Sustainability constraints for insect protein meal production

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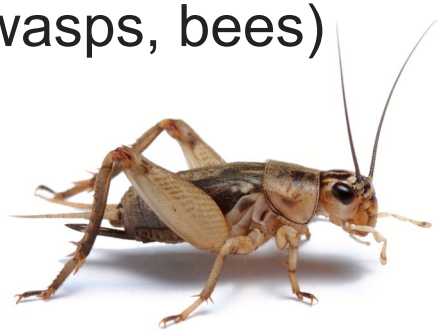
Cultured insects

Honey bees

Silk moths

Agriculture controllers (predators, parasites, pollinators)
(ladybugs, caterpillar parasite wasps, bees)

Insects as food (FDA)
(mealworms, crickets, locusts)



Insects as feed (AAFCO)
(*Hermetia illucens*; BSF)

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General benefits of insects

- High diversity (taxonomy & physiology)

- Fast growth

- Less space and water to produce (per kg of protein)

- Simpler but efficient immunology (AMPs) (w. Cecropins and Defensins)

Efficiency of food waste conversion

1,000 kg food waste
70-80% water

200-300 kg DW iMeal
13-14.5 % Protein
4-11 % Fat

40-75 kg pMeal
53-55 % Protein
8-12 % Fat
70 kg DW Frass

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Land efficiency

Composting

1 mt/day 200-700 m^2

Anaerobic digestion

1 mt/day 25 m^2

BSF

1 mt/day 60 m^2

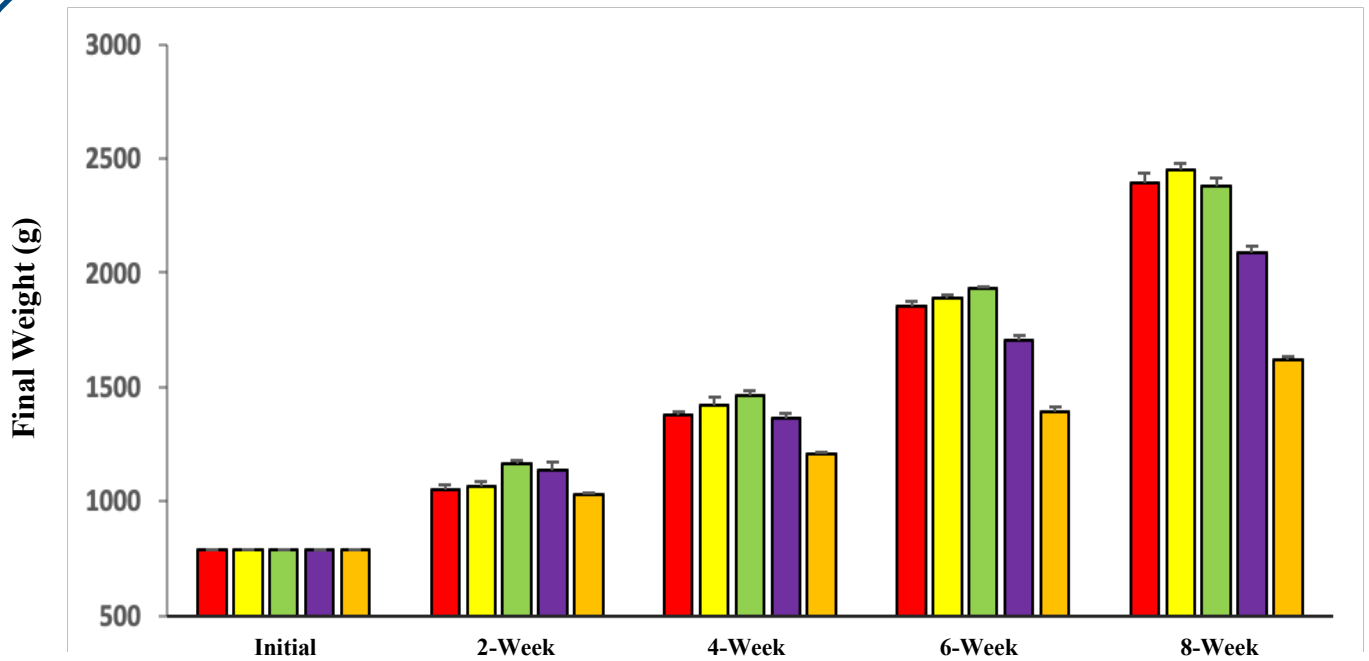
4 acres for a city with 1 million people (@ 0.1 mt/person/year)

