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Insect biomass quality and safety: basic concepts, recent issues, and future challenges

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Outline

Legal status

Efficency/Quality

Safety

Challenges and future prospective

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New proteins

News | 3 Jul 2017 | 6151 views | 4 comments

July 1: A milestone for insect protein

As of July 1 2017, insect protein will be allowed to be used in aquafeed. The insect sector is thrilled that this milestone to start using insect protein is now official.

The EU Regulation 2017/893 now permits the use of insect proteins as fish feed, derived from the following insect species:

- Black Soldier Fly (*Hermetia illucens*) and Common Housefly (*Musca domestica*)
- Yellow Mealworm (*Tenebrio molitor*) and Lesser Mealworm (*Alphitobius diaperinus*)
- House cricket (*Acheta domesticus*), Banded cricket (*Gryllodes sigillatus*) and Field Cricket (*Gryllus assimilis*).

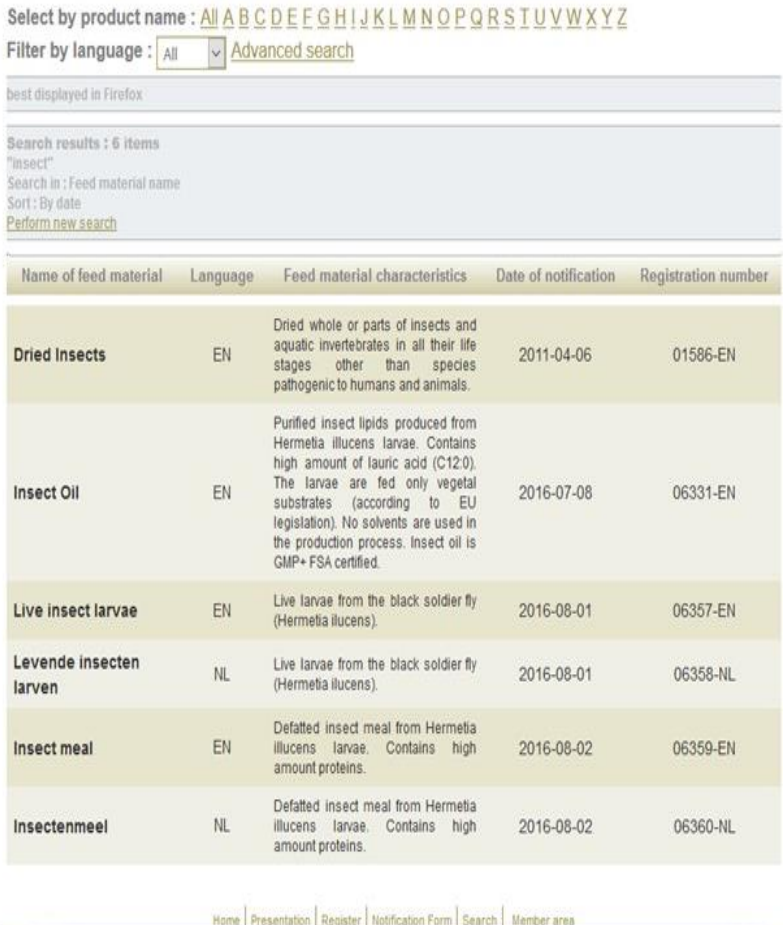
The use of insect protein for other livestock species is not allowed yet.

In the wake of this legislative reform, IPIFF President Antoine Hubert reacted: "We are particularly pleased with the opening of this legislation, which constitutes a major milestone towards the development of the European insect production sector".

"We also trust that this legislation will bring new opportunities for the European aquaculture sector, as insects should represent a promising source of proteins for farmed fish in the near future: as being a natural component of the diets of carnivorous fish, whilst combining high proteins levels - between 55% and 75% - and ex-

Insects as feed

- Reg.(EU) No 2017/1017 **which amended Reg. 68/2013 on the EU Catalogue of feed materials introduces revised descriptions explicitly referring to processed animal proteins and fats from insects** (*see 9.4.1 'processed animal protein' & 9.2.1 'animal fat', whose descriptions now refer to invertebrates).*
- *Processed animal protein more limitations*
- *Animal fat less limitations*



Select by product name : All A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Filter by language : All Advanced search

best displayed in Firefox

Search results : 6 items
"insect"
Search in : Feed material name
Sort : By date
Perform new search

Name of feed material	Language	Feed material characteristics	Date of notification	Registration number
Dried Insects	EN	Dried whole or parts of insects and aquatic invertebrates in all their life stages other than species pathogenic to humans and animals.	2011-04-06	01586-EN
Insect Oil	EN	Purified insect lipids produced from Hermetia illucens larvae. Contains high amount of lauric acid (C12:0). The larvae are fed only vegetal substrates (according to EU legislation). No solvents are used in the production process. Insect oil is GMP+ FSA certified.	2016-07-08	06331-EN
Live insect larvae	EN	Live larvae from the black soldier fly (Hermetia illucens).	2016-08-01	06357-EN
Levende insecten larven	NL	Live larvae from the black soldier fly (Hermetia illucens).	2016-08-01	06358-NL
Insect meal	EN	Defatted insect meal from Hermetia illucens larvae. Contains high amount proteins.	2016-08-02	06359-EN
Insectenmeel	NL	Defatted insect meal from Hermetia illucens larvae. Contains high amount proteins.	2016-08-02	06360-NL

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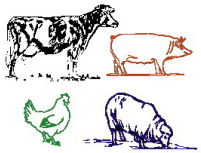
Insects as feed

- the EU 'feed ban rules' contained in the so called 'TSE Regulation' (i.e. Reg. 999/2001) so far prohibited the use of PAP to be used in feed for farmed animals, including for fish.
- Reg. 2017/893 **partially uplifts the feed ban rules** regarding the use of insect processed animal proteins (PAPs) for aquaculture animals.
  - the text introduces a specific section for insects & insect products **(**Annex IV, section F of Regulation 999/2001)

Insect

PAPs



Animal by-products

Rendering and heat processing

Processed animal protein (PAP)

PAPs (mammals poultry fish)

Feed ingredient

Feed ingredient

TSE crysis

Legal status

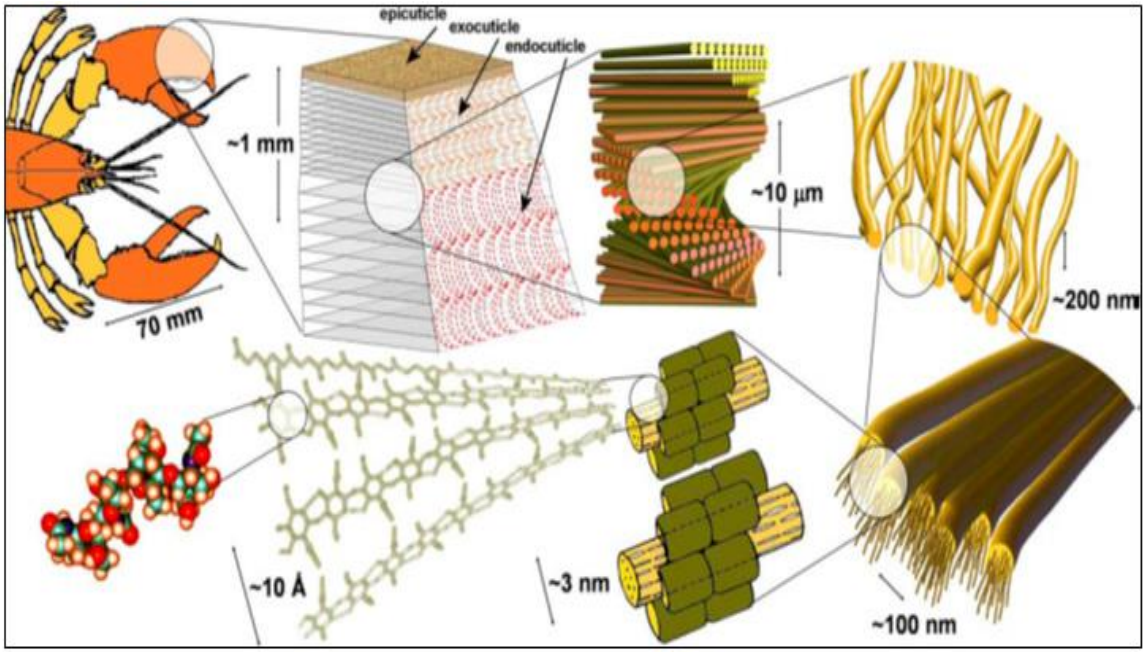
Contaminant

Insect

Contaminant

Lift-ban/methods

- Several similarities with Marine arthropods (Shrimp, krill, contained in fish meal)
- Authorized only for farmed fish



Hierarchical structure of exoskeleton of lobster

Exoskeleton features !

