Insects: A new sustainable (animal) protein source for feed and food

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Global facts...

- **2 billion people eat insects on a regular basis** (primarily Asia, Africa and South America) - consuming ~2000 different species

- In Thailand, the insect food industry has an annual turnover of 130M €
Global potential...

- FAO estimates that **food production has to increase by >70%** to feed the global population in 2050.

- **Animal feed**, estimated at a global volume of 870M tons in 2011, **represents 60-70% of production costs**.

- **China alone imports** half of their animal feed - equivalent to **30M tons annually**.
Global attention...

- **Insects to feed the world** – First international conference (supported by FAO) on insects as new protein source - 14-17 May 2014 in Ede, Holland – **450 participants from 45 different countries**

- **Followed by 4 international meetings** in Canada, Belgium, Denmark and France during 2014 on insects as feed and food

- **News on insects** increasing steadily during since 2013

- **Social media**
Efficient and sustainable production

- **Higher feed conversion rate** (FCR) compared to conventional livestock
  FCR >2-12x higher than poultry, pigs and cattle

- Feasible to use **organic side-streams as feed for insects** (added value compared to current applications, e.g. biogas)

- **Low use of water and energy**

- **Low requirements for production area**
  <2-10x lower than area used for production of equivalent quantity of protein from poultry, pigs and cattle

- **Very low emission (100-1000x) of greenhouse gases** and ammonia compared to production with pigs and cattle

FAO report 171, 2013
(Some) advantages of the insect product...

- Sustainable protein source (environment, economy)
- Animal-based protein (source of essential amino acids for animal feed and food)
- Nutritious (high protein content, fatty acids, minerals and vitamins)
- Non-GMO (source-dependent)
Bioconversion: Valorization of organic side-streams

- ORGANIC RESOURCE
- Lipids
- Insect conversion
  - (non)food product
- Chitosan
- Bioactive compounds
- Vitamins
- Minerals
- Biogas
- Fertiliser
Potential for co-production: Optimized production systems
EU legislation applicable to insects

- **General food legislation** (regulation EC178/2002) and legislation on **food and feed hygiene** (regulations EC852/2004 and EC183/2005) is applicable to all FFBOs (Food & Feed Business Operators) – and thus also for production of insects. The regulations ensure overall demands **safety, hygiene and traceability** (GMP, HACCP)

- Overall **insects** and products derived from insects are considered as **suitable animal feed**. They are listed as invertebrates in the European Catalogue on Feed Materials (EC767/2009)

- Regulation EC1069/2009 on **animal by-products** has listed invertebrates (non-pathogen species) as **category 3-material**, which can be used as feed for livestock and fur production as well as for pets (pending application of various pretreatments, e.g. temperature, pressure and time)
## EU legislation - restrictions

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<tr>
<th>Application</th>
<th>Go!</th>
<th>NO go!</th>
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<tr>
<td><strong>Feed</strong> for animal fur production and pets</td>
<td>- Few restrictions (EC183/2005)</td>
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<td><strong>Feed</strong> for livestock</td>
<td>- Aqua culture (fish feed)* (EC1069/2009) - *pending on origin of feed (e.g. aquatic/terrestrial)</td>
<td>- Insects = livestock = feed may not contain meat or fish (EC1069/2009)</td>
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<td>- Live feed (insects) for free-range animal production (e.g. poultry)</td>
<td>- Insect feed may not originate from faeces and gut-intestine (EC767/2009, Annex III)</td>
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<td>- Processed Animal Protein (PAP) from insects can not be used as feed (EC999/2001)</td>
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<td><strong>Food</strong></td>
<td>- Some EU member states (e.g. Belgium, UK and The Netherlands)</td>
<td>- Novel foods (EC258/97)</td>
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Belgium: Inclusion of insects as food

**Placing on the market of insects and insect-based foods intended for human consumption**

Regulation (EC) no 258/97 provides that foods or food ingredients which have not been used for human consumption to a significant degree within the European Union before 15 May 1997 are novel foods, or novel food ingredients. According to that regulation all novel foods or novel food ingredients must be submitted to a risk assessment and must receive an authorization of the European Commission before they may be placed legally on the Community market.

| House cricket | Acheta domesticus |
| African migratory locust | Locusta migratoria migratorioides |
| Superworm beetles / Giant mealworm beetle / King mealworm | Zophobas atratus morio |
| Mealworm | Tenebrio molitor |
| Lesser mealworm | Alphilobius diaperinus |
| Greater wax moth/ Honeycomb moth | Galleria mellonella |
| American desert locust | Schistocerca americana gregaria |
| Banded cricket | Gryllodes sigillatus |
| Lesser wax moth | Achroia grisella |
| Silk moth | Bombyx mori |
Insects with industrial potential

