

Alternative Protein Sources for Animal Nutrition

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Algae and Insects

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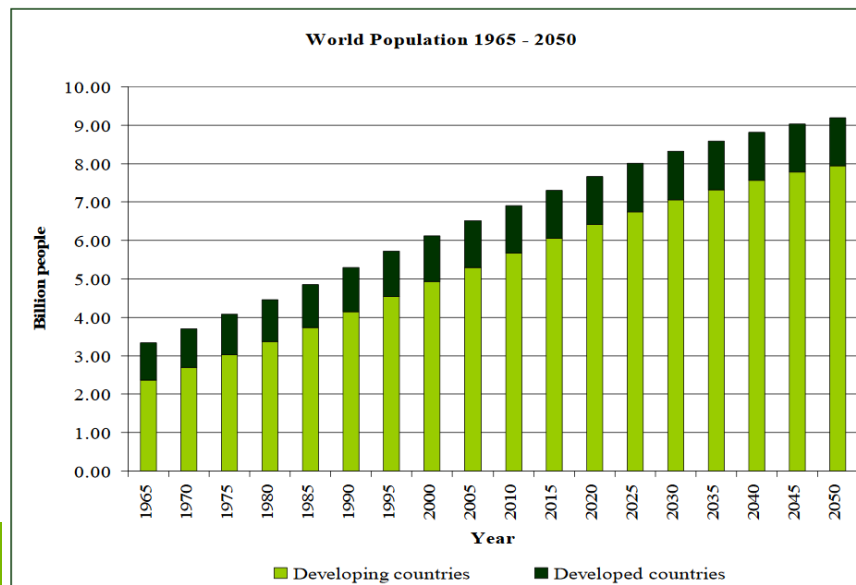
Outline

- 1) Introduction
- 2) Advantages of algae & insects
- 3) Feed safety
- 4) Legislation
- 5) Conclusion