Modified from: Raabe et al. |Acta Matarialia 53 (2005) 4281

	Ruminants	Unweaned ruminants	Non ruminants	Fish	Pets and fur animals
Ruminant PAP (included ruminant blood meal)	NA	NA	NA	NA	A
Non ruminant PAP	NA	NA	NA	A	A
Insect PAP	NA	NA	NA	A	A
Fish meal	NA	A	A	A	A
Ruminant collagen and gelatine	NA	NA	NA	NA	A
Non ruminant collagen and gelatine	A	A	A	A	A
Ruminant blood products	NA	NA	NA	NA	A
Non ruminant blood products	NA	NA	A	A	A
Ruminant hydrolyzed proteins	NA	NA	NA	NA	A
Non ruminant hydrolyzed proteins	A	A	A	A	A
Ruminant hydrolyzed proteins from hides and skins	A	A	A	A	A
Di and tricalcium phosphate of animal origin	NA	NA	NA	NA	A
Milk and milk products	A	A	A	A	A
Colostrum and derivates	A	A	A	A	A
Eggs and egg products	A	A	A	A	A

A = authorised; NA = not authorised

Summary: legal status

- Insect materials are:
  - **Processed Animal Proteins (PAP)**
  - **Animal Fats**

From invertebrates

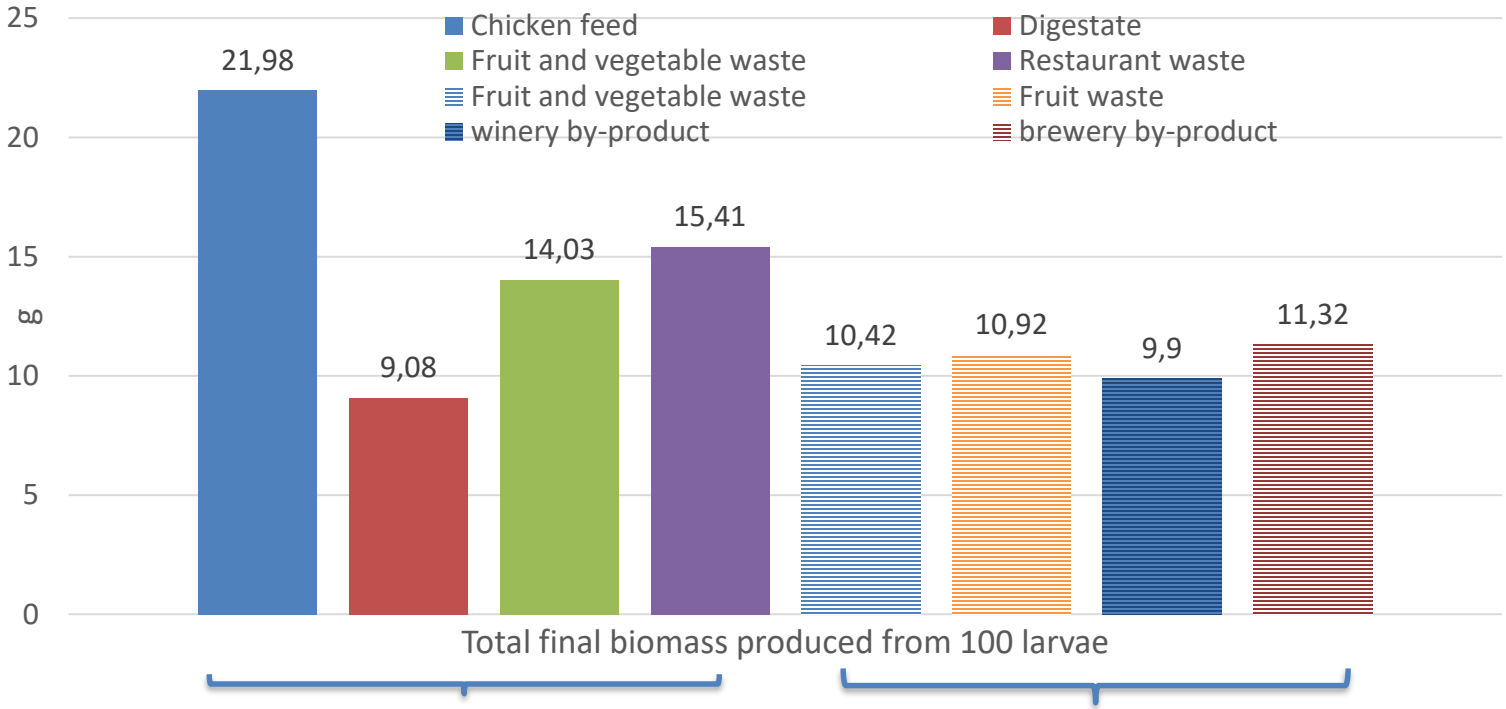
- Several similarities with Marine arthropods (Shrimp, krill, contained in fish meal)
- Authorized only for farmed fish

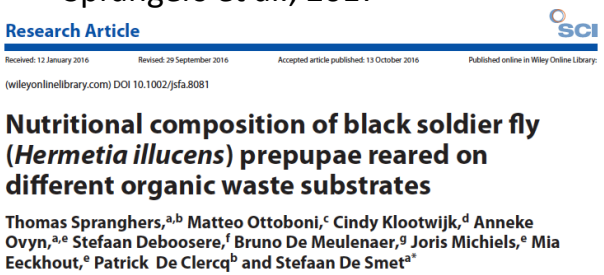
Exoskeleton features !

Outline

- Legal status
- **Efficiency/Quality**
  - substrate
  - Time
  - Insect metamorphosis/harvest life stage
  - Technological quality
- Safety
- Challenges and future prospective

Efficiency: Total final biomass produced





Research Article

SCI

Received: 12 January 2016 Revised: 29 September 2016 Accepted article published: 13 October 2016 Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/jsfa.8081

Nutritional composition of black soldier fly (*Hermetia illucens*) prepupae reared on different organic waste substrates

Thomas Spranghers,[a,b] Matteo Ottoboni,[c] Cindy Klootwijk,[d] Anneke Ovyn,[a,e] Stefaan Deboosere,[f] Bruno De Meulenaer,[g] Joris Michiels,[e] Mia Eeckhout,[e] Patrick De Clercq[b] and Stefaan De Smet[a*]

Research Article

SCI

Received: 12 January 2018 Revised: 27 April 2018 Accepted article published: 11 May 2018 Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/jsfa.9127

Effect of rearing substrate on growth performance, waste reduction efficiency and chemical composition of black soldier fly (*Hermetia illucens*) larvae†

Marco Meneguz,[a] Achille Schiavone,[b,c] Francesco Gai,[c] Andrea Dama,[a] Carola Lussiana,[a] Manuela Renna[a*] and Laura Gasco[a,c]

