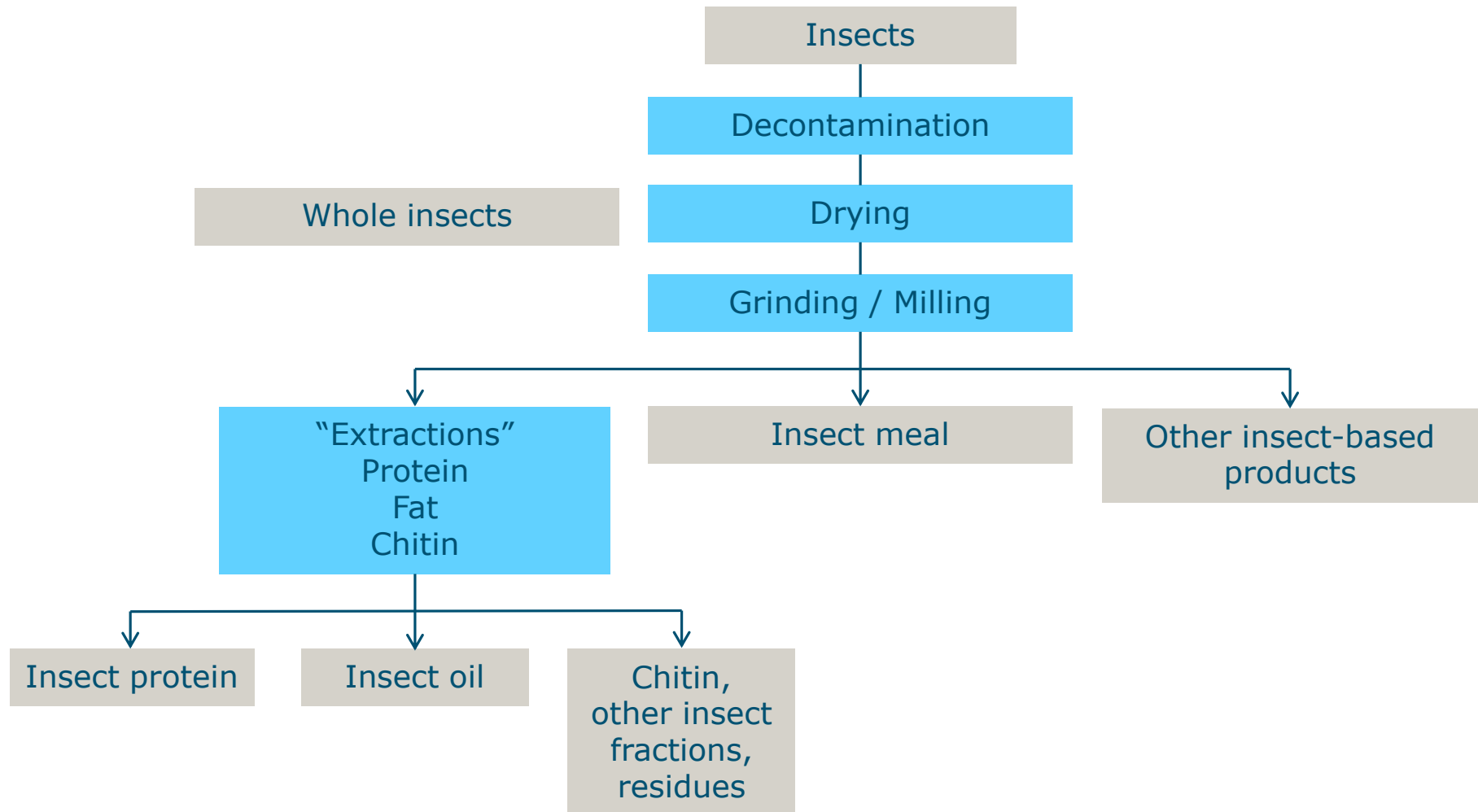


# Mealworm biorefinery and processing for food products

Marieke E. Bruins, Arnoud Togtema

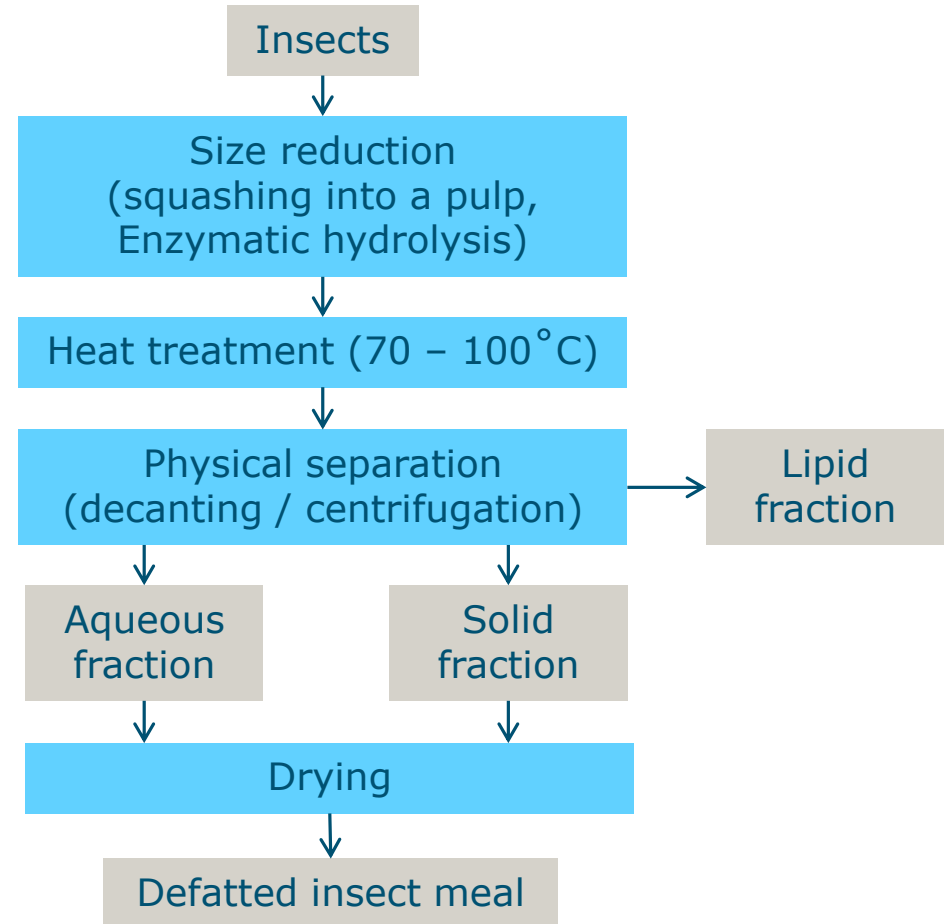


# Elaborate insect processing



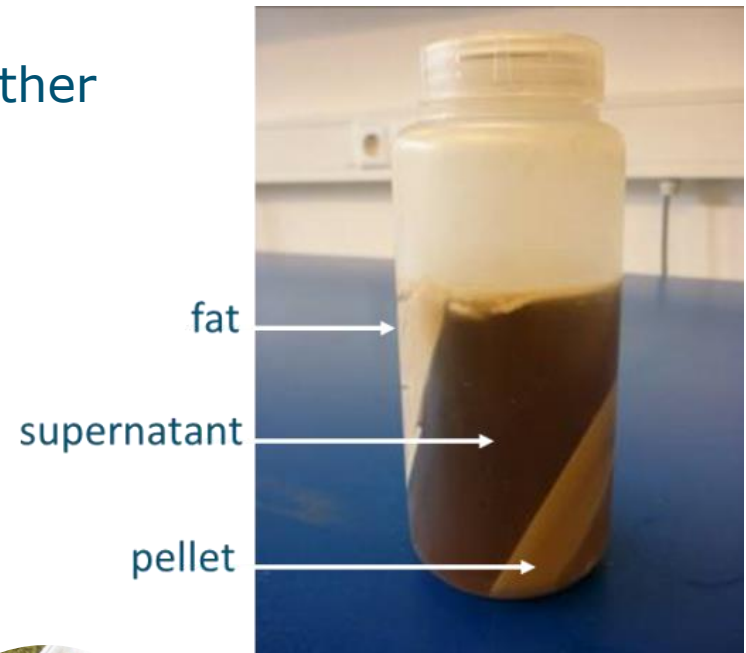
# Simple separation

- Lipid and meal as products
- Protein quality?
- Lipid removal might be complicated by emulsifying agents present in the insects
- Patented method (Arsiwalla & Aarts 2015)



# Straw and seed meal valorisation by insects

- Insect refinery to obtain oils, proteins & other valuable biomolecules
- Shredding & centrifugation
  - With added water
  - No enzymes



# H2020 EU-COSMOS: Camelina and crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals

**Coordinator:**

**Wageningen Research (WFBR)**

**18 partners in 9 countries**

**Budget: € 10.8 million**

**Duration: 4.5 years (2015–2019)**



**Reduce** Europe's dependence on **imported tropical oils** (palm kernel, coconut, castor) as sources for medium-chain-length oleochemical surfactants, lubricants, polymers and other high-value products, by:

- turning **camelina & crambe** into profitable oilseed crops
- creating and optimizing sustainable value chains



**WAGENINGEN**  
UNIVERSITY & RESEARCH



# COSMOS: the Crops



*Crambe abyssinica*



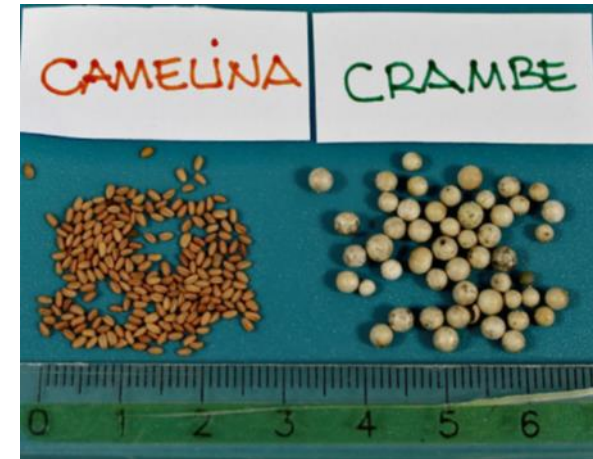
*Camelina sativa*



DOI: 10.1051/ocl/2016021



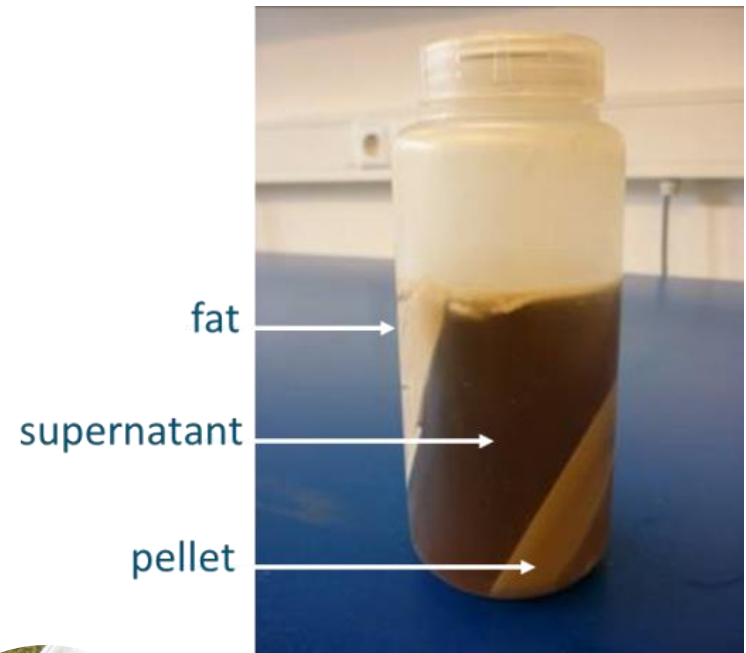
**Crambe meal (top) &  
Camelina meal (bottom)**



DOI: 10.1051/ocl/2016021

# Straw and seed meal valorisation by insects

- Insect refinery to obtain oils, proteins & other valuable biomolecules
- Shredding & centrifugation (with added water)
- Does the special oil composition of the corps translate to the insects?



# Biorefinery of Black Soldier Fly Larvae & Buffalo: no added water



Overview part extraction process:



Blanched BSF



Angel Juicer

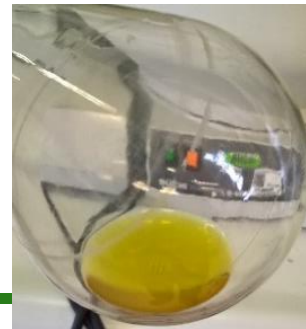


Juice



Fibre

Extraction / Purification protocols available



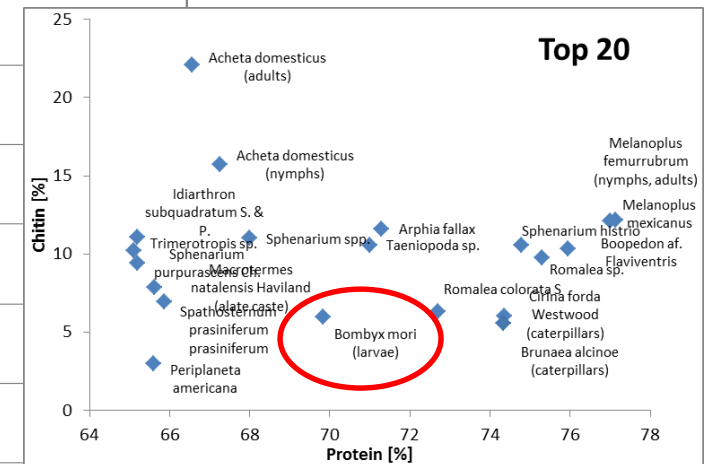
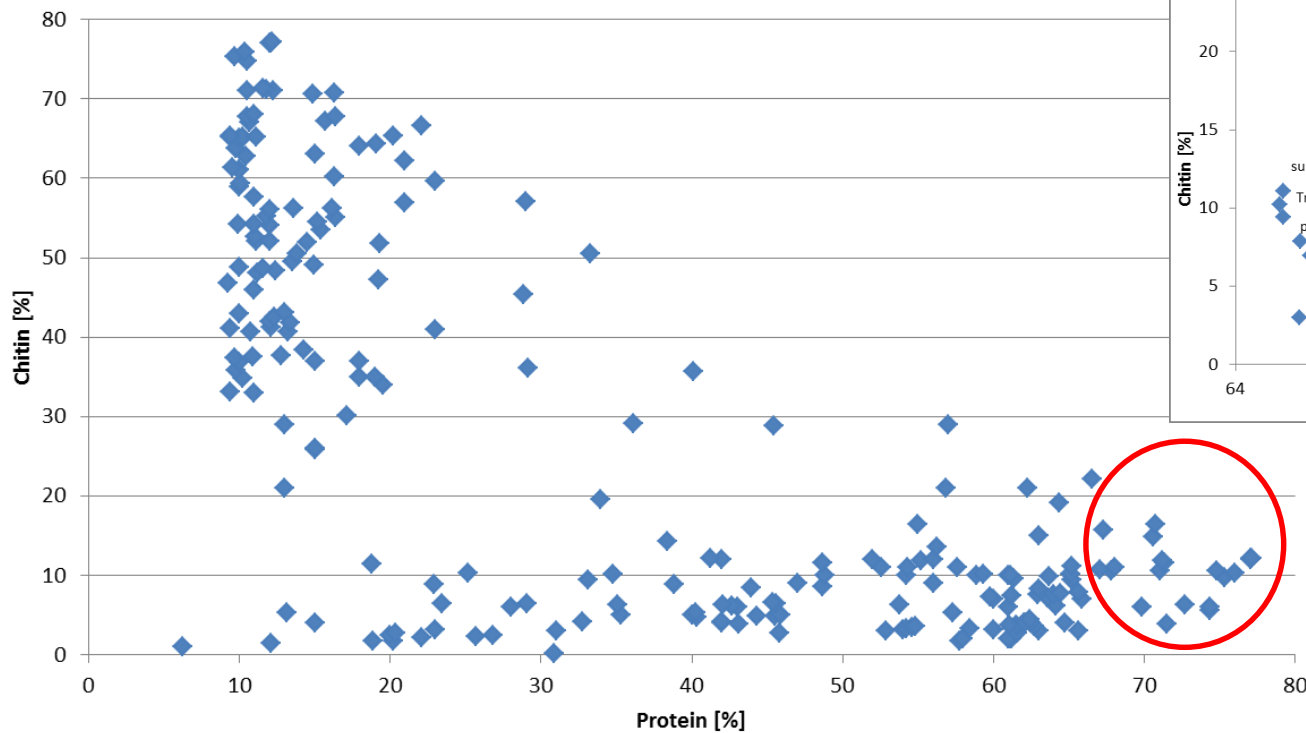
# Can it be even more simple?

- Direct use in food

# Insects in food



Edible insects (based on dry matter)



→ silkworm (*Bombyx mori*) is one of the best choices (very low chitin, high protein)

# Choice of insects

- Mostly studied: mealworm (*Tenebrio molitor*)
  - Adult: Protein: 10-16 %, fat: 38-50%, chitin: 16-68 %
  - Larvae: Protein: 11-18 %, fat: 35-43 %, chitin: 5-63 %
- More logical insect choice:
  - high protein %, low fat %, low chitin %
  - high protein %, high fat %, low chitin %  
(excess of chitin from crab waste)
- Prerequisites for industrial scale insect:
  - suitable for breeding
  - Available whole year in large quantities



**Damhert**  
NUTRITION

# Insecta

◀ GO GREEN - HIGH PROTEIN ▶

Groenteburger  
Burger aux légumes

met buffalowormen  
avec des vers de buffalo



Water, ground buffalo worms (14%), vegetable oil (sunflower oil) (14%), wheat gluten (13%), wheat flour (13%), salt, white pepper, chicken egg protein in powder, inulin, wheat starch, potato fibers, starch (corn, wheat), emulsifier (guar gum), yeast, paprika powder, turmeric.