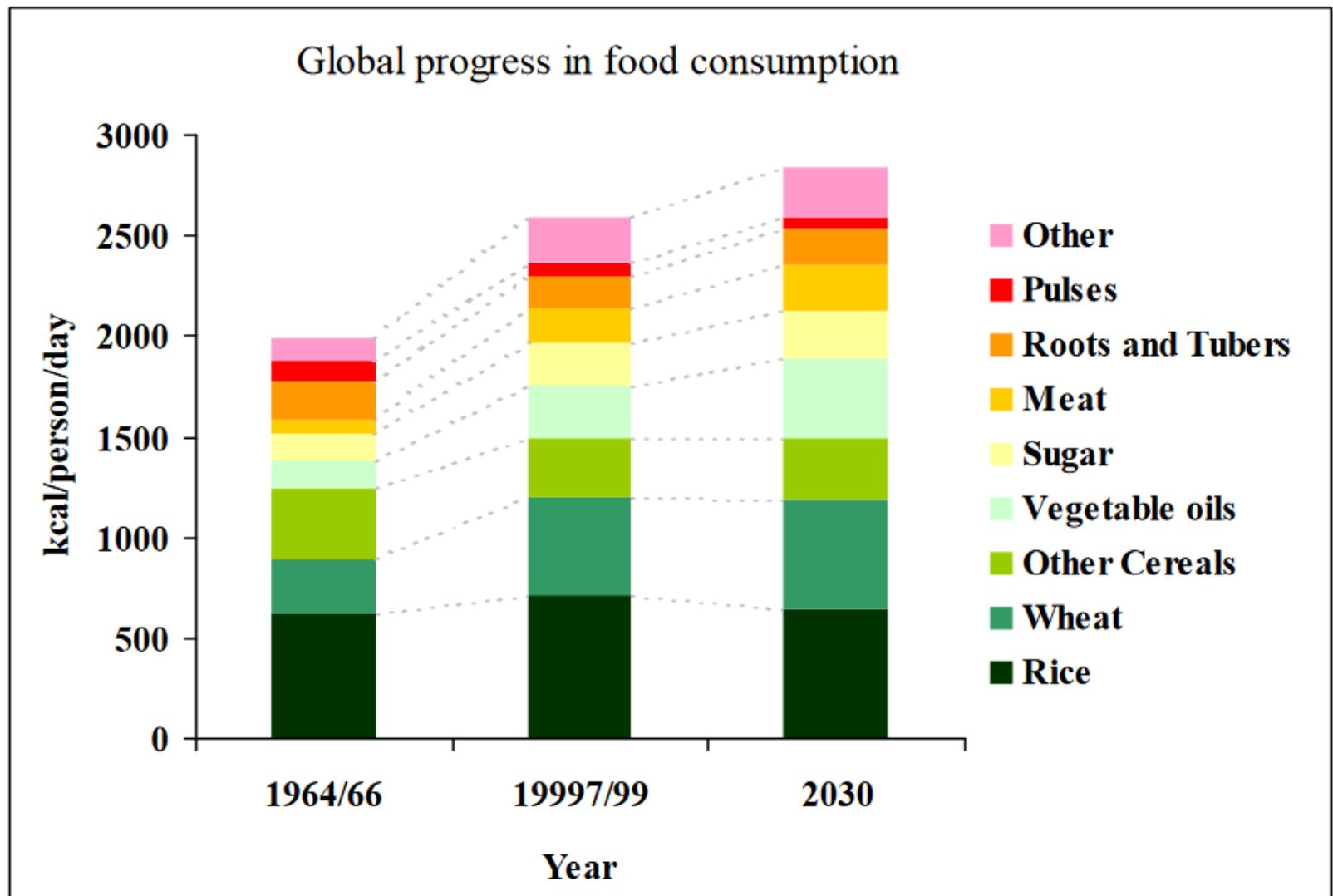
Introduction

- Since 1960 the global meat consumption has increased x 3, the global egg consumption x 5
- In 2050: the global world population will reach 9 billion people
- Changing lifestyle in developing countries



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)



