The Food and Environment Research Agency

Safety and quality considerations of insects for feed and food

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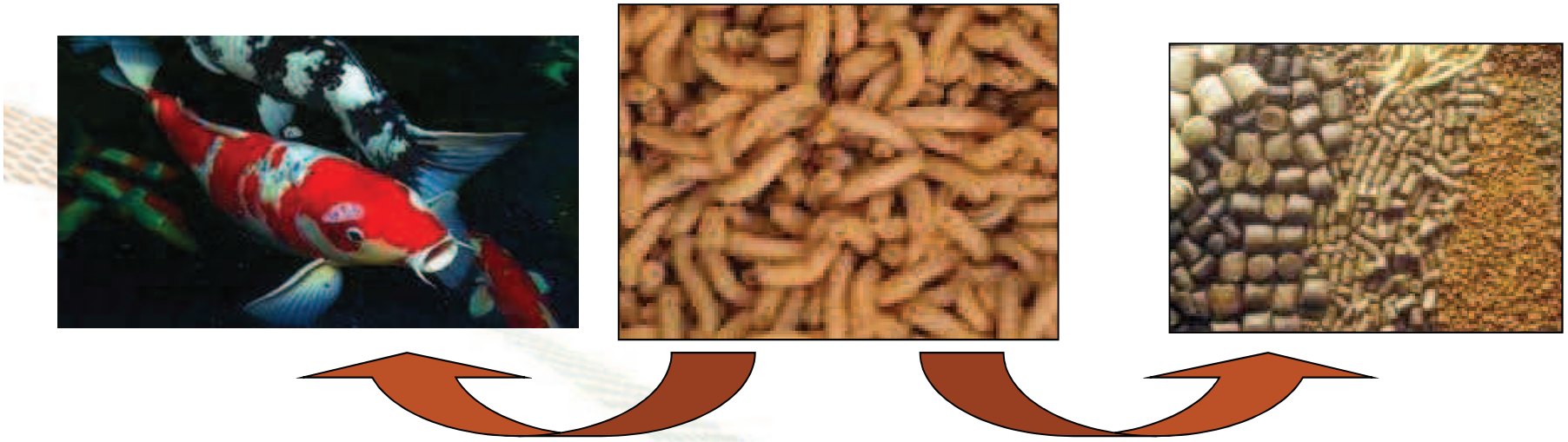

Insects to Feed the World, Ede, 15th May 2014

The Protein Deficit

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EU initiative to find sustainable protein sources

- **Currently only 30% self-sufficient.**

- Land-use i.e. food crops vs feed crops
- Global feed markets volatile
- EU reliance on imported soya
- Global consumption of meat rising

Alternative protein sources required.

Can Insects Help?

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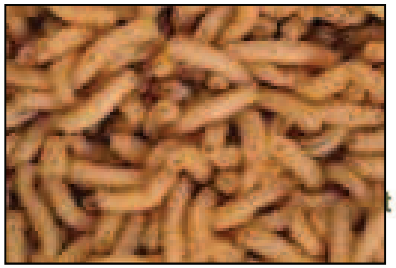
- **Insects are highly efficient at rapidly converting waste into usable protein**
  - **Housefly larvae can complete development in 8-10 days at room temperature with 60% reduction in substrate mass**
  - **Protein digestibility (86-89%) higher than most (all) vegetable based proteins**

Insects have been shown to be an excellent protein source for chick growth (1970's – 1980's)

Protein content (30-80%)
Fat content (5-60%)
Fibre content (4-60%)

Land Use

2013 values



Protein crops (e.g. soya)

2.5 t/ha./year

90% dry wt & 40 % crude protein = 0.9 t protein

Fly larvae potential (non-optimised)

25 t/ha./8-10 days = 1000 t/ha./year.

25% dry wt & 60 % protein = 150 t protein

200 fold reduction in land use

(Value of product ???, Cost of production ???)