Blanched & Freeze-dried

Nice colour

Texture from egg protein and wheat gluten

# New products with (meal)worms

Product Brand	Product description	Category	Sub-category	Unit	Price/kg	Cal. 10%	Cal. 20%	Cal. 30%	Cal. 40%
Green BUGS	A 140g of sensory spread made from carrots and mealworms, in a glass jar. Preparation for toast, sandwiches and cold dishes.	Snacks	Spread	kg	20.62	8.2	1.1	4.2	
Green BUGS	Tomato spread with mealworms preparation for toast, sandwiches or cold dishes, in a glass jar.	Snacks	Spread	kg	23.79	13.7	1.8	2.7	
Green BUGS	Mealworms food for rodents, in a plastic bottle.	Pet Food	Food	kg	95.5	31	54		
Green BUGS	Natural snack with mealworms as a natural source of animal protein. Complementary feed for hamsters, dwarf hamsters, rats, mice and gerbils. Comes in a 140g plastic jarred food in a plastic box.	Pet Food	Food	kg	65.5	-	-	-	
Green BUGS	Big flavoured worm chips	Pet Food	Snacks	kg	33.03	-	-	-	
Green BUGS	Mealworms for wild bird food in plastic pouch.	Pet Food	Snacks	kg	7.06	14.1	Min 20%	Min 40%	Max 6%
Green BUGS	Mealworms To Go All Natural Chicken Treats	Pet Food	Snacks	kg	8.23	82.3	Min 20%	Min 50%	Min 6%
Green BUGS	Aquatic turtle food made with dried shrimps, mealworms, and whole crickets. Comes in plastic container.	Pet Food	Snacks	kg	0	0			
Green BUGS	A 180g breaded chicken based buffalo worms. Comes in a plastic bag, held in a cardboard sleeve.	Meat Substitutes	Snacks	kg	16.5	23.06	18.1	23.5	18.6
Green BUGS	A 130g of vegetable burger with buffalo worms, in a plastic tray held in a cardboard sleeve. Insects is a range of ready-to-eat meat substitutes with buffalo worms.	Meat Substitutes	Snacks	kg	3	20	16.4	23.4	10.7
Green BUGS	A 130g of buffalo worms nuggets with salt and white pepper. Comes in a plastic tray, held in a cardboard sleeve. Insects is a range of ready-to-eat meat substitutes with buffalo worms.	Meat Substitutes	Snacks	kg	3	18.75	18.1	22	18.6
Green BUGS	Dried worms flavoured with imperial mix, in an 18g plastic bag held in a cardboard box.	Savory/Salty Snacks	Snacks	kg	383.33	17.8	23.6	18.2	
Green BUGS	Dried worms flavoured with sesame and coriander, in an 18g plastic bag held in a cardboard box.	Savory/Salty Snacks	Snacks	kg	383.33	27.8	32	34.7	
Green BUGS	Dried worms flavoured with garlic and herbs, in an 18g plastic bag held in a cardboard box.	Savory/Salty Snacks	Snacks	kg	383.33	28.7	33.3	34.5	
Green BUGS	Worm's salt from 100% Chiquito worm, in a plastic sachet. Mix with salt and chilis.	Seasonings - Salts	Snacks	kg	92.8				
Green BUGS	Reggie's worm salt with dried chilis, in a plastic bottle.	Seasonings - Salts	Snacks	kg	21.9				



- Innova database (2010-2015)
- Savoury spread (4%)
- Pet food (100%)
- Worm snacks (99%)
- Burger (14%)
- 20 euro/kg, higher for snacks due to small package size

# Impact of processing on enzymatic browning and texturization of yellow mealworms

Mealworm products with tailor made texture



# Context and Aim

- Insects are processed for microbial food-safety & against chemical degradation
  - Freeze drying & blanching
  - Prevention of browning during processing with high pressure (HP) as an alternative
  - Influence on texture
- 
- Material: Yellow mealworm
  - Methods: HP, T, freeze drying (blanc)

# Starting materials and experimental set-up

Treatment	Sample code	Starting material
None (fresh)	F1 (3 days after delivery) F2 (10 days after delivery)	
Freeze drying	FFD	F1
Blanching	B	F1
Blanching followed by freeze drying	BFD	F1
High pressure	HP + pressure applied	F2