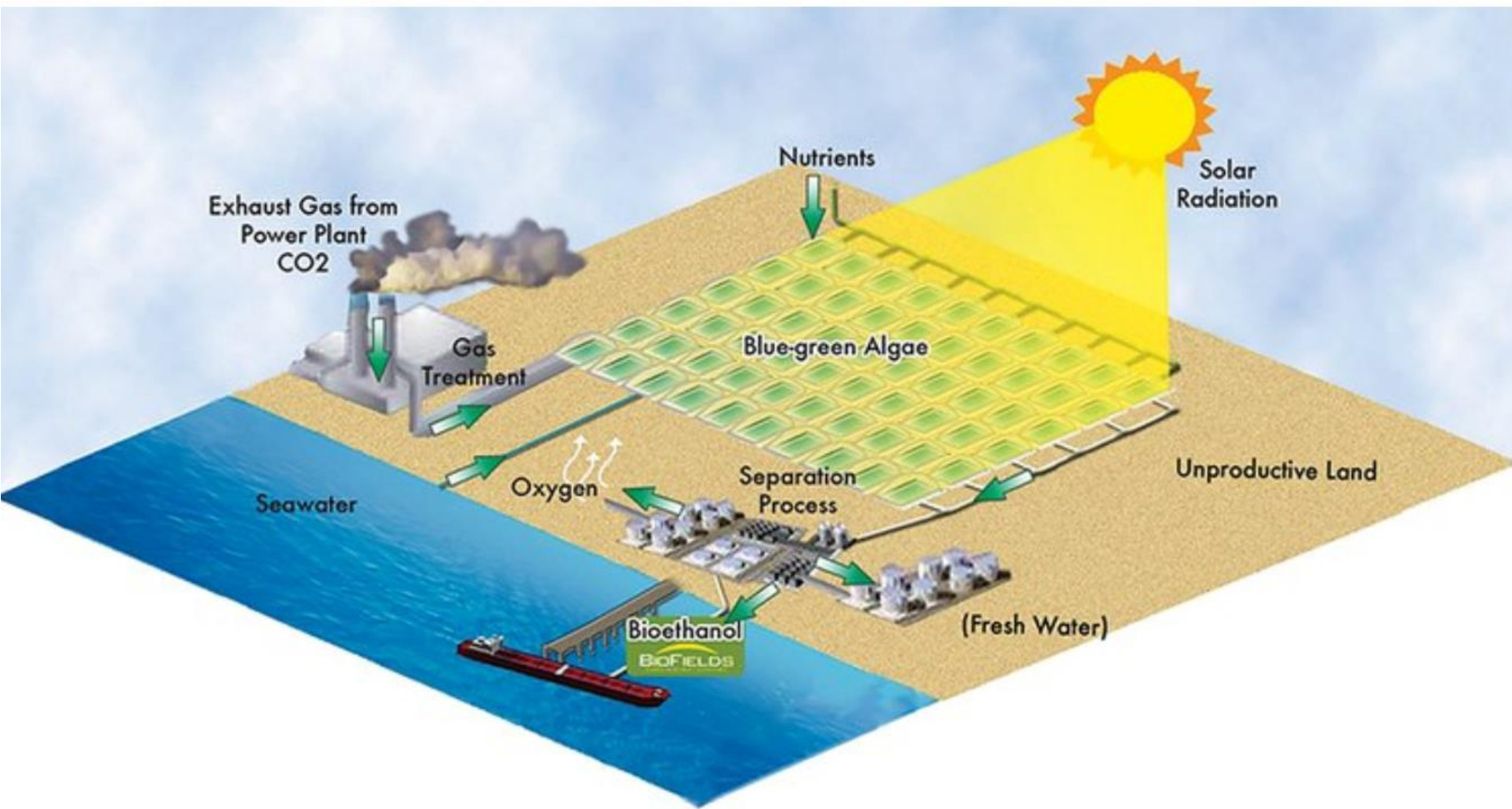


Source: FAO (2002)



- Cattle production:
 - 75% of world agricultural land
 - 8 % of anthropogenic water consumption
 - Direct competition of agricultural land for
 - animal feed production
 - biofuels
 - human food
 - Climate change, soil acidification, water pollution, deforestation, pesticides & fertilisers
- ⇒ **increasing feed costs**





Advantages of Algae and Insects

- Environmental friendly (use of sun energy/low water consume)
- No soil interference (pesticides/herbicides/fertilizer)
- Labor efficient
- Low carbon footprint
- Low space usage (multi level growth)