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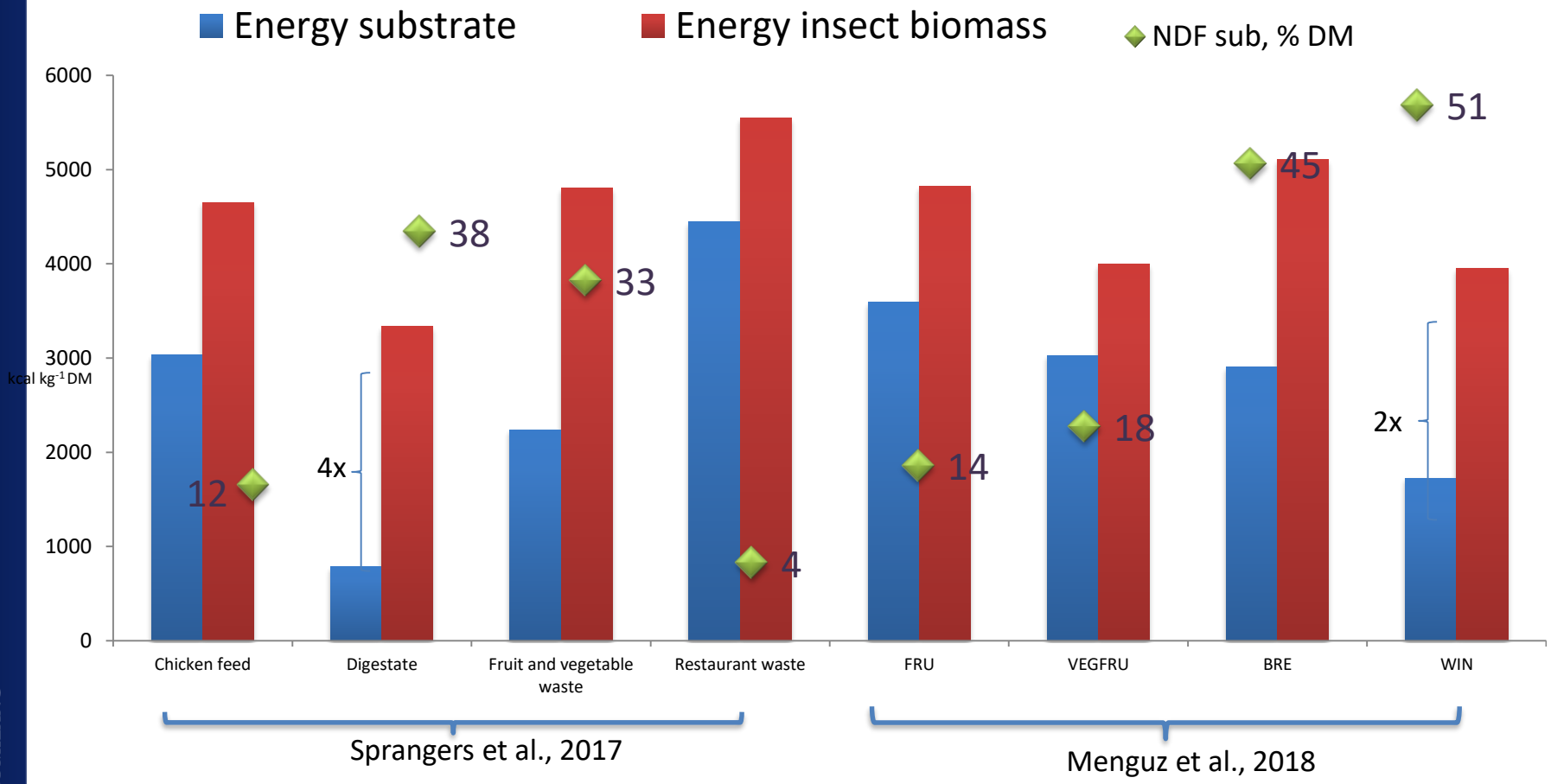
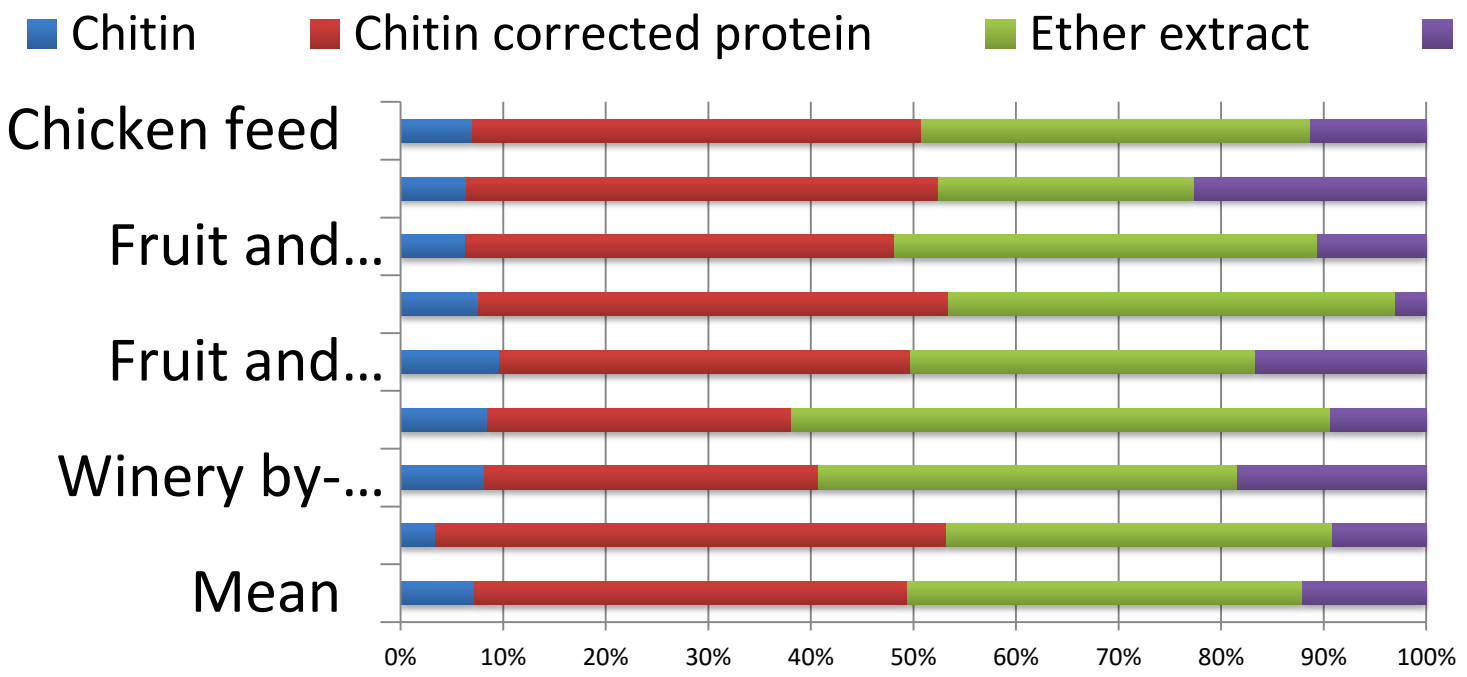
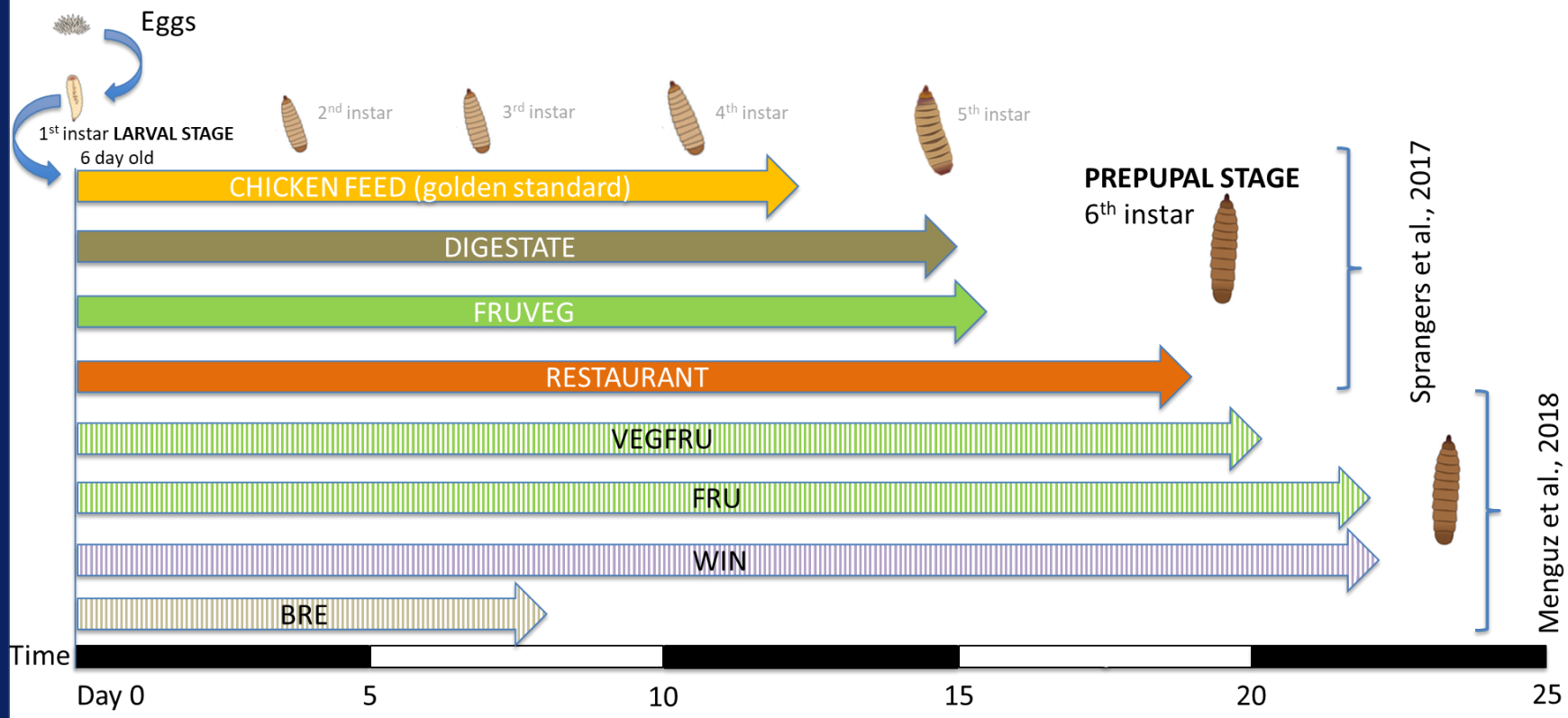
Energy and NDF in substarte vs Energy in biomass



