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Insects – a potential protein source for feed and food

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Introduction

- Insect rearing is a novel opportunity to produce protein to human consumption and to animals
  - High protein content, even up to 50-70%
  - Can potentially use low-value sidestreams from bio-based industries
- The use of edible insects is controlled by novel foods legislation, since there is no track record on their safety
  - Commercial use of edible insects was allowed in Finland in late 2017
  - Feed use is controlled by feed legislation
- Althought edible insects have emerged only recently in Europe, about two billion people consumer insects globally
- Because insects are a novel line of production, there is little experience on how to organize insect rearing.

Objective

- The aim of this presentation is to analyse the potential of insect rearing in Finland.
- Our analysis is based on literature review, data collected from a farm rearing house crickets in Finland and calculations prepared based on the data during a development project *Entolab* which has received funding from the European Agricultural Fund for Rural Development - The Rural Development Programme for Mainland Finland
- We will discuss the following poinst
  - Environmental aspects and efficiency
  - Automation
  - Food safety considerations
  - Economic potential of insect rearing

Edible insect species

- Approximately 2000 insect species are edible, but the main focus is on about ten species
- Reared insects are considered as farm animals
  - ➔No harmful insects or endangered species
  - ➔Generic animal welfare regulations apply
- Edible insect species in Finland include at least
  - House cricket (*Acheta domesticus*)
  - Bees (*Apis mellifera*)
  - Meal worm (*Tenebrio molitor*)
  - Tropical house cricket (*Gryllodes sigillatus*)
  - Buffalo worm (*Alphitobius diaperinus*)
  - Migratory locust (*Locusta migratoria*)
  - Southern field cricket (*Gryllus bimaculatus*)

Environmental risks

- Introduction of new species may pose a risk to the environment
  - Invasive species have been estimated to reduce the global agricultural production by 14 % (Pimentel 2007; Kenis & Branco 2010)
  - ➔ Therefore, no insect species, which may damage the environment (if released into the environment) can be farmed
  - ➔ This includes insects which are known vectors of zoonotic pathogens
- Pests and diseases
  - Some viral diseases pose a severe production risk as they can extinguish the insect population on the farm
  - Genetic diversity should be maintained and inbreeding to be avoided in the farmed population

Environmental footprint of insects

- Mealworms *need less land* and *produce less* CO_2 per kilogram of protein they produce than conventional livestock. However, their *energy consumption* may be higher (Oonincx and de Boer, 2012)
- In a Finnish study, feed crop production and direct heating energy were responsible for at least 95% of the total global warming potential of mealworms (Joensuu & Silvenius 2017).
- From the environmental perspective it would be essential to:
  - Feeds insects with feed that is currently not used as feed or food, and which they could utilize efficiently.
  - It is not well known which feedstuffs are best-suited for insect rearing.
  - Use low-emission energy sources. Insects require a tropical temperature in order to grow and reproduce well.

Insects can utilise feed efficiently

Parameters for house cricket, mealworm and broilers

	House cricket	Mealworm	Broiler
Feed conversion ratio (body weight)	1,3-1,8	2,2	1,7-2,3
Feed conversion ratio (edible weight)	1,7-2,3		2,4-4,2
Protein conversion efficiency	35-23		33-25

Source: Lundy and Parrella (2015), Oonincx et al. (2015)

Feed conversion ratio for house crickets

- The results from an Entolab trial indicate that crickets can convert feed efficiently into biomass, but need to pay attention on how to reduce mortality and feed waste.
- Feed quality and composition may have a substantial influence on the survival rate of insects (observed also by Oonincx et al. (2015) for Argentinian wood roach, mealworms, house cricket)

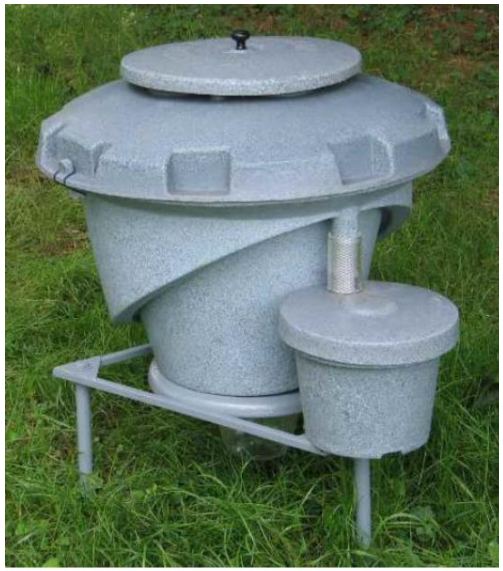
Treatment	Industrial feed	Potato and faba bean-based feed	Potato and faba bean-based feed (low protein)
Feed kg/kg crickets	1.23[a]	1.20[a]	1.78[b]
Cucumber kg/kg crickets	2.73[c]	4.31[d]	5.81[e]
Faeces, feed, dead crickets kg/kg crickets	2.13[f]	3.19[g]	3.46[h]

Columns with different superscripts differ $p<0.05$.
N=6 rearing boxes per treatment.