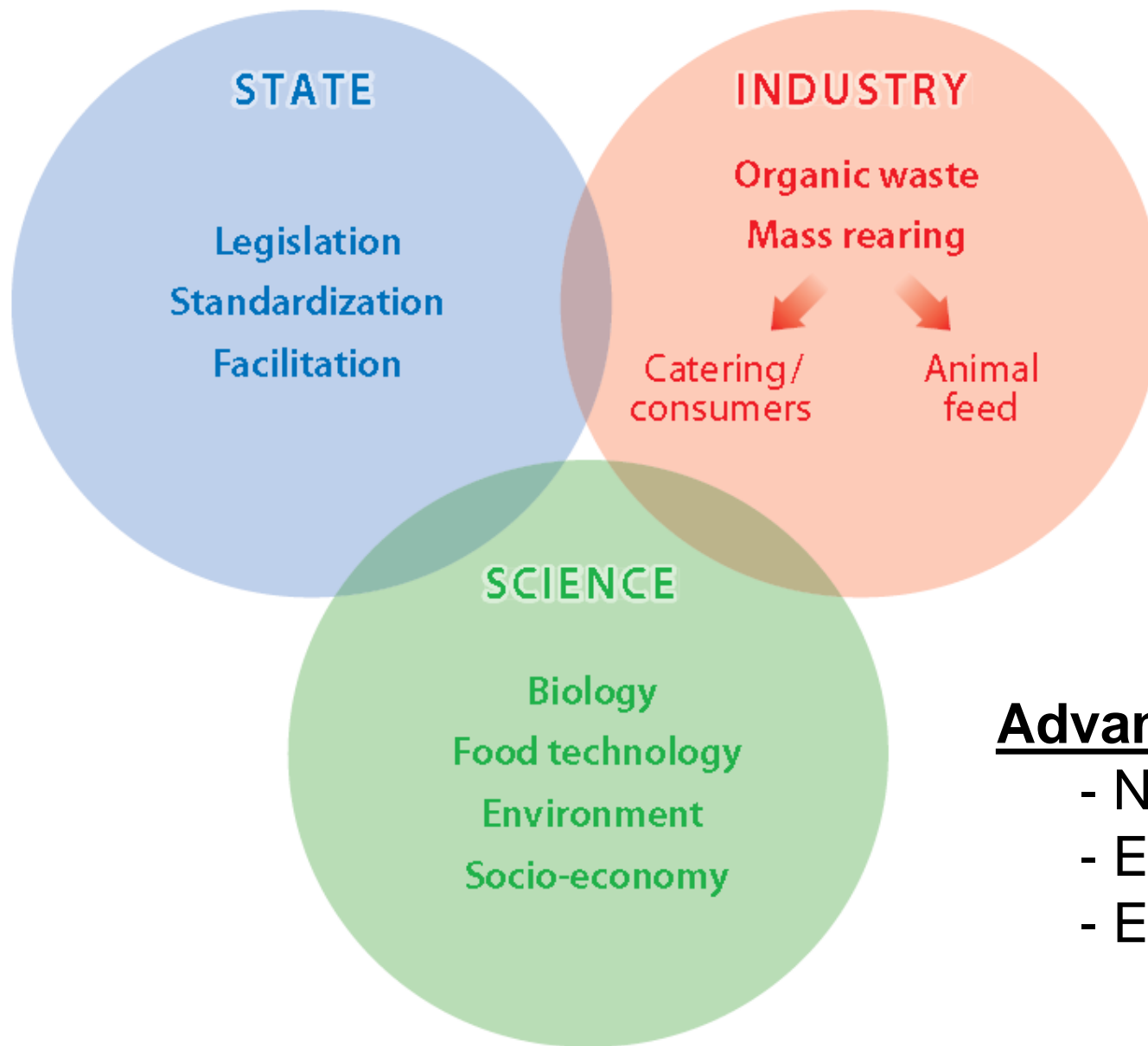
www.greenoptions.com



www.cnn.com



Cancino et al., 2012



Advantages:

- Nutritional
- Ecological
- Economical



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Alternative Protein Sources

- Algae: organisms using photosynthesis \neq terrestrial plants, 4000 varieties
 - 30% of the current worldwide algae production for aquaculture, pet, livestock
 - Microalgae (single celled organisms)
 - Seaweed (complex, multicellular organisms in salt water)
- Insects: >1 mio. different known species
 - Aquaculture, pets, pig, poultry, human consumption
 - Biggest potential for feed in EU:
 - housefly larvae (*Musca domestica*) BSF larvae (*H. illucens*)
 - yellow mealworms (*Tenebrio molitor*) silkworms (*Bombyx mori*)
 - grasshoppers (*Acridids spec.*) termites (*Kaloterms flavicollis*)