Treatment

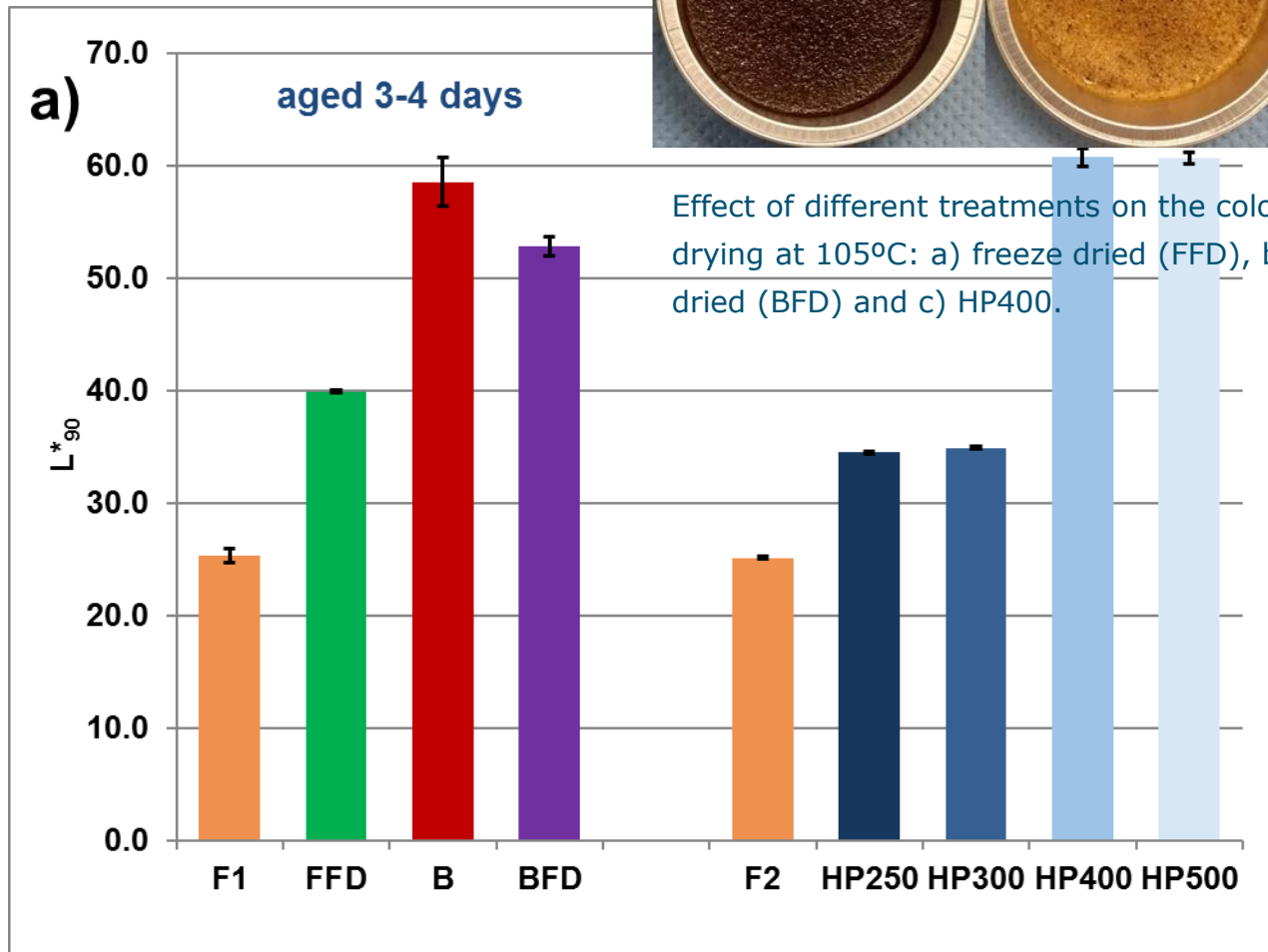
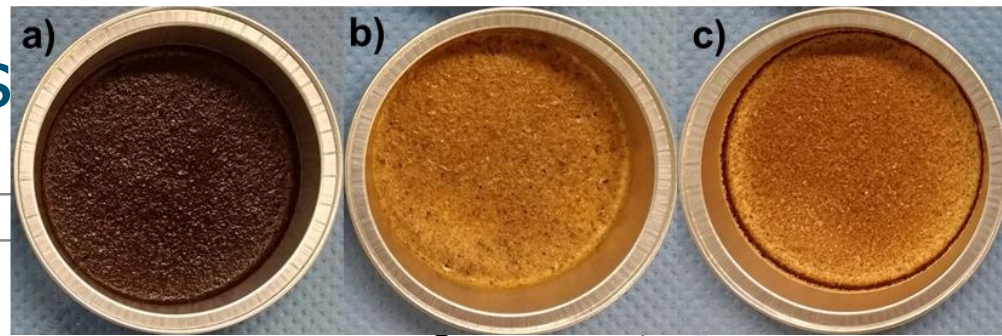
Make a paste