Global Research

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Primary focus on fly species able to develop on a range of waste substrates

Black soldier fly *Hermetia illuscens*

- food, swine, human & poultry waste
- min. 14 days: egg to mature larvae
- require > 30 °C for development
- mean wt 0.2 g/ larvae

House fly: *Musca domestica*

- food, swine & poultry waste
- 4-13 days: egg to mature larvae
- require > 17 ° C for development
- mean wt 0.02 g/larvae

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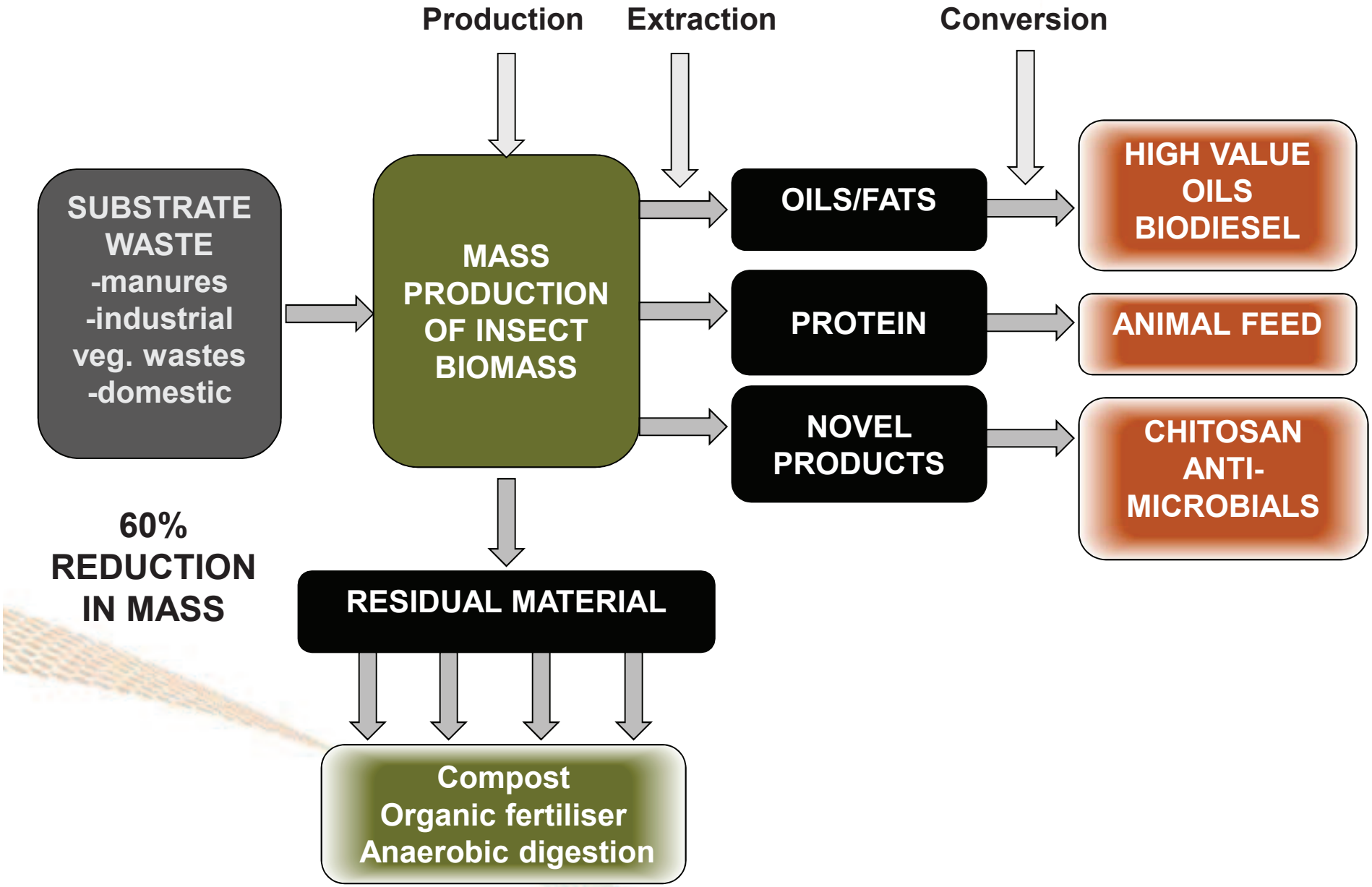
The Food and Environment Research Agency