Nutritional Advantages of Algae

Algal class Species	Dry weight (pg.cell ⁻¹)	Chl a	Protein	Carbo- hydrate	Lipid
Bacillariophyceae					
<i>Chaetoceros calcitrans</i>	11.3	3.01	34	6.0	16
<i>Chaetoceros gracilis</i>	74.8	1.04	12	4.7	7.2
<i>Nitzschia closterium</i>	-	-	26	9.8	13
<i>Phaeodactylum tricornutum</i>	76.7	0.53	30	8.4	14
	52.2	1.21	25	4.6	10
<i>Skeletonema costatum</i>					
<i>Thalassiosira pseudonana</i>	28.4	0.95	34	8.8	19
Chlorophyceae					
<i>Dunaliella tertiolecta</i>	99.9	1.73	20	12.2	15
<i>Nannochloris atomus</i>	21.4	0.37	30	23.0	21
Cryptophyceae					
<i>Chroomonas salina</i>	122.5	0.80	29	9.1	12
Eustigmatophyceae					
<i>Nannochloropsis oculata</i>	6.1	0.89	35	7.8	18

Nutritional Advantages of Algae

- Omega 3 Fatty acids

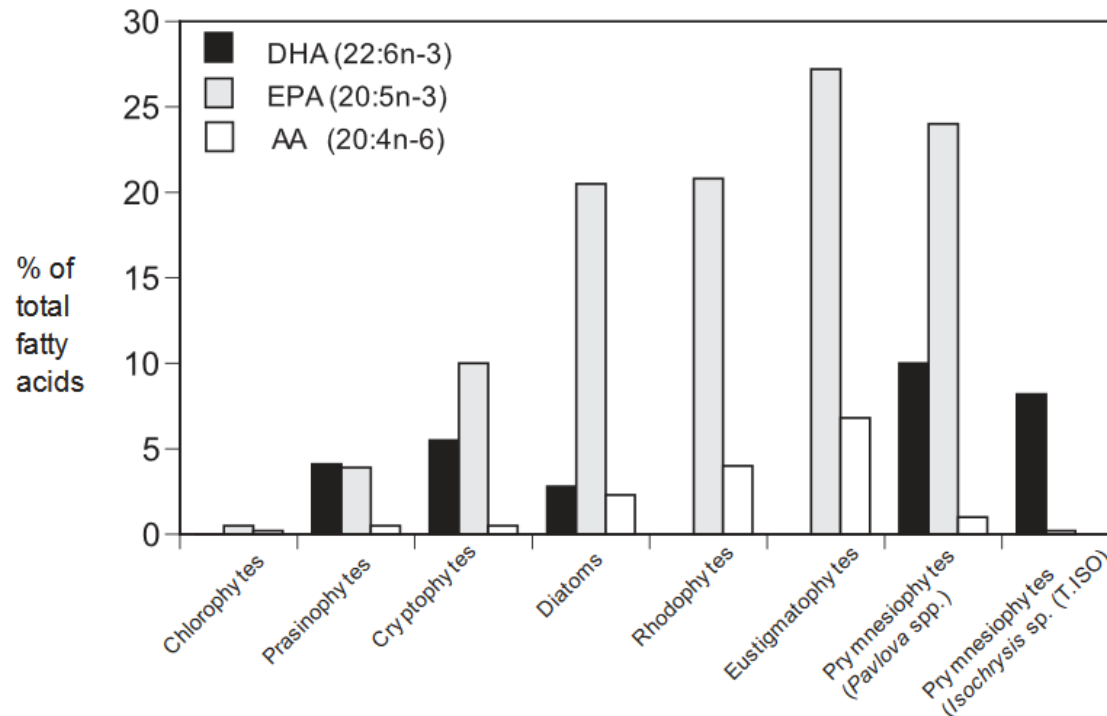


Fig 1. Average percentage compositions of the long-chain PUFAs docosahexaenoic acid (DHA; 22:6n-3), eicosapentaenoic acid (EPA; 20:5n-3) and arachidonic acid (20:4n-6) of microalgae commonly used in aquaculture. Data compiled from over 40 species from the laboratory of CSIRO Marine Research.



