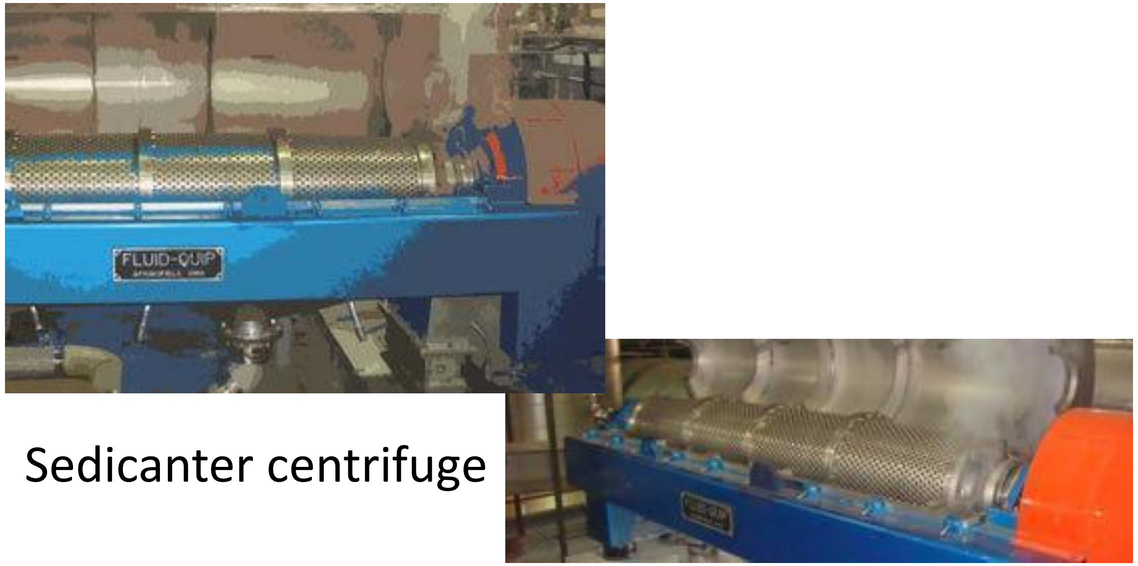
Creating a more suitable protein product for the poultry sector

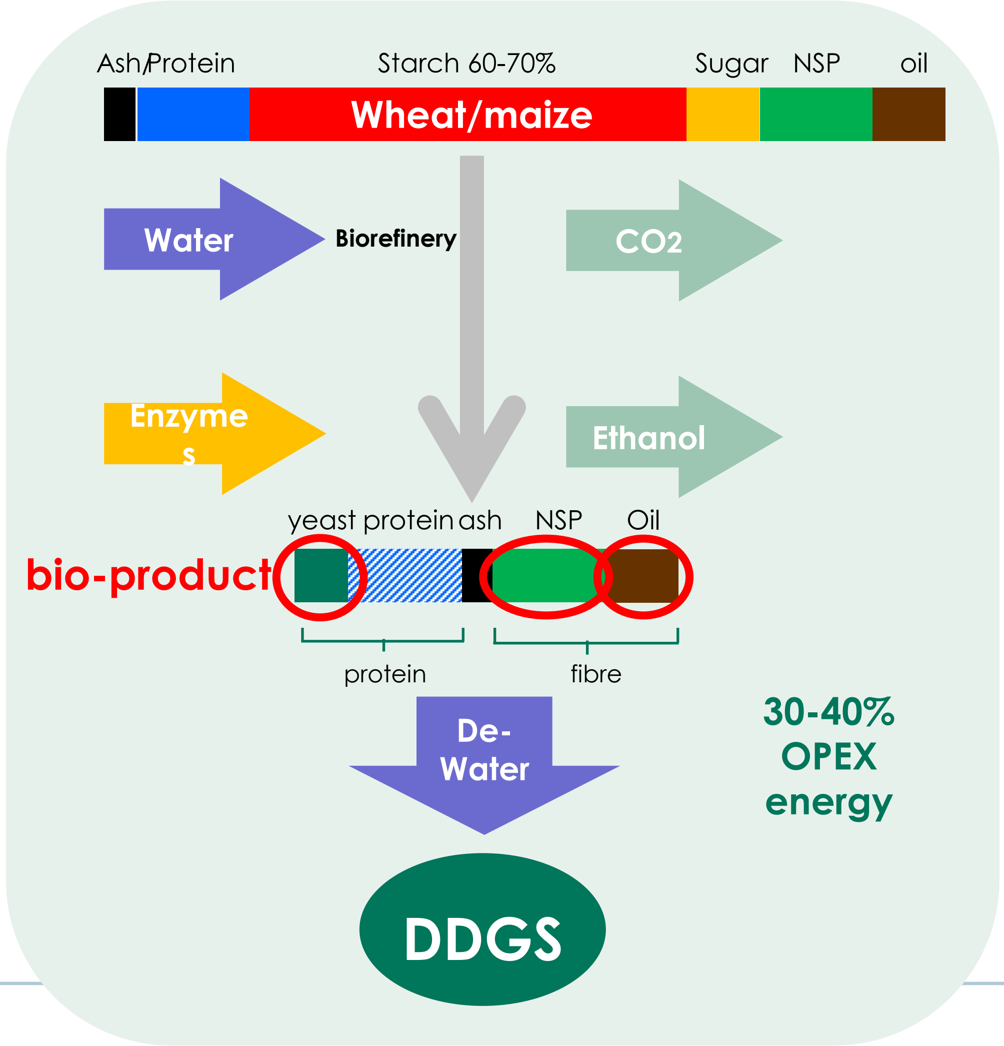
- Increase protein content and decrease fibre
  - Avoid recombining thin stillage and cake
- De-water and dry the thin stillage to produce a high yeast protein

