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Centro per il Miglioramento e la Valorizzazione delle Risorse Biologiche Agroalimentari - BIOGEST-SITEIA

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SCALIBUR
LEADING A REVOLUTION IN BIOWASTE RECYCLING

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The black soldier fly (*Hermetia illucens* L.) strategy within "SCALIBUR – Scalable technologies for bio-urban waste recovery" H2020 project

Giuseppe Montevecchi, Lucian Miron, Alejandro Aragón Gutiérrez, Laura Ioana Macavei, Giacomo Benassi, Elena Zanelli, Luke Mizzi, Sara D'Arco, Pilar Albaladejo Sánchez, Geert Bruggeman, Menno Thomas, Lara Maistrello, Andrea Antonelli - UNIMORE, KOUR ENERGY, ZETADEC, NS, ITENE

This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 817788

The project

SCALBUR

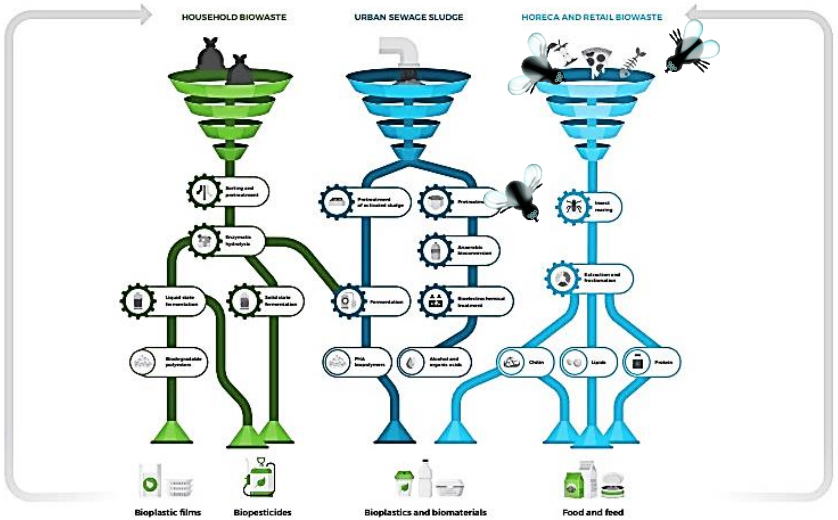
WWW.SCALIBUR.EU

@SCALIBUR_H2020 SCALIBUR project

SCALABLE TECHNOLOGIES FOR BIO-URBAN WASTE RECOVERY

Leading a revolution in biowaste recycling

Grant agreement ID: 817788
Overall budget € 11,728,483,61
EU contribution € 9,999,391,39
Kickoff – Nov 1st, 2018
End – Oct 31st, 2022