Nutritional Advantages of Insects

Constituents (% in dry matter)	Black Soldier Fly larvae	Soybean meal	Wheat	Lupine	Sunflower meal
Crude protein	36.9 – 47.0	42.0 – 51.8	10.0 – 15.0	30.0 – 31.3	30.0 – 42.0
Ether extract	15.0 – 35.0	1.6 – 3.5	1.7 – 3.0	6.5	7.6
Crude fibre	6.7	6.5 – 7.0	2.8	NA	21.0
Ash	8.6 – 15.5	6.0 – 6.7	2.0	2.6	6.8 – 7.0
Calcium	5.00 – 7.56	0.20 – 0.39	0.05	0.21	0.43
Total phosphorus	0.90 – 1.5	0.60 – 0.69	0.30	0.30	1.00

References: Newton *et al.*, 1977; Feillet, 2000; Courtney, 2002; St-Hilaire *et al.*, 2007; Finke, 2008; Batal and Dale, 2011; Sánchez-Muros *et al.*, 2013; Van Huis *et al.*, 2014; De Marco *et al.*, 2015; Food Standards Australia New Zealand, 2015; Payne *et al.*, 2015 ; USSEC, 2016

Essential amino acids	Amount in BSF larvae (g/kg DM)	Non-essential amino acids	Amount in BSF larvae (g/kg DM)
Arginine	19.4 – 23.6	Alanine	30.3 – 32.4
Histidine	11.3 – 12.6	Aspartic acid	32.2 – 46.3
Isoleucine	17.2 – 21.5	Cysteine	13.8
Leucine	24.0 – 33.3	Glycine	19.1
Lysine	22.3 – 27.8	Glutamic acid	38.5 – 45.9
Methionine	8.8 – 9.05	Proline	27.8 – 37.3
Phenylalanine	14.4 – 21.9	Serine	13.05 – 18.4
Threonine	15.2 – 15.5	Tyrosine	21.6 – 29.05
Valine	22.0 – 34.5	Tryptophan	2.1

References: Newton *et al.* 1977; Makkar *et al.*, 2014; De Marco *et al.*, 2015

Feed Safety

- Common risks:

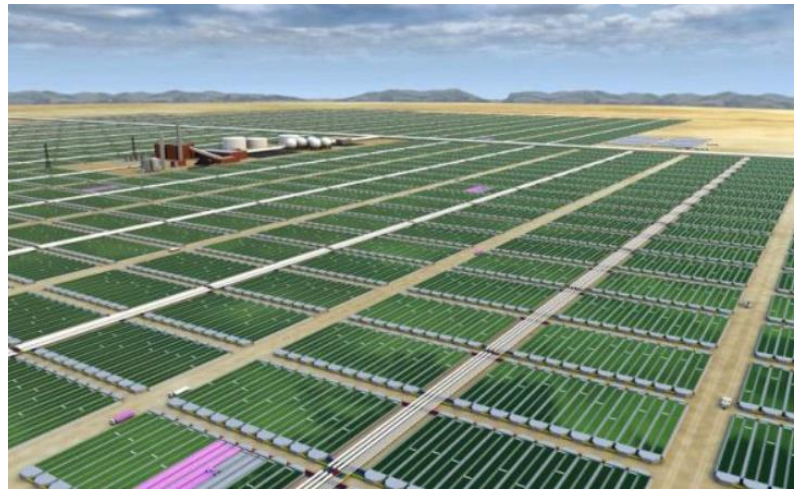
Potential hazard	Insects	Microalgae	Seaweed
Heavy metals	X	X	X
Pesticides	X	X	X
Pathogens	X	X	
Allergens	X	X	
ANFs			X
Toxins		X	
Natural toxins	X		
Mycotoxins	X		
Veterinary residues	X		
Dioxins			X
Iodine			X
Phenols			
Processing contaminants	X	X	X

- 2 % of algae varieties can form neurotoxins & hepatotoxins
- Non-processed insects: *Salmonella*, *Camylobacter* and *Escherichia coli* strains, *Enterobacteriaceae*