Insect (BSFL) produced on different substrate



Time needed to reach the harvesting stage



Summary: Substrate

Efficiency

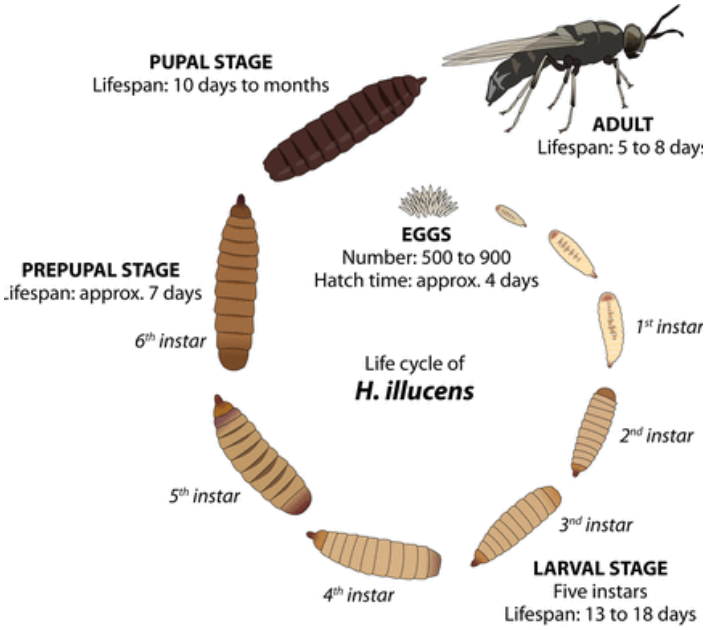
- Insect are able to process efficiently substrate high in moisture and fibre.
  - **from 8% DM**
  - Opportunity for limited pre-processing
  - Can bioconvert wastes high in fibre content (**38-55% NDF)**

Quality

- Protein content and quality is high and comparable for insects reared on different substrates
- **Lipid and Ash contents may depend on the substrate**
  - Ash in the substrate are higly correlated to ash in harvest insect ($r=0.85$;$P<.001$)
  - Ash in the substrate are inv. correlated to fat in harvest insect ($r=-0.72$;$P<.005$)

Summary:Time

- Time needed to reach harvest phase is variable
  - 1-3 wks, species, substrate dependent
- Micro-livestock features (environment, density,..)

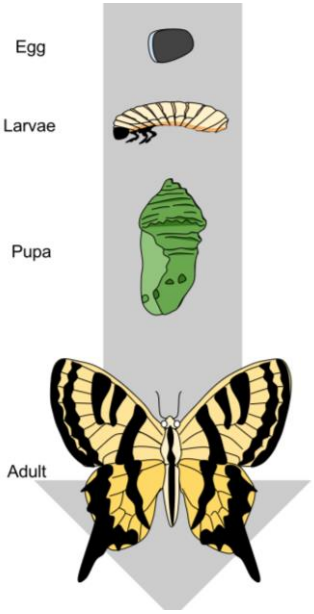


INSECT METHAMORPHOSIS

COMPLETE

88% of al insects

- Four Stages
  1. Egg
  2. Larva
  3. Pupa
  4. Adult



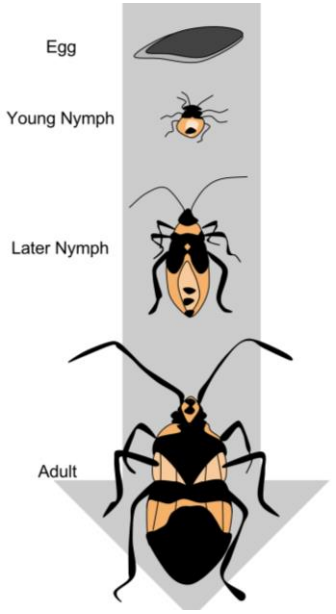
COMPLETE
e.g. butterfly, housefly, bees

1. black soldier fly,
2. house fly,
3. yellow mealworm,
4. lesser mealworm,

INCOMPLETE

12% of all insects

- Three Stages
  1. Egg
  2. Nymph
  3. Adult



INCOMPLETE
Cricket, locust,

1. house cricket,
2. banded cricket
3. field cricket

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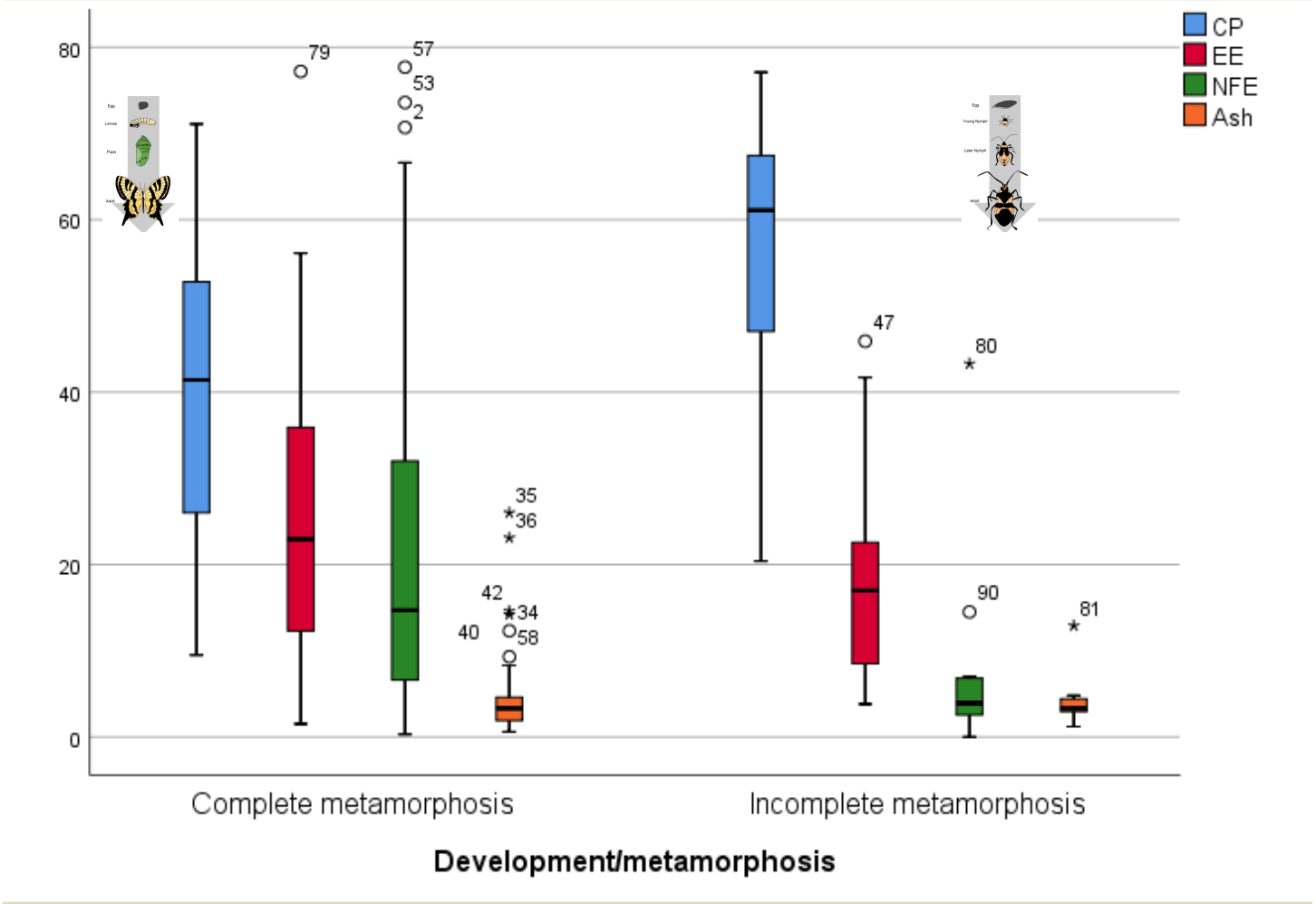
Type of development: source of variability