Black soldier fly

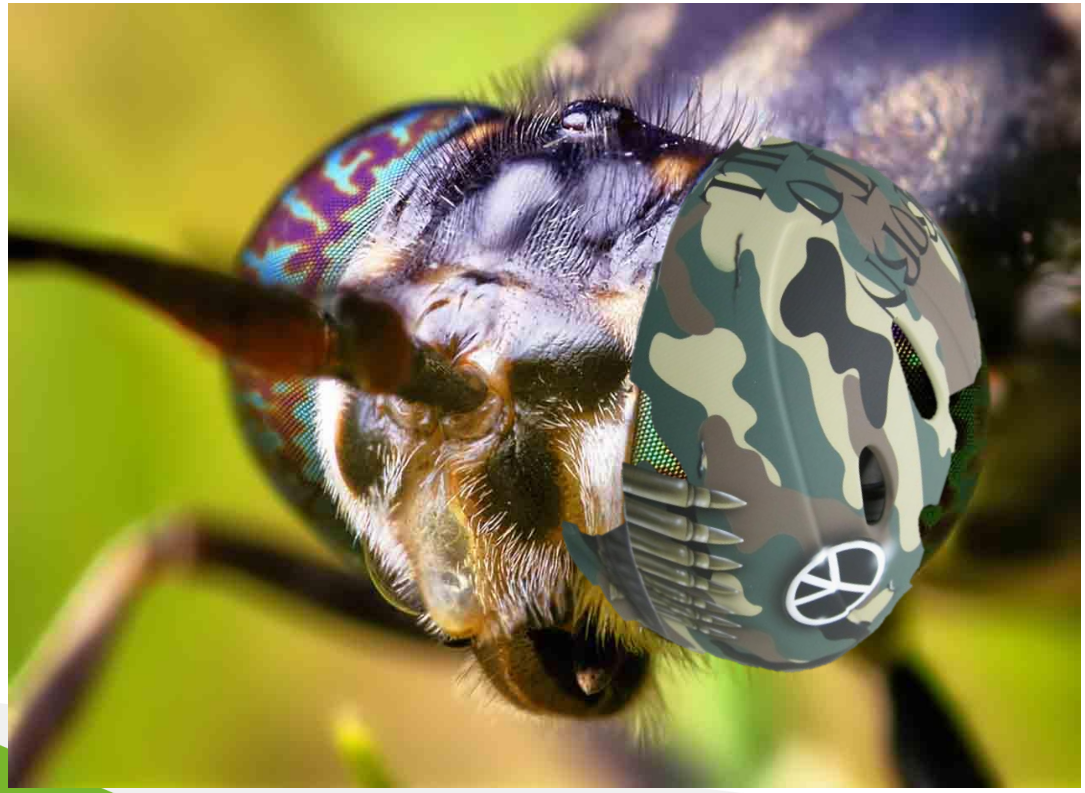
Hermetia illucens

Mosca soldato

Black soldier fly

جندي أسود يطير

Mouche soldat noir



Advantages

Food waste management

Flexible technology

Water removal/mass reduction

Food waste bioconversion

- steady composition of **protein**
- modulable composition of **fat** and **chitin**
- frass accumulation → fertilizer

Hermetia illucens

Black soldier fly

Advantages

Using black soldier fly larvae to bio-convert food waste into high quality feed ingredients can be classified as "**PREVENTION**" therefore, it is preferred to anaerobic digestion (AD) as a method for organic food waste management in the waste hierarchy [1,2]

[1] European Commission. Directive 2008/98/EC of The European Parliament and of The Council of 19 November 2008 on Waste and Repealing Certain Directives; Official Journal of the European Union: Aberdeen, UK, 2008

[2] WRAP. Why Take Action: Legal/Policy Case. Available online: http://www.wrap.org.uk/content/why-take-action-legalpolicy-case

The substrate

CIRFOOD
Feed the future

The pilot plant

The pilot plant

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Seasonal variability of the HO.RE.CA. food leftovers employed as a feeding substrate for black soldier fly (*Hermetia illucens* L.) larvae and effects on the rearing performance

Giuseppe Montevecchi [a, b, *], Laura Ioana Macavei [a, 1], Elena Zanelli [a], Giacomo Benassi [c], Giulia Pinotti [a], Sara D'Arco [a], Silvia Buffagni [a], Francesca Masino [a, b], Lara Maistrello [a, b], Andrea Antonelli [a, b]