Measure

- Colour
- Texture
- Water holding capacity
- pH

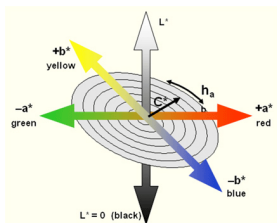


# Browning: Blacknes



Darkness  $L^*_{90}$  of  $\pm 10\%$  mealworm pastes after 90 minutes at RT

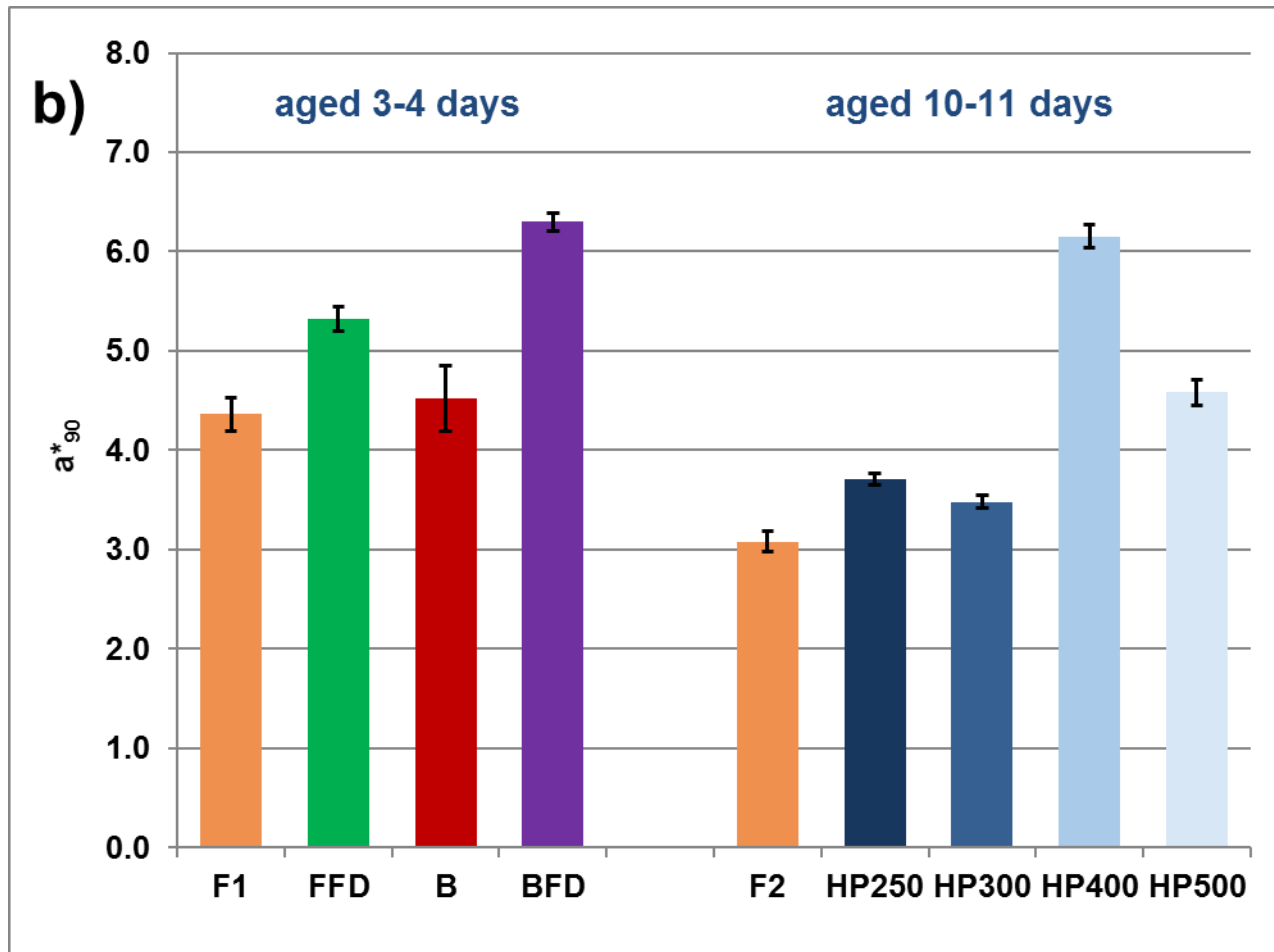
F1, F2 – fresh with different aging, FFD – fresh freeze dried, B – blanched, BFD – blanched freeze dried, HP250 to HP500 – HP treated with pressures from 250 to 500MPa