Box plots displaying mean, median, quartiles, minimum and maximum observations and outliers for nutrient composition (expressed on DM basis) in complete and incomplete metamorphosis insect species (data from Sánchez-Muros et al., 2014). CP – crude protein %; EE – ether extract; NFE nitrogen free extracts;



Can Feeding/substrate chenge this?

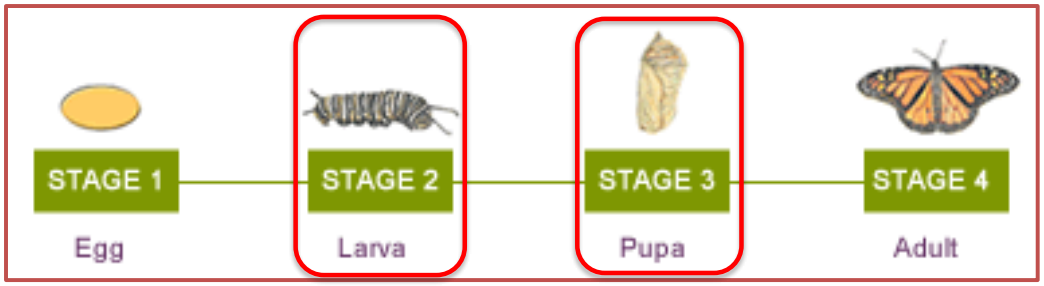
Challenges to adding insect materials to farm animal feeds

- Variation in nutrient content and nutrient availability between batches/sources…
- Technical aspects/qulaity: processing, feed technology…
- Co-product handling, storage, and transportation…
- Effect on animal performance, end-product quality….
- Safety ….

Technological quality: effect of Insect life stage

Rationale of the study:

- to add insect material without processing (high moisture)
- To test the **physiological stage: I.E. *PREPUPAE* VS *LARVAE***



Tecnologycal treatment investigated: extrusion

Ottoboni et al., 2018: IJAS

Results & discussion _Experiment 1

***Torque** is a measure of the turning force on an object (screw)*

premix Insect+wheat 25:75	Crude fat %af	Torque value Ncm	Extrudability
Prepupae	3.15	>400	Not extrudable
Prepupae **low oil**	3.89	200-400	Not extrudable
Prepupae **medium oil**	4.63	100-130	OK
Prepupae **high oil**	5.37	50-100	OK
Larvae 	4.62	80-120	Best value

BEST MIXTURE
Larvae + wheat 25:75 NO OIL

Ottoboni et al., 2018: IJAS

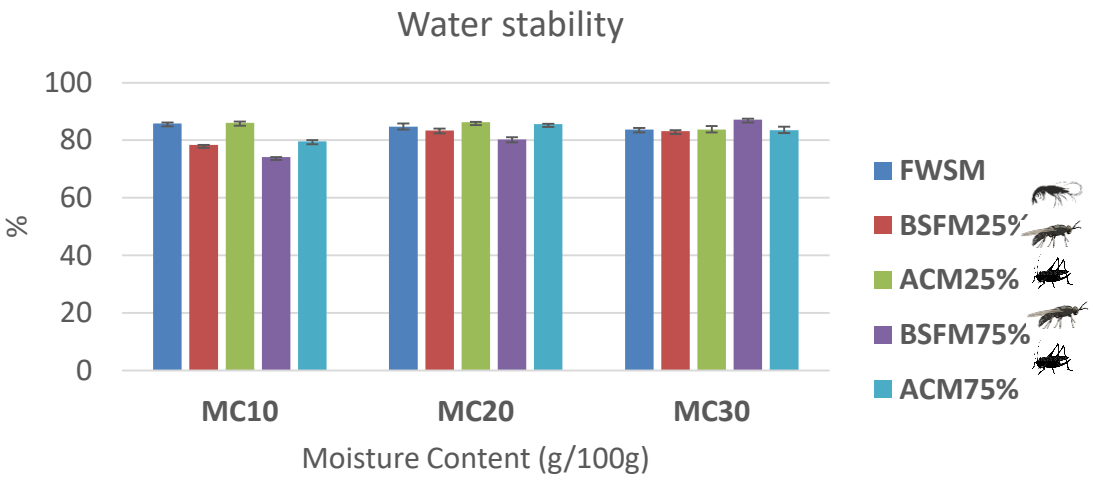
Technological quality: effect of Insect life stage and extrusion

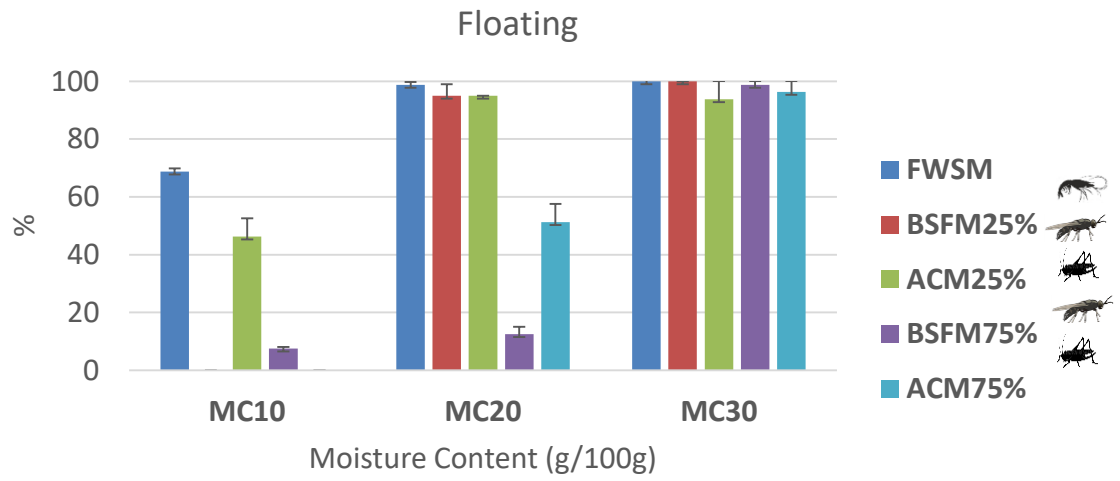
- LARVAE better than pre-pupae (NO OIL needed)
- **Fat** content in the mixture is a **key variable**
- Extrusion
  - do **not affect CP digestibility**
  - **increasing OM digestibility**
- **Results obtained on simple blends!**