Fractionation concept

PRODUCTS FROM INSECT FRACTIONATION

Hermetia illucens

Black soldier fly

Fractionation set-up

PRODUCTS FROM INSECT FRACTIONATION

KU LEUVEN

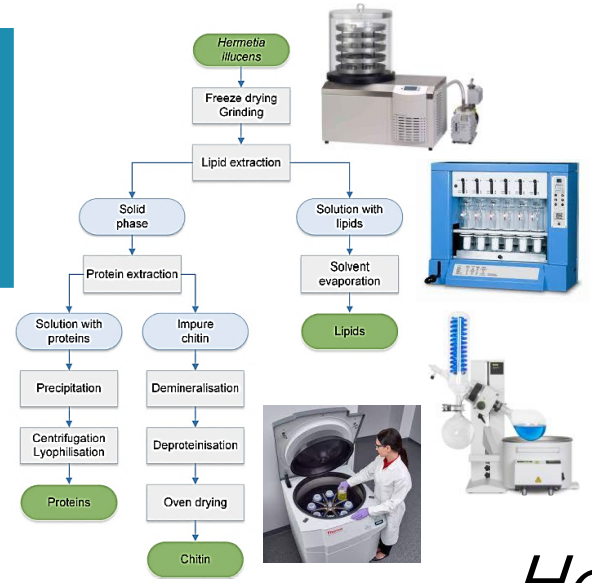
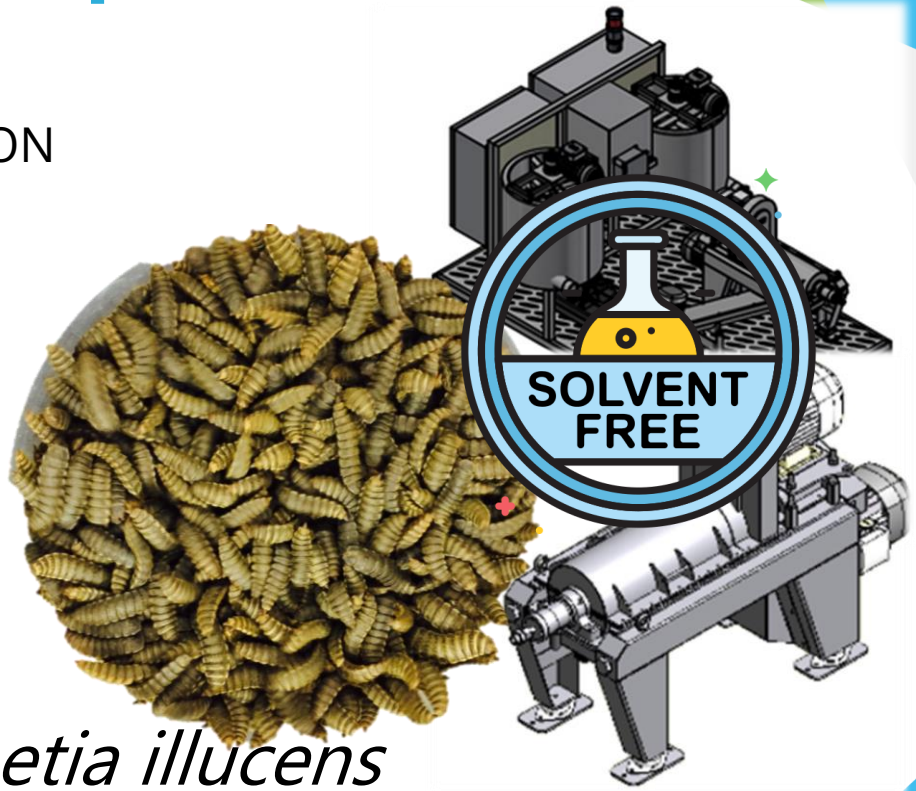


Fig. 1 Overview of the sequential extraction of lipids, proteins, and chitin from larvae, prepupae, and pupae of *Hermetia illucens*



Hermetia illucens

Black soldier fly

SCALIBUR

The optimization of the fractionation pilot plant

- Flow rate of the progressing screw pump - 10 L/h
- Drum speed - 8500 rpm (max)