Disc stack centrifuge



Sedicanter centrifuge

Grain based dry grind ethanol: A nutritionists perspective



1^{st} generation dry grind bioethanol plant

- Dry milled grain
- Starch converted to ethanol
- Grain residue traverses process
- Grain protein modified by process
- Yeast generated in the process
- Yeast a valuable feed additive

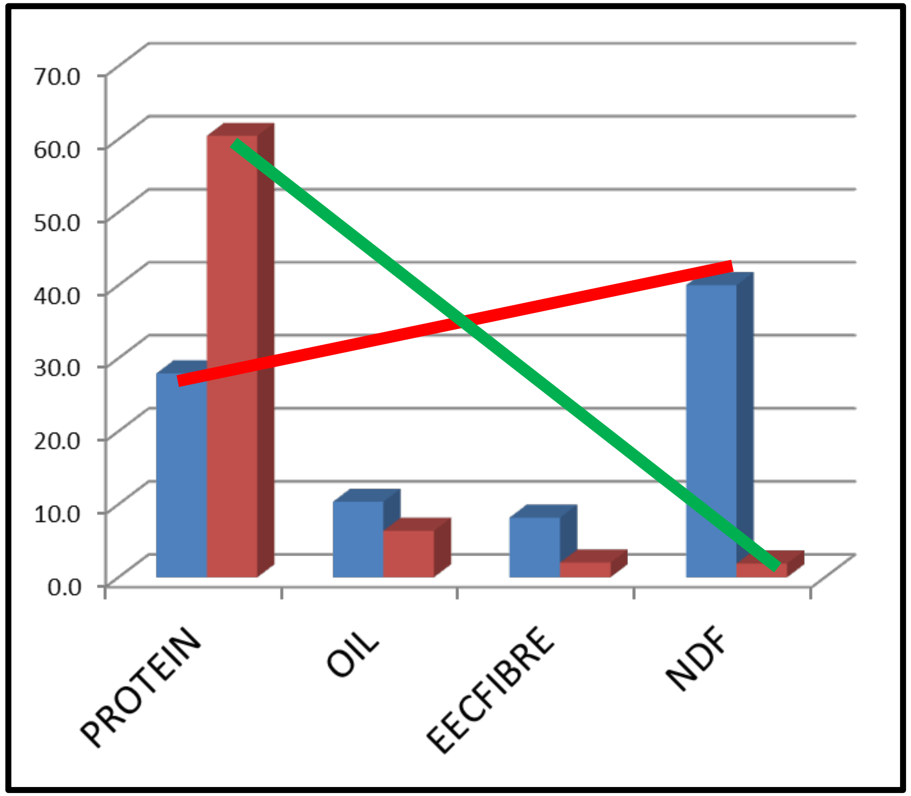
Thousands tonnes protein

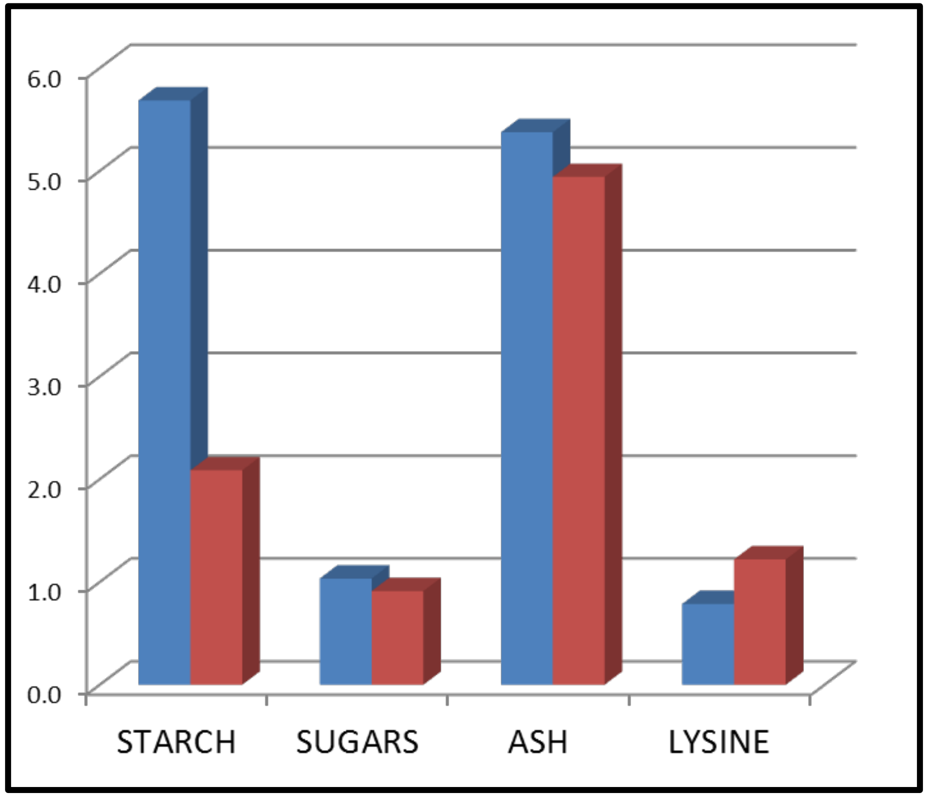
Compare nutrient composition of DDGS and YPC