Ingredient	Control	Fish meal substituted formulations					
		BSFM25	BSFM50	BSFM75	ACM25	ACM50	ACM75
Sunflower cake	19.0	18.5	18.1	17.6	19.2	19.4	19.6
Maize germ	19.0	18.5	18.1	17.6	19.2	19.4	19.6
Wheat pollard	28.5	27.8	27.1	26.5	28.8	29.1	29.4
FWSM	28.5	20.9	13.6	6.6	21.6	14.5	7.3
BSFM	–	9.5	18.4	27.1	–	–	–
ACM	–	–	–	–	6.3	12.5	19.1
Cassava flour	5.0	4.9	4.8	4.6	5	5.1	5.2
Proximate							
Protein	26.6	26.2	25.7	25.3	26.9	27.1	27.4
Fat	11.4	12.7	14	15.2	11.6	11.7	11.9
Fibre	13.7	13.9	14.1	14.5	14.1	14.4	14.8
Ash	9.5	8.7	8	7.3	8.5	7.5	6.5
Carbohydrate	38.8	38.5	38.2	37.7	38.9	39.3	39.4

[1] FWSM = fresh water shrimp meal; BSFM = black soldier fly meal; ACM = adult cricket meal; BSFM25 = BSFM substitutes 25% of the protein supplied by FWSM in control; BSFM50 = BSFM substitutes 50% of the protein supplied by FWSM in control; BSFM75 = BSFM substitutes 75% of the protein supplied by FWSM in control; ACM25 = ACM substitutes 25% of the protein supplied by FWSM in control; ACM50 = ACM substitutes 50% of the protein supplied by FWSM in control; ACM75 = ACM substitutes 75% of the protein supplied by FWSM in control.

Irungu et al., 2018





Feed technological quality was **maintained** for all insect meal tested and for all the inclusion levels

Expansion ratio, surface area and volume of pellets were **not influenced** by insect type and level of substitution

Floating compromised by moisture content in the extruder

Irungu et al., 2018

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Summary:Technological quality

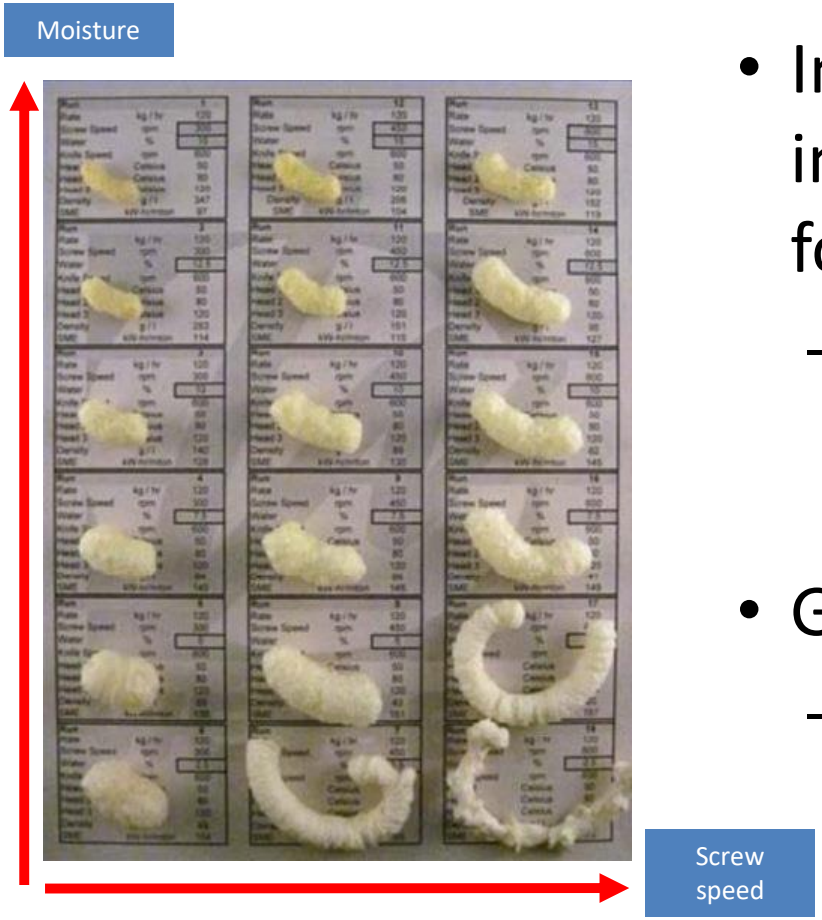

Figure courtesy of Dr. Colovic & Wagner Co.

- Insect material an be included in high amount in feed formulas
  - Inclusion up to 25-30% has not detrimental effect on aquafeed technological quality
- Good results with Extrusion
  - Moisture and probably fat content of the blends needs to be adjusted prior to extrusion

Outline

- Legal status

- Efficency/Quality

- **Safety**
  - Hazards associate with substrate

- Challenges and future prospective

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Risk profile of insects used as food and feed

Microbiological hazards

- Bacteria
- Viruses
- Parasites
- **Fungi -> mycotoxins**
- Prions

SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 5 October 2015

PUBLISHED: 8 October 2015

doi:10.2903/j.efsa.2015.4257

Risk profile related to production and consumption of insects as food and feed

EFSA Scientific Committee

«…hazards associated with other types of **substrate**, such as **kitchen waste**.»

EFSA Scientific Committee. (2015). Risk profile related to production and consumption of insects as food and feed. *EFSA Journal*, *13*(10).

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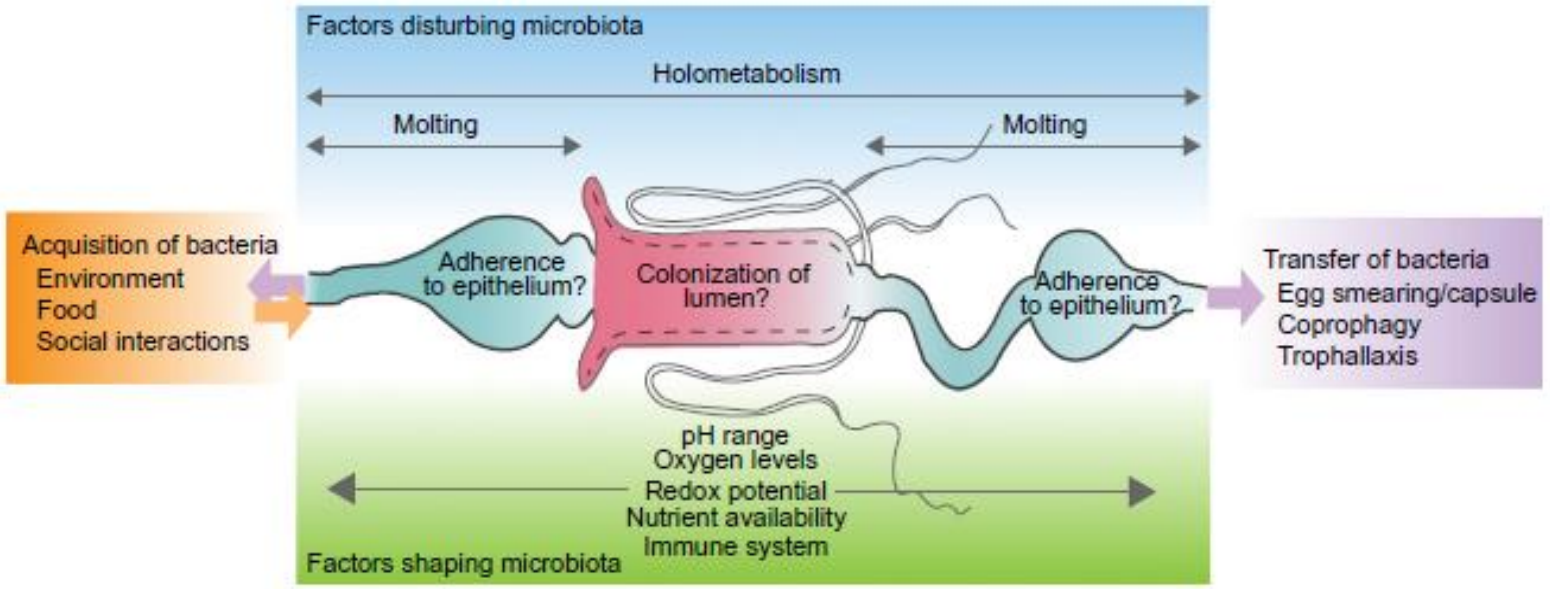
Insect GUT