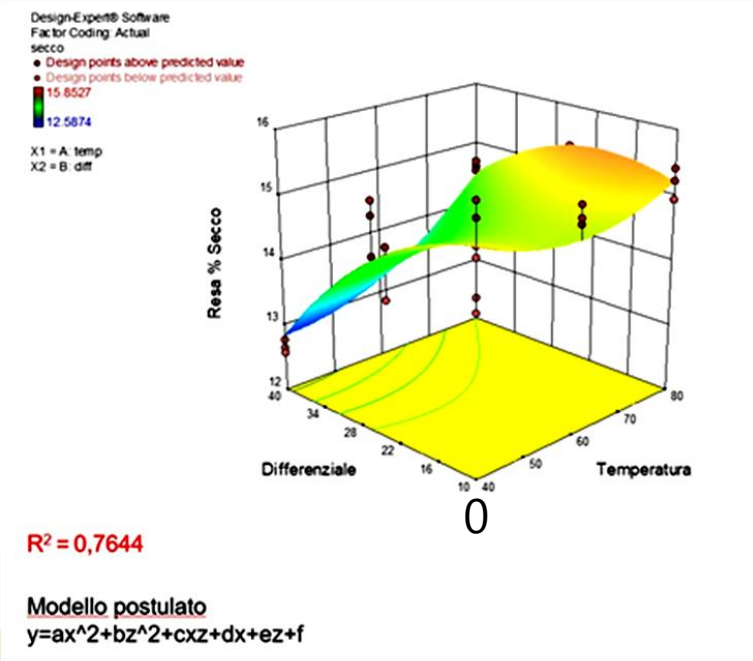
- The critical parameters selected and evaluated were:
  - 1) **temperature** of the aqueous suspension of ground larvae
  - 2) **differential speed**, i.e. the difference in rotation speed between the drum and the cochlea (Archimedes screw)

- FDOE 3^n (n = 2) + 1 replication using average conditions

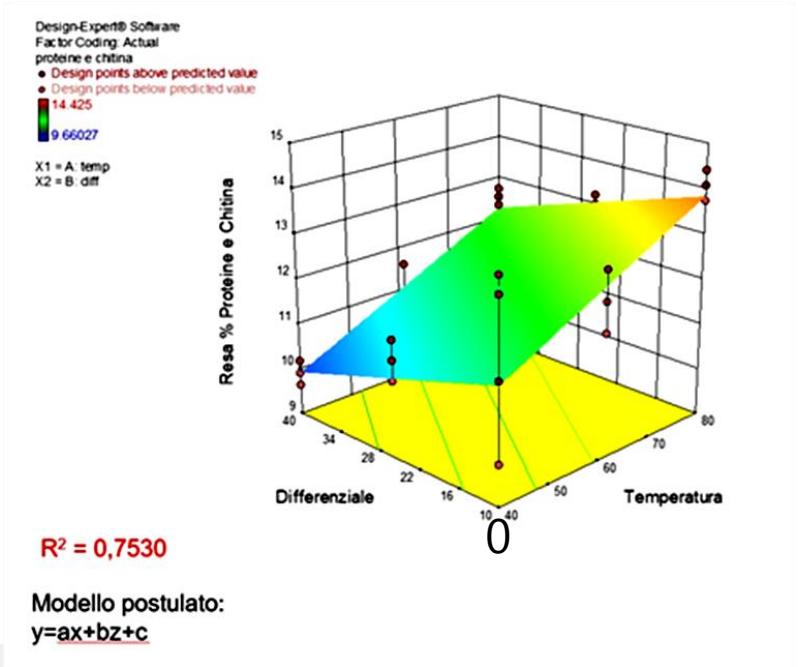
Sample	T (°C)	Δn
1	40	10
2	60	10
3	80	10
4	40	25
5	60	25
6	80	25
7	40	40
8	60	40
9	80	40
10	60	25