Alternative protein production technology for animal feed (April 2012)

SEVENTH FRAMEWORK PROGRAMME

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

Enabling the Exploitation of Insects as a Sustainable Source of Protein for Animal Feed and Human Nutrition (Feb 2013)


Production
Extraction
Conversion
SUBSTRATE WASTE -manures -industrial veg. wastes -domestic
MASS PRODUCTION OF INSECT BIOMASS
OILS/FATS
PROTEIN
NOVEL PRODUCTS
HIGH VALUE OILS BIODIESEL
ANIMAL FEED
CHITOSAN ANTI-MICROBIALS
60% REDUCTION IN MASS
RESIDUAL MATERIAL
Compost
Organic fertiliser
Anaerobic digestion

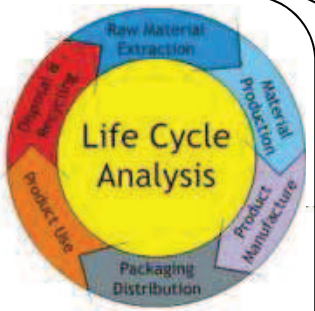
WP6 Dissemination

(Eutema)

(Minerva)

WP5 Pro-Insect Platform

WP4



(KUL)

WP3

&

(Fera)

WP1
Insect Production

(CABI)

WP2
Processing & Feeding Trials

(NS)

PROteINSECT
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

Quality and Safety

- Little published data about the risks of using insects in feed and how these can be managed.
- Robust nutritional data also sporadic.
- Performance traits of animals fed on insects need to be established.
- Analysis of meat from insect reared animals to be undertaken (e.g. taints).
- Potential for high value by-products such as fats and oils.

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INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

Safety testing
(DIRECTIVE 2002/32/EC)

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- Heavy metals (As, Pb, Hg)
- Pesticides
- Dioxins and PCBs
- Veterinary medicines
- Mycotoxins
- Salmonella

Chemical Safety

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- Risks will be dependant on **processing.**
- Different feedstocks and insect combinations = different risks

Examples might include:

- **Bioaccumulation** of metals and environmental contaminants.
- **Concentration** of natural contaminants such as mycotoxins.
- **Transfer** of toxic residues e.g. pesticides

Metals

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- Toxic (e.g. cadmium, mercury, arsenic, lead)
- Nutritional but toxic at low levels (e.g. selenium, zinc)
- Nutritional but toxic at high levels (e.g. iron, potassium).

EU regulations in feed range from 0.5 to 5 ppm.

Initial tests show levels in some insects higher than permissible EU limits for feed

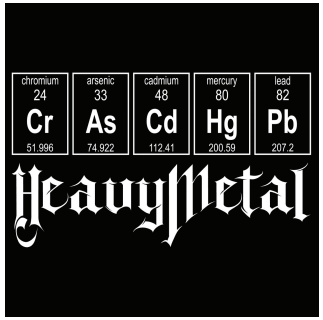

Image courtesy of www.angrygirlwear.com

Pesticides

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- Multi residue screen. Total 416 compounds.
- Covers non-permitted pesticides (e.g. DDT) and permitted (e.g. dimethoate).
- EU regulations in feed range from 5 to 200 ppb

What is ppb?

One ppb is 10^{-9} the equivalent to finding one person in the population of India or adding one grain of salt to a 10 ton bag of crisps.