1 mt food waste =>

40-75 kg pMeal

70 kg DW frass

Effects of fish meal substitution with BSF pMeal Red Drum Diets (*Sciaenops ocellatus*)



Fish Meal:BSFM
100: 00
75:25
50:50
25:75
00:100

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Take home slide
Constrains to feed insects

1) Life cycle
2) Interaction w. other life forms
    - War w. fungi; mycoinsecticides vs. cecropin-AMPs (Stomoxyn)
    - Culture-specific parasites and pests
    - Limited knowledge about BSF diseases
3) Physiology
    - Heterotrophs => loss in CNP&E
    - Compete for feeds with other farm animals
    - Biomagnification of pesticides
4) Nutrition safety
    - Food-safe insects compete with us for quality feeds
    - Sloppy eaters are cheaper … but have limitations

5) Larvae feed quality
6) Protein & fats quality
7) Production costs

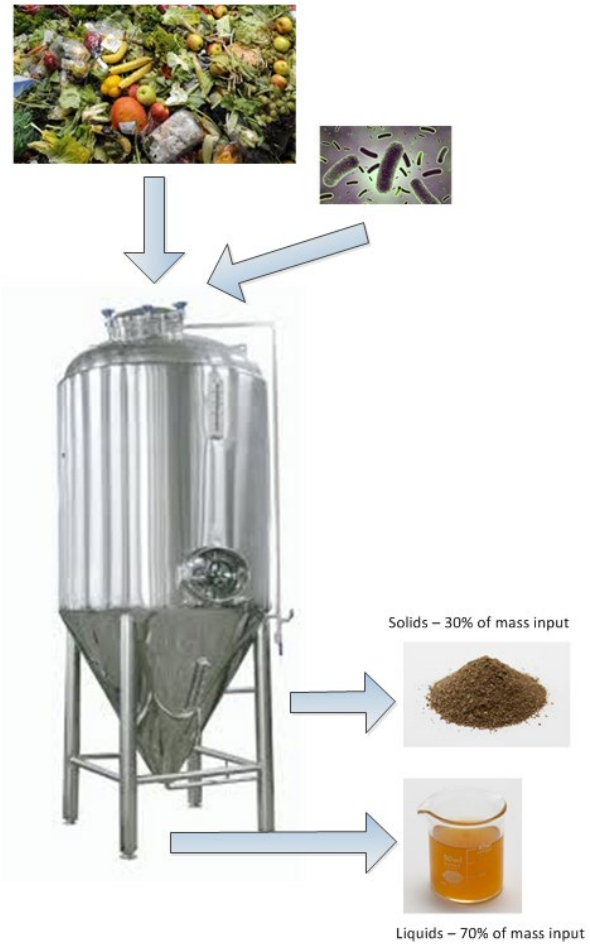
Larvae feed quality

Feed composition
Organic nitrogen, carbohydrates, fats, vitamins, mycotoxins,

Feed pre-processing
Refrigeration, Drying, Cooking, Fermentation.