The optimization of the fractionation pilot plant

Solid raw material



Protein + chitin



Response surface methodology

LCA – Input and Output

HO.RE.CA. substrate - 121.2 kg

5-days old BSF larvae - 55 g

Mature BSF larvae - 20 kg

Substrate/larval biomass conversion factor - 10:1.65

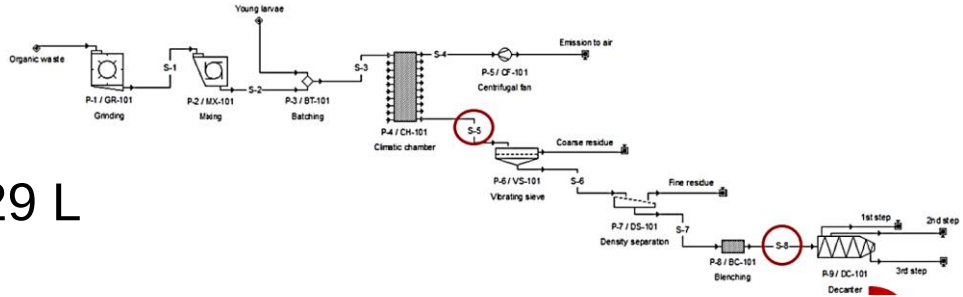
Solid residue - 1/3 Moisture - 2/3

Hot tap water (boiler) - 22.55 L

Tap water at room temperature - 22.29 L

NaOH pellet - 178.32 g

Hydrochloric acid (30-33%) - 2.23 kg



LCA - Power

using 0.25 €/kWh

Process	Equipment	Time (min)	Power (kWh)	kWh cost (€)
Larval killing and blanching	Larval blanching system	35	1.149	0.29
Larval mincing	Mincer	10	0.073	0.02
Homogenization and fat melting	D - Stirring system + heating	30	1.888	0.47
1st decanter separation	D - Decanter + stirring system + heating	15	1.018	0.25
pH change (12.5) and protein solubilization	D - Decanter + stirring system + heating	120	7.550	1.89
2nd decanter separation	D - Decanter + stirring system + heating	15	1.018	0.25
Protein precipitation	Fridge +4 °C	720	3.000	0.75
3rd decanter separation	D - Decanter + stirring system	15	0.341	0.09
Entire process		960 (16 h)	16.036	4.01

Larval main components

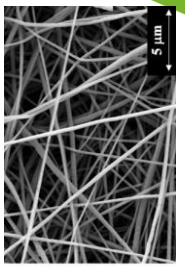
PRODUCTS FROM INSECT FRACTIONATION

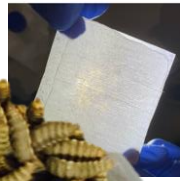
Hermetia illucens

Black soldier fly

Possible applications

PRODUCTS FROM INSECT FRACTIONATION





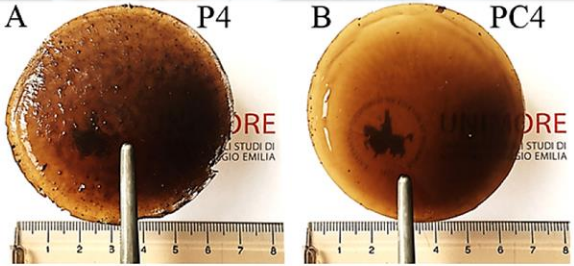


Fig. 1. Images of protein film obtained from film casting of protein solutions: film with whole proteins, P4 (A); film with soluble proteins, PC4 (B). Soluble protein films appear as more transparent and homogeneous with respect to whole protein films.

Hermetia illucens

Black soldier fly

The applications of isolated proteins for the preparation of food and feed

All **essential amino acids** were present in high enough quantities for human requirements (EAAI = 1.94).

Other proteins:

- *Tenebrio molitor*, EAAI = 1.60
- *Zophobas morio*, EAAI = 1.66
- Pea, EAAI = 1.37
- Bean, EAAI = 1.34
- Soybean, EAAI = 1.56-1.85
- Casein, EAAI =1.93