Dioxins, PCBs and PAHs

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70 compounds:

- 28 Polycyclic aromatic hydrocarbons (PAHs)
- 25 Polychlorinated biphenyls (PCBs)
- 17 Dioxins

Persistent organic pollutants enter food chain through incineration (e.g. forest fires, use of fuels for drying).

Known to **bioaccumulate** in fat.

Highly toxic.

EU limits in feed range from 0.75 to 10 **ppt**

What is ppt?

One ppt is 10^{-12} so adding one grain of salt to a 10,000 ton bag of crisps!

Veterinary Medicines

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68 EU regulated compounds:

- 17 Sulphonamides
- 7 Tetracyclines
- 8 Penicillins
- 8 Cephalosporins
- 10 Quinolones
- 13 Macrolides
- 5 “Others”, e.g. Chloramphenicol

Exit animals through faeces. Antibiotic resistance risk if transferred.

Also screening to detect the presence of 492 compounds including those known to be used worldwide.

Limits in range 0.2 – 150 ppb

Mycotoxins

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- Natural plant toxins – risk if rearing on food waste as produced by fungus.
- Aflatoxin B1 has 5 ppb regulatory limit 2002/32/EC.
- Fumonisins, deoxynivalenol, T2 toxins, Ochratoxin A and Zearalenone all with recommended limits between 50 and 5000 ppb.

Non-targeted Profiling

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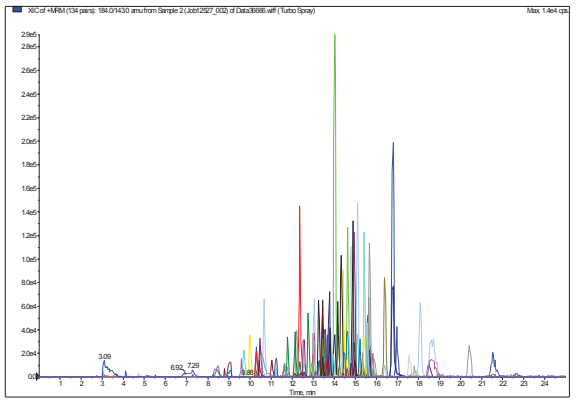
- Broad non-selective analytical approach.
- Data scrutinised against a database of currently 5,500 compounds including shellfish toxins, plant toxins and pharmaceuticals.

Risks we may not detect at the moment:
Some inorganic compounds (e.g. nitrite).
Proteins (e.g. prions).
Insect toxins.
Others (e.g. Brominated flame retardants).



Shellfish toxins cause paralysis at very low levels of exposure

Microbiological Safety

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- Feedstock and insect species dependant. Potentially managed through processing e.g. heat, pressure.

- Anticipated persistent risks may include; *Salmonella spp,* and Hepatitus E.

Allergenicity

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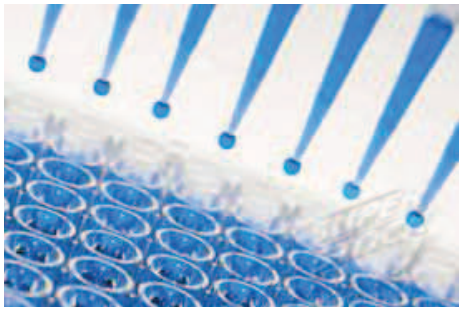
- Assessment of allergenicity in animals during feeding trials:
  - monitor **symptoms**,

    e.g., scratching, watery eyes

Wikimedia.org

  - measure **IgE levels**: antibodies produced upon exposure to allergen.