Yeast Protein Concentrate is high protein low fibre product

Equalised to 92% Dry matter

DDGS YPC





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A mutual benefit to bioethanol and poultry sectors?

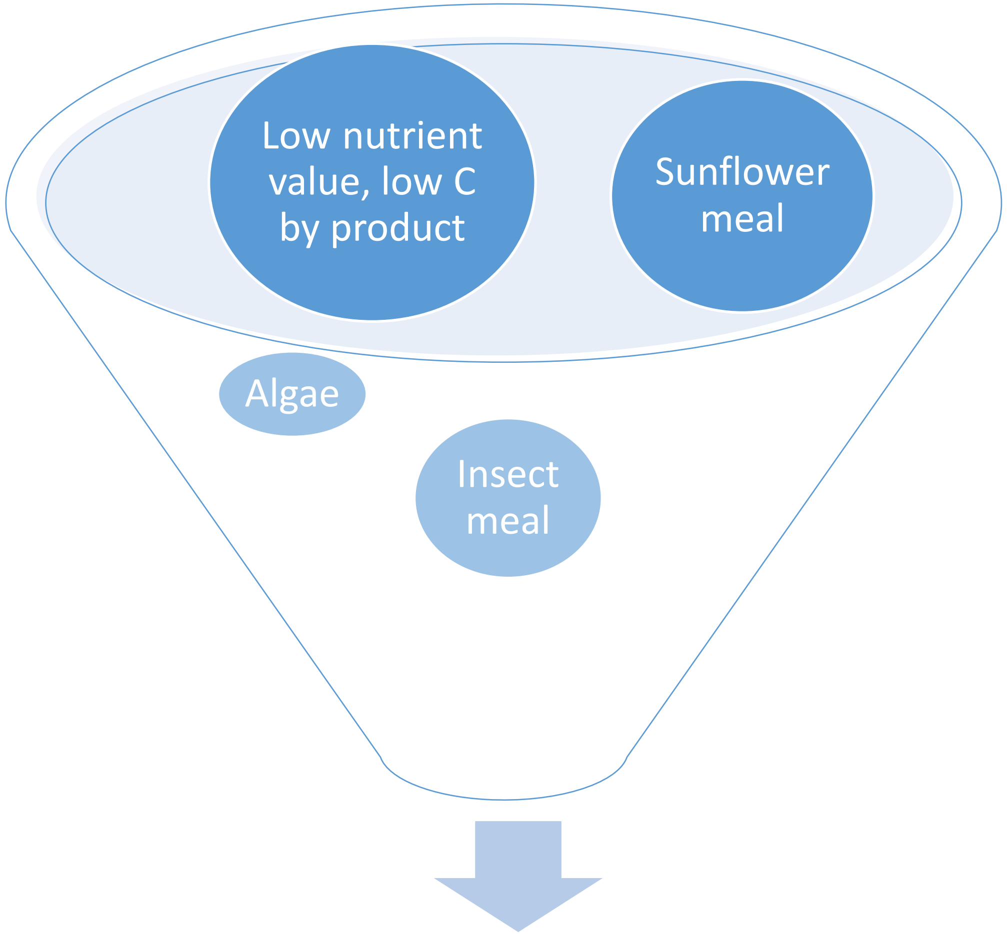
Bioethanol

- Reduced energy requirement for stillage drying
- Major revenue streams from two independent markets
- Mitigation of land use challenges associated with bioethanol production

Poultry

- Commercially viable protein source with higher nitrogen retention than soy
- Mitigation of consumer concerns associated with soy in animal feed
- Reduced carbon footprint of feed

Future alternatives may offer added functionality OR low carbon cost



Protein component

Mill set up is a major barrier to this model: bin limitations require big volumes

Consumer desire will have to overcome price ceiling before change will come

Legislation could make create push or pull factors that influence rate of change

Take home messages

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We are a LONG way from total replacement of soya but now there is multiple stakeholder interest in the journey…

Alternatives are generally expensive but legislation may force through change

Success hinges on co-location of industries to create circular economies: tipping point for insects?

Nutritionists and vets will have to work together to maintain bird health while we navigate change

Contact: Emily.burton@ntu.ac.uk