Dog food kibbles

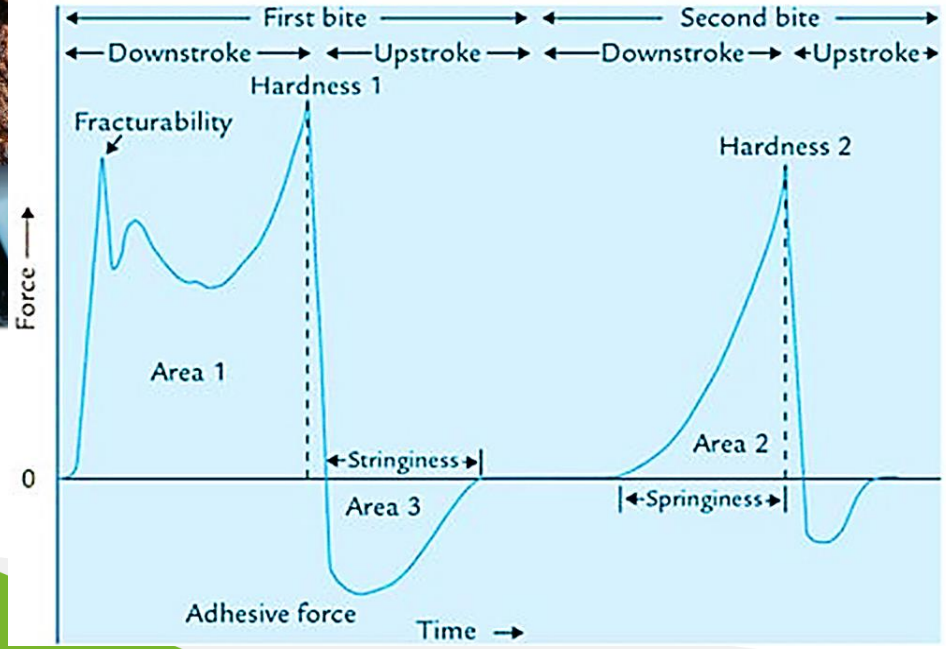
Conventional (130 °C)

With insects (130 °C)

Conventional (150 °C)

With insects (150 °C)

Meat analogues - Texture profile analysis



Hardness – Force to attain a given deformation

Popular terms: Soft - Firm - Hard

Cohesiveness – Extent to which a material can be deformed before its ruptures

Popular terms: Crumbly – Crunchy - Brittle

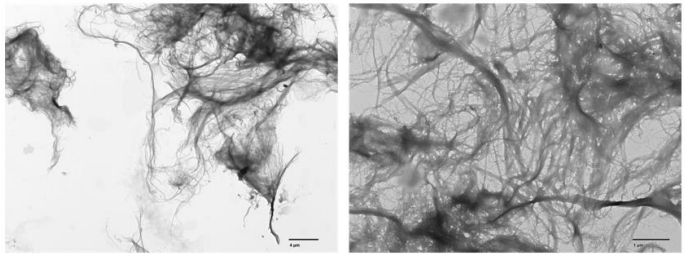
Springiness – Rate at which a deformed material goes to its undeformed condition after deforming force is removed

Popular terms: Plastic - Elastic

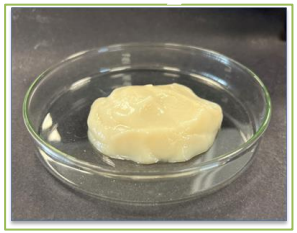
Chewiness - Energy required to masticate a solid food to a state ready for swallowing

Popular terms: Tender – Chewy - Tough

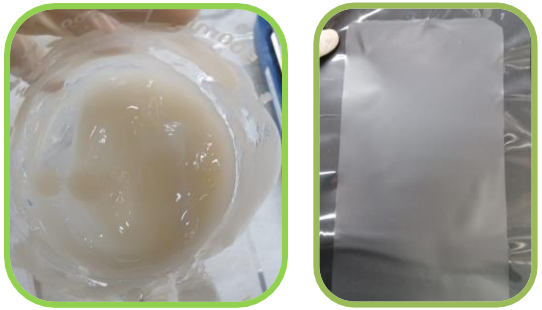
Validation and characterization of the chitin fraction