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Allergenicity in Humans

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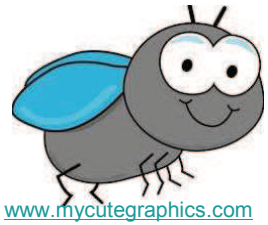
- Very little information available about insect allergens
- Low probability of insect proteins being contained in meat/egg/fish produced from insect-fed animals.
- Higher risk from insects as food.
- Potentially allergenic proteins include tropomyosin

Tropomyosin

- main allergen in shellfish
- protein sequence very similar in insects
- some insect tropomyosins known to be allergenic

Tropomyosin sequence alignment

The Food and Environment Research Agency



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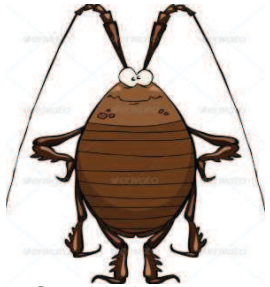

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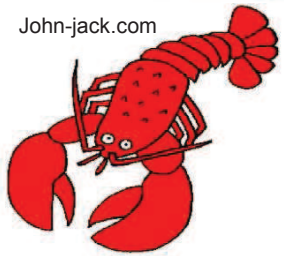

John-jack.com

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Musca domestica       MDAIKKKMQGMKIDKDAALERAATCEQQARDANLRAEKAEEEARQLQKKIQTVENELDQT
Coakroach             MDAIKKKMQAMKLEKDNAMDRALLCEQQARDANLRAEKAEEEARSLQKKTQQIENDLDQT
Lobster               MDAIKKKMQAMKLEKDNAMDRADTLEQQNKEANIRAEKTEEEIRITHKKMQQVENELDQV
North Sea shrimp      MDAIKKKMQAMKLEKDNAMDRADTLEQQNKEANNRAEKSEEEVFSLQKRMQQLENDLDSV
                      *********.**:**  *::**    *** ::** ****:***     :*: * :**:**..

Musca domestica       QEALTLVTGKLEEKNKALQNAESEVAALNRRIQLLEEDLERSEERLGSATAKLSEASQAA
Coakroach             MEQLMQVNAKLDEKDKALQNAESEVAALNRRIQLLEEDLERSEERLATATAKLAEASQAD
Lobster               QEQLSLANTKLEEKEKALQNAEGEVAALNRRIQLLEEDLERSEERLNTATTKLAEASQAA
North Sea shrimp      QEALLKANAHLEEKDKALSNAEGEVAALNRRIQLLEEDLERSEERLNTATTKLAEASQAA
                       * *   .. :*:**:***.***.************************ :**:**:*****

Musca domestica       DESERARKILENRALADEERMDALENQLKEARFLAGEADRKYDEVARKLAMVEADLERAE
Coakroach             DESERARKILESKGLADEERMDALENQLKEARFMAEEADKKYDEVARKLAMVEADLERAE
Lobster               DESERMRKVLENRSLSDEERMDALENQLKEARFLAEEADRKYDEVARKLAMVEADLERAE
North Sea shrimp      DESERMRKVLENRSLSDEERMDALENQLKEARFLAEEADRKYDEVARKLAMVEADLERAE
                      ***** **:**.:.*:*******************:* ***:**********************

Musca domestica       ERAEQGENKIVELEEELRVVGNNLKSLEVSEEKANQREEEYKNQIKTLNTRLKEAEARAE
Coakroach             ERAESGESKIVELEEELRVVGNNLKSLEVSEEKANLREEEYKQQIKTLITRLKEAEARAE
Lobster               ERAETGESKIVELEEELRVVGNNLKSLEVSEEKANQREEAYKEQIKTLANKLKAAEARAE
North Sea shrimp      ERAETGESKIVELEEELRVVGNNLKSLEVSEEKANQREEAYKEQIKTLTNKLKAAEARAE
                      **** **.*****************************  *** **:*****  .:** ******

Musca domestica       FAERSVQKLQKEVDRLEDEYIIEKERYCLVGDSLDEAFMDLIPGLEPFYTPRNPKPPTPK
Coakroach             FAERSVQKLQKEVDRLEDELVHEKEKYKFICDDLDMTFTELVGY----------------
Lobster               FAERSVQKLQKEVDRLEDELVNEKEKYKSITDELDQTFSELSGY----------------
North Sea shrimp      FAERSVQKLQKEVDRLEDELVNEKEKYKSITDELDQTFSELSGY----------------
                      ******************** : ***:*  : *.** :* :*
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Allergen Detection

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- LC-MS/MS enables the identification of known allergens.
- Bioinformatics search for orthologues of other allergens where insect genomes are available – high homology may indicate allergenic potential.