Feed Safety Risks in Algae

- Heavy metals depending on:
 - Species, collection time, growth phase, and collection site
- Contamination due to:
 - Industrial wastewaters
 - Contamination wild animals, wind



Heavy Metals in Insects

- Depending on:
 - species, rearing material, growth phase, and collection site

Concentrations of cadmium (mg/kg DM) in insects compared to European Union limits in animal feed

Feed material of animal origin ¹	Complete feed ¹			Housefly	Blue bottle fly	Blow fly	Black soldier fly
	Cattle, sheep, goat and fish	Pet animals	Other species				
2.00	1.00	2.00	0.50	0.33 – 0.72	0.02	0.37	0.12

¹Maximum limit in animal feed, based on 88% DM

References: European Commission, 2013b; Charlton *et al.*, 2015

Commission Regulation (EU) No 1275/2013 of 6 December 2013 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for arsenic, cadmium, lead, nitrites, volatile mustard oil and harmful botanical impurities.



Legislation: Feed Safety

- EC 178/2002: regulation on food safety
- EC 852/2003 & 853/2003: general hygiene for feed manufacturing
 - control contamination, use of pesticides, vet products, record keeping
- EC 852/2004: HACCP, requirements for premises
- EC 853/2004: production of food of animal origin
- EC 2073/2005: microbiological criteria
- EC 2002/32: undesirable substances
- EC 258/97: “novel foods & novel food ingredients”
 - GMO food • With a new or modified molecular structure
 - Consisting or isolated from MO, fungi or algae
 - Consisting or isolated from plants or food ingredients isolated from animals except traditional & with history of safe use
 - Production process with significant change in composition or structure

Legislation: Algae

- Seaweeds and other algae incl. micro-algae:
(EC) No 834/2007 (organic production)
- *the definition of 'aquaculture' is that given in Council Regulation (EC) No 1198/2006 of 27 July 2006 on the European Fisheries Fund (1);*
- *(d) 'aquaculture': the rearing or cultivation of aquatic organisms using techniques designed to increase the production of the organisms in question beyond the natural capacity of the environment*



Legislation: Algae

- Seaweeds and other algae incl. micro-algae:
(EC) No 834/2007 (organic production)

- *Follow up legislation* (EC) No 889/2008:
implementation of (EC) No 834/2007:

no detailed production rules have been laid down
until now (2016) for micro-algae used as food



Legislation: Algae

- **Production**

- EC No 2009/41 /EC (contained use of GM algae)

‘genetically modified micro-organism’ means a micro-organism in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination

- EC No 2001 /18/EC (deliberate release of GM algae)

- **Market introduction**

- EC Regulation on Genetically Modified Food & Feed (EC 1829/2003)
 - EC Regulation on traceability and labelling of GMOs and of food and feed products produced from GMOs (EC 1830/2003)
 - EC Regulation on Nutrition & Health claims made on foods (EC 1924/2006)



Legislation: Insects

- *“whole or parts of terrestrial invertebrates, in all their life stages, other than species pathogenic to humans and animals, with or without treatment such as fresh, frozen, dried”* (Commission Regulation (EU) No 68/2013 of 16 January 2013 on the Catalogue of feed materials)
- No use of processed animal proteins in livestock feed, which does not include pet food and fish feed
(European Regulation (EC) No 999/2001 prevention, control and eradication of TSE)



Legislation: Insects

“aquatic and terrestrial invertebrates other than species pathogenic to humans or animals”: Category 3

- suitable for human consumption but, for economic reasons, not used for this.
- allows insects in livestock, fish feed, pet food.
- animal manure, any meat and fish feedstuff cannot be used as substrates to rear insects, as they are considered as ‘farmed animals’

European Parliament and Council of the European Union, 2009. Regulation (EC) No 1069/2009 of the European parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002



Conclusion

- Algae and Insects provide advantages regarding
 - Environment
 - Economy
 - Nutrition
- Risk assessment highly diverse & specific
- Laws diverse and unspecific, registration possible



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