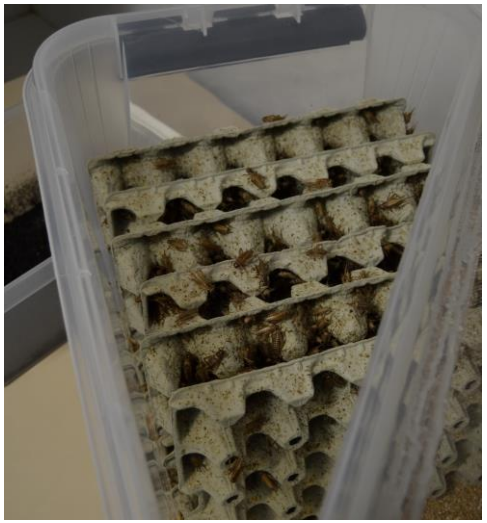
Large potential for automation

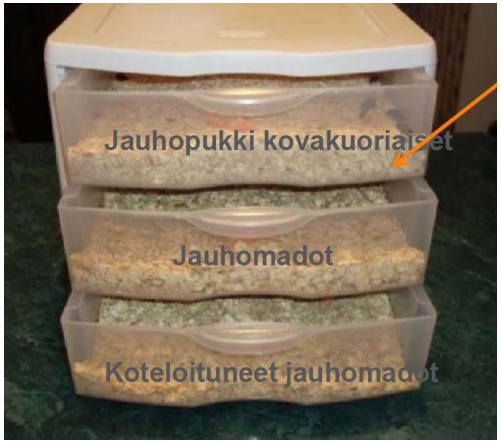
- Currently insect rearing is a labour-intensive for of production and most daily management tasks are carried out manually
  - ➔ Labour cost is the most important individual cost item
  - ➔ Production costs per kg insect biomass is high
- Attempts to increase the level of automation are being developed
- At least feeding and waste management can be automatized with existing technologies although their functionality has not yet been tested
- Automation would allow increasing the scale of production
  - ➔ Improved availability of insect-based products
  - ➔ Reduced production costs per kg biomass, increased demand for insect-based products

Some examples on currently available small-scale rearing equipments



The BioPod™





Food and feed safety

- Foods placed on the market in Europe must be safe, and food safety is a priority.
- Insect food manufacturers must meet the hygiene standards
  - HACCP / own control
  - Hygiene
  - Traceability
- To ensure both product safety and insects requires good hygiene practices and biosecurity
- The sanitation of breeding grounds and platforms is an essential part of biosecurity.
- Feed hygiene: Feed fed to insects must meet the requirements set by the feed law.
  - No waste can be used to feed insects

Potential food safety risks that need to be controlled

- Allergens
- Toxicological risks, mycotoxins
- Pesticides
- Heavy metals and alkali
- Pathogenic micro-organisms
  (e.g. *Staphylococcus* and *Bacillus*, *Campylobacter*, *Enterobact eriaceae*; fungi: *Aspergillus*, *Fusarium* ym)
- Inaoppropriate handling of insects can boost pathogenic risks
- Risks must be taken into account in the prduction process and in product labels
- Heat treatment (boiling) is often used to reduce biological risks

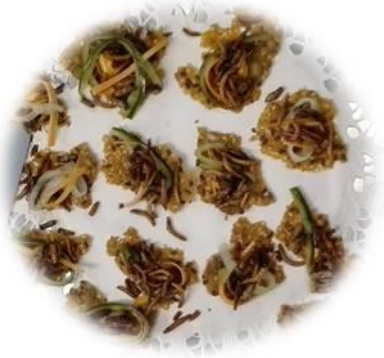
Economic potential

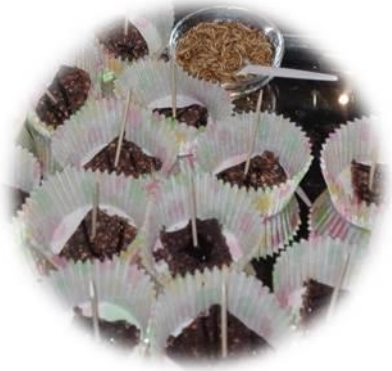
- Economically, majority of production costs in insect rearing are either fixed costs, or due to feeding or labour use.
- In a case study (Caraballo 2017) based on a real farm, labour costs were 50%, other variable costs 20% and fixed costs 30% of the production costs (€81.5 per kg)
- Profitability is greatly influenced by the price of product sold
- The current level of production costs suggest that insects are currently better suited for food use than for feed use.
- Food use allows innovative approaches to develop high-premium products to the markets.
- However, as the production efficiency is improved and production volumes increased in the coming years, also feed use can become economically viable option.

How consumers view edible insects?

- More than 70% respondents in a Finnish survey viewed insect food as interesting and more than half of the respondents were willing to buy it
- Consumers' willingness to buy insect food is influenced by (Piha et al. 2017)
  - Knowledge (both subjective and objective) ➔ Attitudes
  - Experiences from insect products
  - Fears related to (novel) food
- Crisps/snacks and bread including insects are perceivd favourably

Concluding remarks





- Insect rearing provides has the potential to become a new branch of food industry
- Further research is needed to…
  - Increase the rate of automation
  - Find appropriate sources of feed
  - Reduce the production costs
  - Develop novel consumer products
- Reseach and development is likely to be able to provide substantial improvements in the production
- Each enterprise should determine what is their core business: edible insects, feed, non-food use?