Nutrition & Quality

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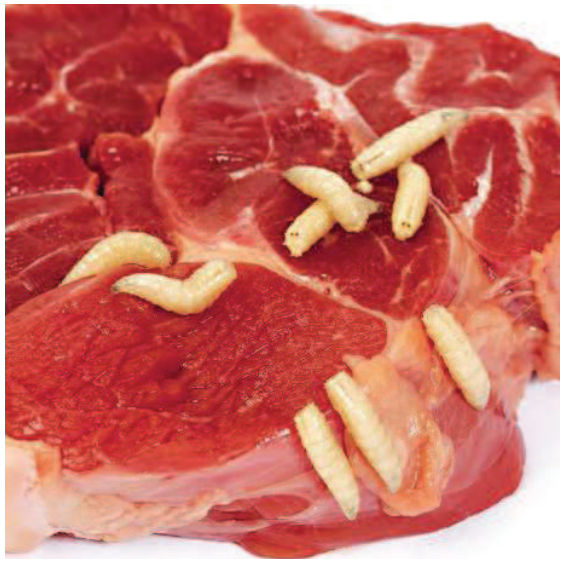
- Nutritional profiles of insects for designing feeding trials.
- Product quality parameters may include e.g. taints in meat from animals reared on insect based diets.



Nutrition – Literature review

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- *Musca domestica* larvae (dry matter)*:*

- Crude protein: 37-68% (27 articles)
- Fat: 4-36% (24 articles)
- Total carbohydrates:1.3-2.9% (2 articles)
- Total ash (mineral content): 5-14% (19 articles)
- Gross energy:14-25 MJ/Kg (8 articles)

Nutrition – Literature review

The Food and Environment Research Agency

- *Hermetia illucens* larvae (dry matter)*:*

- Crude protein: 37-48% (9 articles)
- Fat: 12-46% (9 articles)
- Total ash (mineral content): 15-16% (4 articles)
- Gross energy:21 MJ/Kg (1 article)

Added Value

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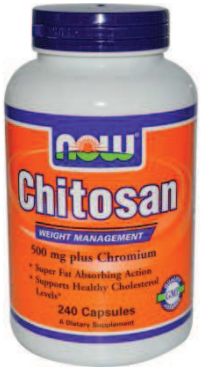
- Investigate potential use of waste and by-products.
- Current insect products include chitin/chitosan and shellac.
- Insect oils may have value as fuel/lubricants.
- Insect manures as fertilisers?

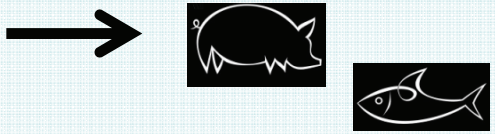
Refined protein

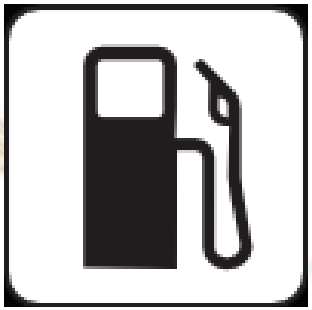
Animal Feed



By-products

Nutrition & Quality





Oils & Fuels

Cosmetics & pigments

Bioactives

Summary

- There is huge potential for using insect protein as a source of animal feed.
- There is a lot of work to do to understand and manage safety risks for both food and feed.
- Legislation for the nutritional use of insects is currently prohibitive
- This is entirely correct until we have ensured that a robust international safety framework for insects in the food chain can be adopted.

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Thanks for your attention!

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