- **Beetles (feed and food)**
  - Common mealworm (*Tenebrio molitor*)
  - Giant mealworm (*Zophobas morio*)
  - Lesser mealworm (*Alphitobius diaperinus*)

- **Flies (feed)**
  - Black soldier fly (*Hermetia illucens*)
  - Common housefly (*Musca domestica*)

- **Crickets (feed and food)**
  - House cricket (*Acheta domesticus*)
  - Banded cricket (*Gryllodes sigillatus*)
Generic production process

Culture: Eggs/larvae transfer to production

Production (1-2 mths)

Harvest of larvae

Processing (drying, grinding)

~10% larvae back to culture
International producers
Marketing potential

Danish example: Marketing potential in multiple sectors equals >500,000 ton/yr (market value >650 mill. EUR/yr)

- Danish import of soy = 1.5 mill. ton/yr (Landbrug & Fødevarer)
  - 20% insect meal = 300,000 ton/yr – priced at level of fish meal (~2,000 EUR/ton)

- Pet food: 8.5 mill. ton/yr (FEDIAF)
  - 10% insect meal = 850,000 ton/yr – priced at level of soy (~333 EUR/ton)

- Feed for fur producing animals: 800,000 ton/yr (Kopenhagen Fur)
  - 20% insect meal = 150,000 ton/yr – priced at level of soy (~333 EUR/ton)
Business model (simplified)

- Production: 2000 ton insect meal (production area 2-4.000 m²)
- Revenue: 4-14 mill. EUR (feed vs food)
- Main cost (insect feed): 0.33-1.33 mil. EUR (~2.5-5.000 ton)
- Margin: 2.67-12 mill. EUR (salary, depreciation, etc.)

Potential to increase out/profit in ‘next generation(s)’, e.g.:

- Higher protein price
- Improved ‘bio-insight’
- More batches/yr
- Cheaper/better feed
- Co-production (biogas)
- Automation (robotics)
The ‘Insect Value Chain’
Fueling the economy by recirculating resources

**Resource (Insect feed)**
- BB, CB
- Legislation
- Mapping
- Insect matching
- Business model
- Co-production
- Bioeconomy

**Insect Production**
- CB, RT
- Legislation
- Business model
- Lab-pilot scale
- Co-production
- Mass balancing
- Optimization
- MO/tox safety
- Automation
- Monitoring

**Processing (refining)**
- BB, FT, WB
- Analytics
- Functionalities
- Quality
- Extraction
- Fractionation
- Product devel.

**Industrial sectors**
- BB, CB, FT, WB
- Energy
- Petfood
- Feed
- Food
- Legislation
- Product devel.
- Business model
- Co-production
- Marketing

**End-user (consumer)**
- BB, CB, FT, WB

DTI centers: Biomass & Biorefining (BB), Chemistry & Biotechnology (CB), Food Technology (FT), Robot Technology (RT), Wood & Biomaterials (WB)
DTI Insect Projects (completed)

- **BioConVal: Bioconversion to value** - R&D project carried out amongst Danish R&D institutes and European SMEs (2012-2014)
  
  Developing an integrated system for cultivating pathogen-free fly larvae in poultry manure locally at farms; and subsequently use them as dietary supplement for the livestock.

- **BoB: Bioconversion of by-products** - R&D project with Danish SME - ScrapTrans (2014-2015)
  
  Analysis of mealworm (beetle larvae) production on industrial feed/food by-products; and assessment of business model(s) based on marketing of mealworm biomass as animal feed.
DTI Insect Projects (initiated)

- **Utilization of resources for insect production of protein feed with mealworms** (National funding, 2015-2016)
  - Development of ‘first generation’ insect feed for *T. molitor* from by-products; including demo-production on Danish farms.

- **VALIN - VALorization of organic side-streams through bio-conversion with INsects** (National funding, 2015-2017)
  - Mealworms for feed and food: Development of ‘second generation’ insect feed from food-grade by-products.

- **SUSMEAL - Sustainable Mealworm Production for Feed and Food** (Eurostars, 2015-2017)
  - Development of feed for *A. diaperinus* based on utilization of low-cost organic side-streams to reduce current feed costs
  - Automation of a cost-effective mass production system to reduce the current level of man-hours needed.
Frågor?

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