Feed sources
Some feeds will never make it toward feeds
(manure, sewage sludge; pesticide-contaminated)

Some feeds are of secondary/local interest
(post-consumer food wastes; leafy vegetables;
yard clippings; algae)



Industrial byproducts and commercial waste (fruit pulp, vegetable trimmings, wheyt, shelf-expired food, small-scale brewery and distillery waste)

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Protein & fats quality

Fat content is very high and composition variable (lauric acid is high)

Digestibility

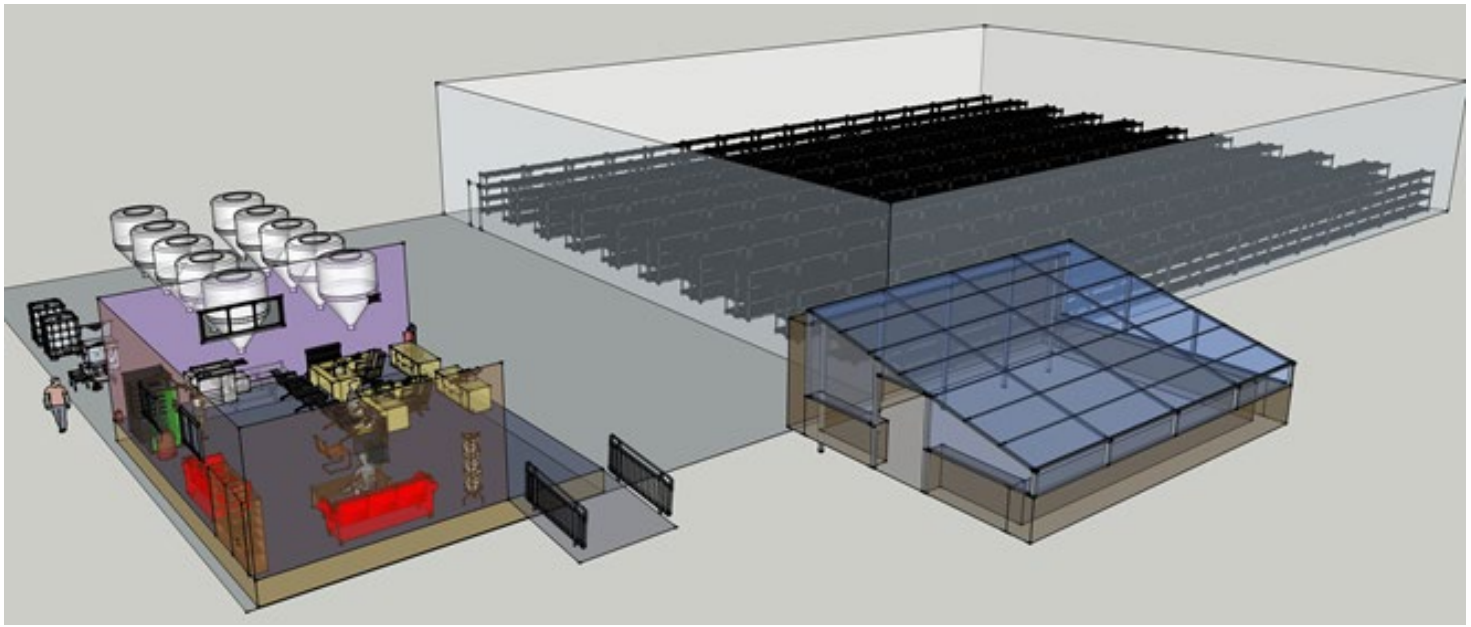
- Protein/melanin complex.
- (2 heating steps)
- Maillard rxn. materials?

Hazards

- Pathogens
- Microbial toxins
- Allergens

No industry standards for pMeal quality (feed sources and the drying method are the main causes of product variability)

Production costs



3.5-7.5 $/kg BSF meal

1.5-1.7 $/kg Fish meal

0.5-0.7 $/kg Soy meal

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Strategies to survive the ride

- Legislation (tipping fees & carbon credits)
- Automation
- Diversify revenue (tipping fees, frass, fats, treats, polymers, AMPs)
- Split the industry
  (eggs / larvae growing / biomass processing)
- High quality protein (solvent defatting, less denaturation)
- Low BSF protein addition to feeds
  (to temper soy antinutritional factors or for AMPs)
- Target specialized feed markets
  (e.g. predatory fish & customer-targeted feeds)
- BSF for waste reduction
  (pig manure, spoiled food waste, industrial organic wastes

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Thank you!

(any questions?)

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