- Factors afecting gut insect microbiota and mycobiota

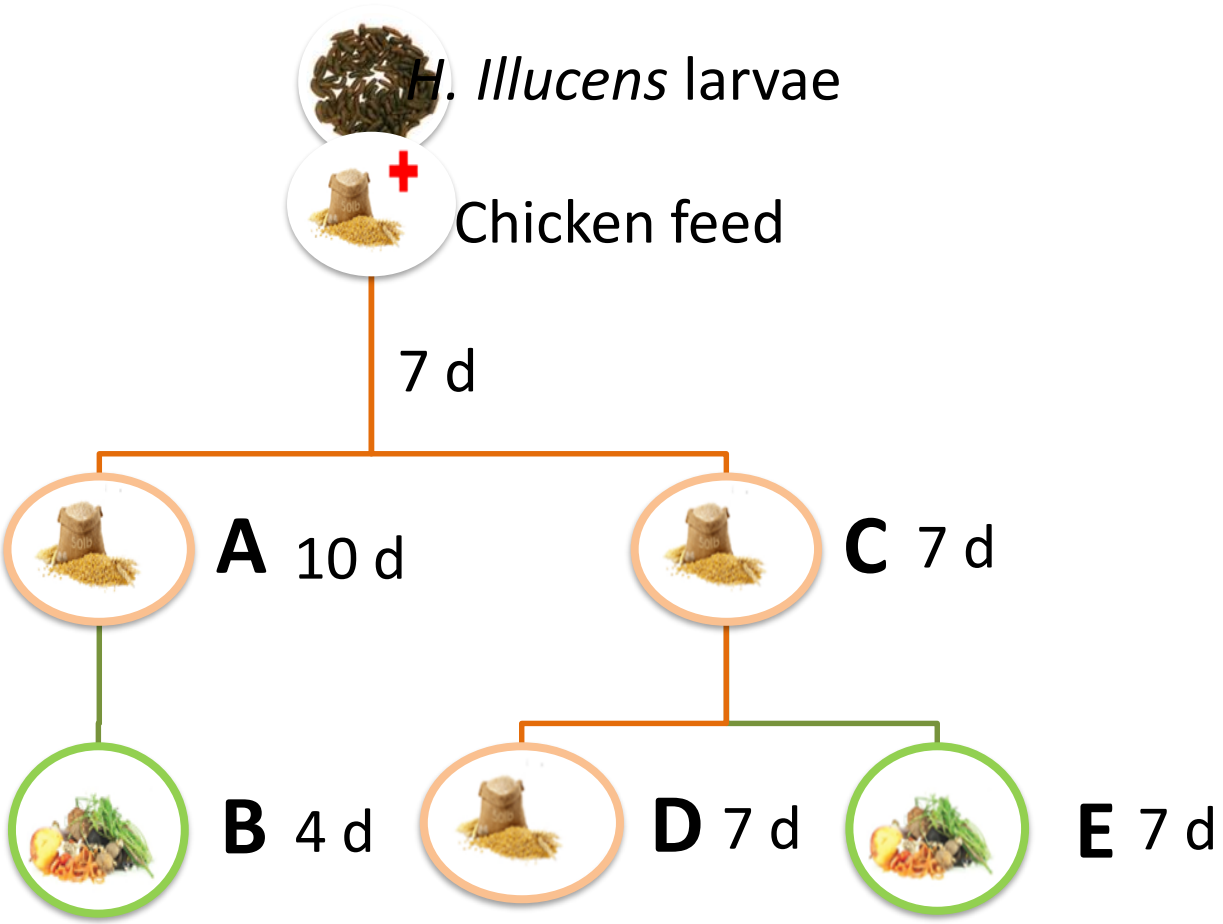


In insects with distinct larval, pupal, and adult stages, there is a radical remodeling of the gut at metamorphosis…

Engel & Moran, 2013

Aim: Evaluate the impact of the substrate on the intestinal fungal community in *H. Illucens*

Experimental design



Isolation of yeasts and moulds from the intestinal content of larvae

Typing of isolates by ITS-RFLP

Inhibition assays to test the **killer phenotype** of isolated yeast strains

Analysis of fungal community by **Next Generation Sequencing** 454

Varotto Boccazzi et al, 2017

Results

Molecular characterisation

Pichia yeast were present in insect exposed to vegetable waste

Mould isolates were associated with the species

Geotrichum candidum:

Group of larvae	Species	ITS RFLP profile
A Chicken feed 17gg	*Trichosporon jirovecii*	1
	Rhodotorula mucilaginosa	2
	Trichosporon asahii	3
B Chicken feed and vegetable waste 17gg+4gg	*Pichia fermentans*	4
	Saccharomyces servazzii	5
	Saccharomyces spencerorum	6
	Pichia kluyveri	7
	Trichosporon asahii	3
	Pichia kudriavzevii	8
C Chicken feed 14gg	*Candida tropicalis*	9
	Meyerozyma guilliermondii	10
	Geotrichum candidum	11
	Trichosporon asahii	3
D Chicken feed 21gg	*Trichosporon asahii*	3
	Meyerozyma guilliermondii	10
	Geotrichum candidum	11
E Chicken feed and vegetable waste 14gg+7gg	*Pichia kluyveri*	7
	Meyerozyma guilliermondii	10
	Pichia fermentans	4
	Saccharomyces servazzii	5

-No mycotoxin producer

-No foodborne disease has been linked to the consumption of products containing *G. candidum* (Pottier et al., 2008).

Varotto Boccazzi et al, 2017

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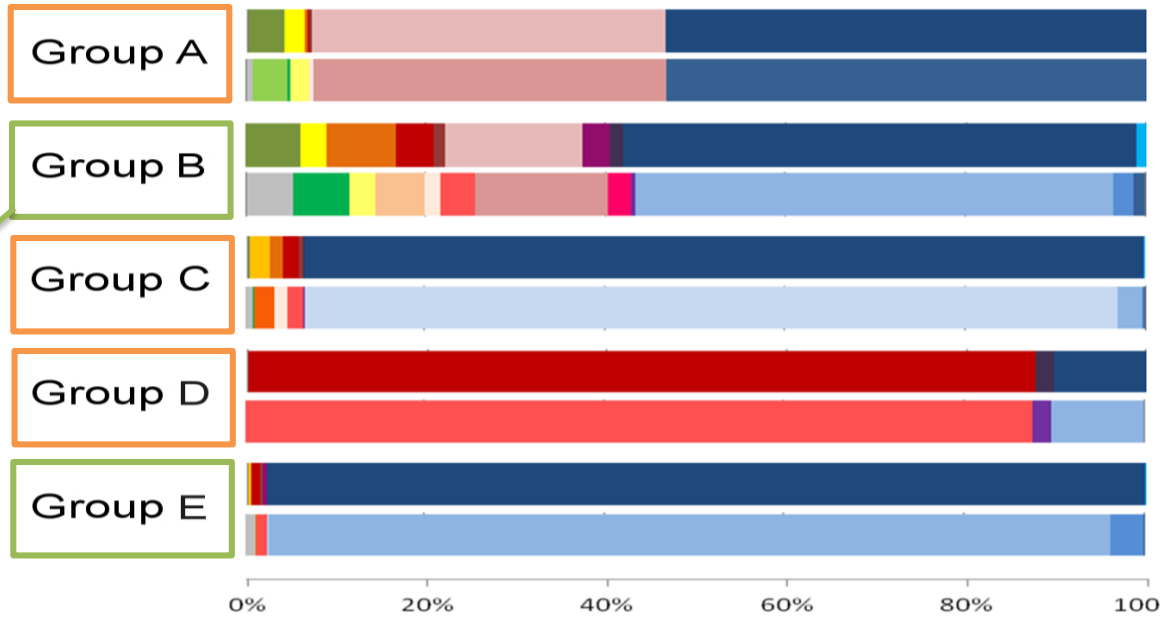
Results