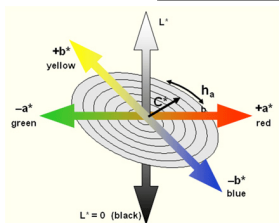
VINGEN  
& RESEARCH



# Browning: Redness



Redness  $a^*_{90}$  of  $\pm 10\%$  mealworm pastes after 90 minutes at RT

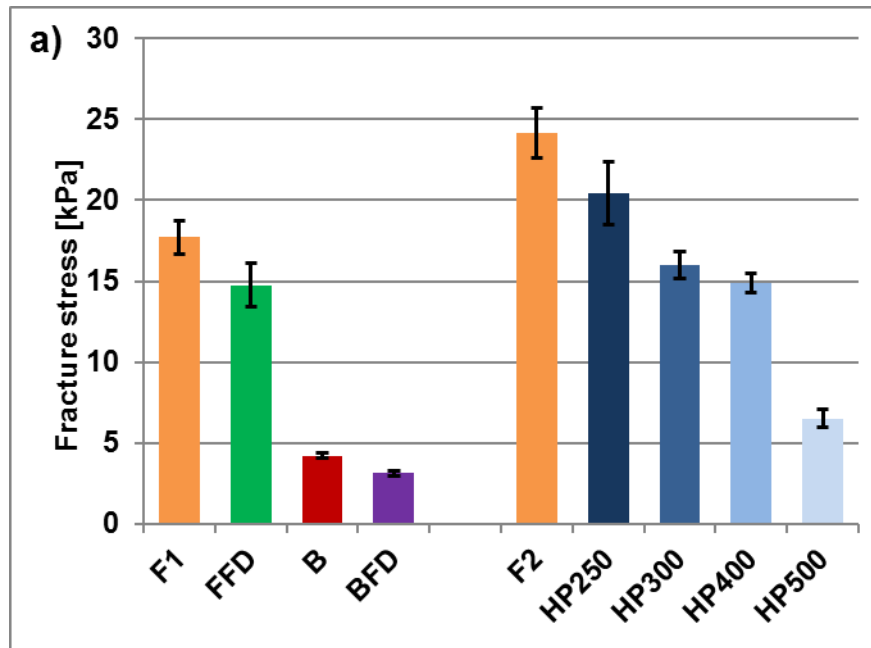


VINGEN  
& RESEARCH



F1, F2 – fresh with different aging (3 versus 10 days), FFD – fresh freeze dried, B – blanched, BFD – blanched freeze dried, HP250 to HP500 – HP<sub>18</sub> treated with pressures from 250 to 500MPa

# Texture of heat set gels from pastes



- Fracture stress and Young's modules similar
  - Gel strength and stiffness was best for fresh, worst for blanched
  - Weak texture for blanched and HP500
  - Coarse texture, chitin?, serum loss
- F1, F2 – fresh with different aging (3 versus 10 days), FFD – fresh freeze dried, B – blanched, BFD – blanched freeze dried, HP250 to HP500 – HP treated with pressures from 250 to 500MPa

# Product Application

- Tailor texture by combining the results of blanching and high pressure treatments allows us to tailor the texture of the mealworm product.
- Spread (light colour & soft texture): blanching
- Burger (brown, crumbly): fresh, freeze dried
- Pâté type of texture: HP400

# How the researchers perceived the paste

- HP treated mealworms showed an appealing orange / light brown colour
- Aroma of (fresh) mealworm paste was savoury, with a mushroom and nut note
- Upon baking, the aroma even intensified.

# Conclusions

- Blanching and freeze drying of insects is current industrial method
- Needed to prevent spoilage
- Blanching decreased browning
- Loss of texturizing properties
- High pressure could be an alternative: better texture, no browning, spoilage?
- Future work
  - Test for microbial activity: now only checked via pH
  - Combine P&T



# Thank you

- Maurice Baumgarten & Elisa Venturini
- The COSMOS project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 635405.
- This insect research on structure and colour was funded by the TTW (STW) Protein Innovation Program together with the Dutch Ministry of Economic Affairs within the project In2Food (12638).