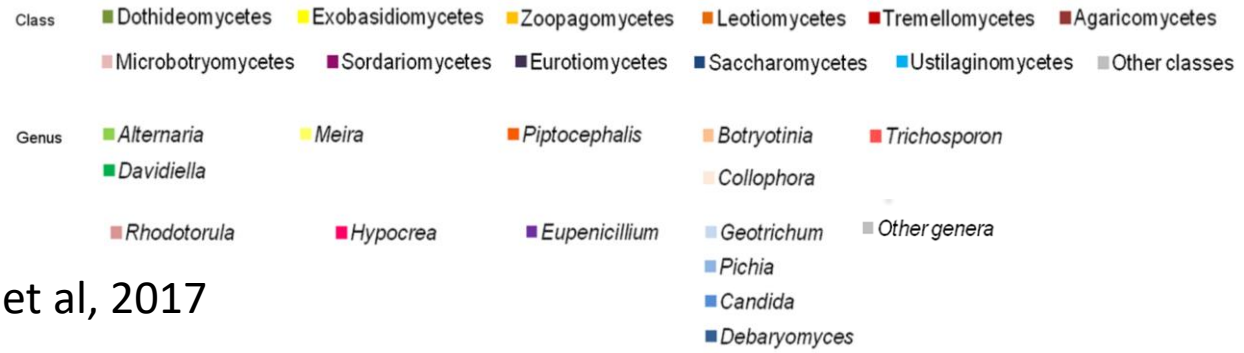
Next Generation Sequencing

(fungal ribosomal ITS region)

Taxonomic composition of intestinal mycobiota of HI larvae

Chicken feed (17d) + Vegetable waste (4d): **The greatest fungal diversity**



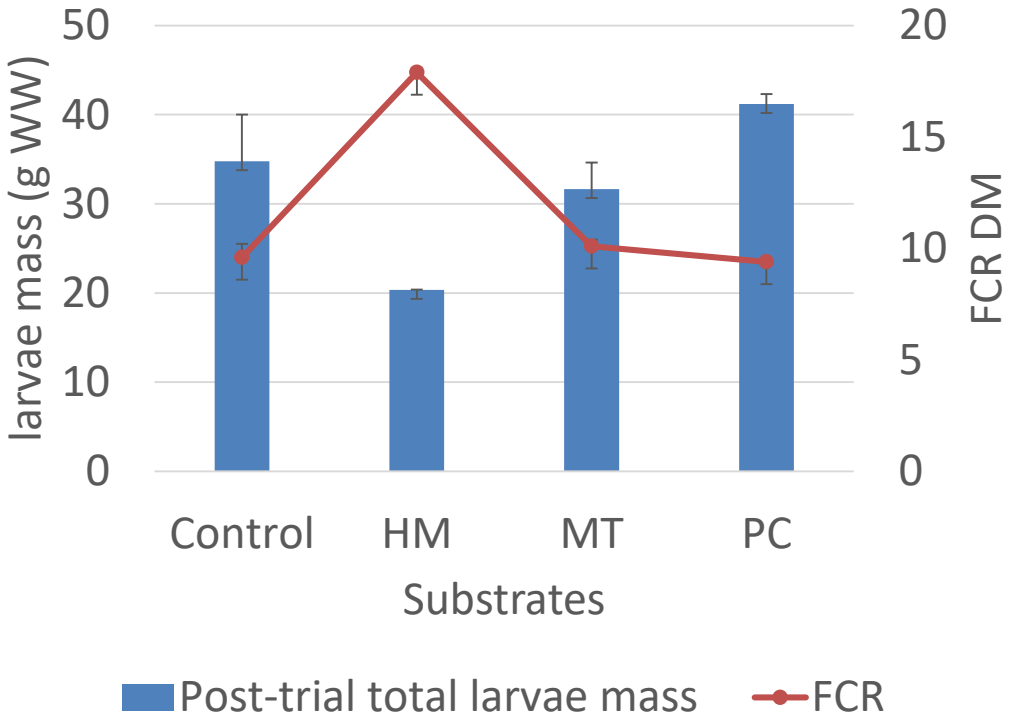


Varotto Boccazzi et al, 2017

Impact of substrate contamination with mycotoxins, heavy metals and pesticides on the growth performance of BSF larvae

Purschke et al., (2017). *Food Add Cont: Part A*, *34*(8), 1410-1420.

- Heavy metals reduce larvae mass
- Mycotoxins and pesticides does not affect larvae growth



Control and contaminated substrates,
containing defined amounts of :

- heavy metals (HM)
- mycotoxins (MT)
- pesticides (PC)

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Rearing larvae on contaminated substrates

Purschke et al., (2017).

Mycotoxins and pesticides have neither been accumulated in the larval tissue

Significant bioaccumulation of Cd and Pb was observed in the larvae.

Bio-accumulation Factors:
Cadmium: >9
Lead: > 2

	Heavy metal (HM) – contaminated substrates	
	Initial substrate (mg kg–1)	**Residual substrate (mg kg–1)**
Chrome	15.2	19.9 ± 3.0
Nickel	15.2	19.7 ± 3.0
Arsenic	3.0	3.8 ± 0.6
Cadmium	1.5	1.8 ± 0.3
Mercury	0.2	0.3 ± 0.08
Lead	15.2	19.8 ± 3.0

	Control (mg kg–1)	**HM (mg kg–1)**
Chrome	0.064 ± 0.01	3.4 ± 0.5
Nickel	0.048 ± 0.007	4.2 ± 0.6
Arsenic	< LOQ of 0.024	2.8 ± 0.4
Cadmium	**0.048 ± 0.007**	**13.7 ± 2.1**
Mercury	< LOQ of 0.012	0.1 ± 0.03
Lead	**0.032 ± 0.005**	**35.6 ± 5.3**

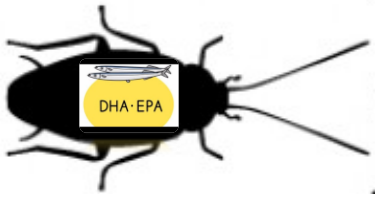
Summary: Safety

- Insects for feed are processed with their GIT content, which can harbour different species of transmissible microorganisms.
  - Insect mycobiota and microbiota can be enriched/modulated during farming and processing.
- Chemical hazards, like pesticides, fluorine, heavy metals, and dioxins, merit specific evaluation.
  - **Bioaccumulation** risks

Outline

- Legal status
- Efficency/Quality
- Safety
- Challenges and future prospective

Opportunity….



- Theuse of appropriate and tailored substrates could lead to the production of a premium feed specialty, providing new opportunities for raw materials and diet formulations.
  - E.g. The case of BSF on fish offal
- This implies that a standardization of the rearing protocols is needed
- Setting type of substrate /Time (e.g. Growth vs finishing phase)
- Limits; ABP regulation

Fatty acids (%)	Ingredients	
	Normal black soldier fly prepupae	Enriched black soldier fly prepupae
12:0	23.6	37.1
14:0	5.1	6.3
16:0	19.8	17.3
16:1n7	6.3	7.6
18:0	6.5	2.0
18:1n9	22.7	18.8
18:2n6	6.8	5.9
18:3n3	0.0	0.5
18:4n3	0.0	0.5
20:5n3	0.1	3.5
22:5n3	0	0.35
22:6n3	0	1.7

[1] All values are reported as means of duplicate analyses

Sealey et al., 2011

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General conclusions (1/2)

- Insects
  - can be used as PAP or animal fats
  - Can upgrade waste biomasses/streams to valuable feed ingredients
  - are able to process efficiently substrate high in moisture and fibre.
  - have not detrimental effect on feed technological quality
  - Safety evaluation cannot be considered as complete

General conclusions (2/2)

- Source of variability
  - Insect species
  - Substrate
  - Exposure time
  - Harvesting growing phase
  - Types of development metamorphosis

…To be defined/adressed

- Balance diet is needed ??(chicken feed results)
  - Requirements??
  - Feeding phases (growing, finishing….)
  - Feed speciality production
- FCR not defined (from 1.5 to 16!!)
- Micro-livestock features (environment, density,..)

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Thanks for the your attention

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