Chitin nanofibers

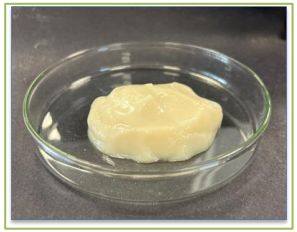


Additive in food packaging materials



Formulation of high-barrier coatings

Production and validation of chitin nanofibers

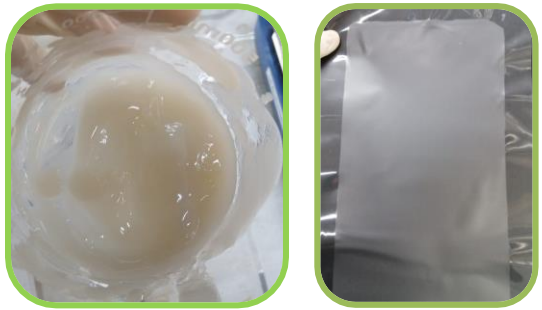


Additive in food packaging materials

Main results of the influence of chitin nanofibers on the properties of PBSA-TPS and PBAT-TPS composites:

- The addition of chitin fibers improved the thermal stability of the biodegradable formulations.
- The Young Modulus of the composites increased as the content of nanofibers increased in the sample, as a consequence of a reinforcing effect of the additive
- A remarkable decrease in both the oxygen and water vapor transmission rate was observed, indicating the positive effect of the incorporation of nanofibers

Production and validation of chitin nanofibers

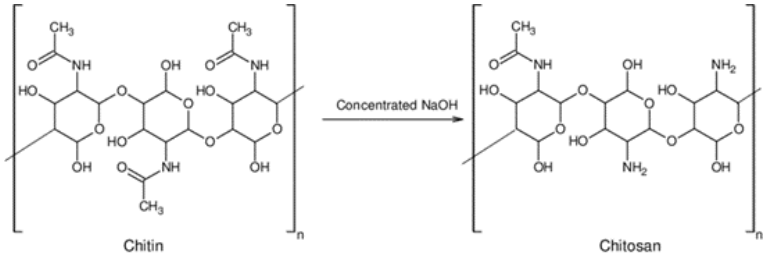


Formulation of high-barrier coatings

The application of a coating based on chitin nanofibers resulted in a considerable decrease of the oxygen transmission rate.

Considering the thickness of the sample, the oxygen permeability coefficient was calculated, and a **reduction of 8.5** in the oxygen permeability was observed for the coated with the **ChNF1-Sorb10** coating formulation.

Production, characterization, and validation of chitosan as raw material for plastic packaging



Reference	Tensile modulus (GPa)	Tensile strength (MPa)	Strain at break (%)
PLA	3.5	45	<3
PLA-CS5	3.7	47	6.8
PLA-CS10	4.1	48	5.2

Chitosan obtained from chitin extracted from BSF

- Chitosan was **compounded** with poly lactic acid by **melt extrusion.**
- The addition of 5 and 10 w/w of plasticized chitosan resulted in an **increase in the Young Modulus**, indicating a more rigid behavior of the blend formulations.
- Tensile strength did not significantly change by the presence of chitosan
- The **strain at break slightly increased**, probably due to the presence of glycerol in the blend formulation.

Final remarks

The **critical parameters** of the decanter system have a significant effect on the separation yield:

- the **temperature** maintained at the upper level (80 °C) decreases the viscosity of the larval fat allowing a **better separation** from the solid phase
- the **differential speed** set to the minimum level (10) increases the residence time inside the drum-cochlea system, thus **facilitating the separation and dehydration** of the protein-chitin material

Final remarks

Although still underway, the **LCA** shows that the cost to stabilize and fractionate a 20-kg pilot lot of BSF larvae is around 4 €

The scenarios published by authoritative organizations (WWF and Tesco) estimate that within a few years the **price of BSF larvae and their factions will become competitive compared with other protein sources currently used in animal feed**. Therefore, the completion of the LCA results will provide further elements to achieve an overall assessment

Final remarks

The decanter system is an effective equipment to fractionate BSF larvae in a **continuous way**

With a **single device** it is possible to carry out the separation of the solid phase (chitin and proteins) from the liquid phase (fats and water) **without using solvents** and numerous lab equipments

It is suitable not only on a lab scale but is potentially **up-scalable** to be included in a wider local dimension with a a look at an **economy of scale**, which is reflected in the **reduction of costs**

SCAN ME

Congrats

SCALIBUR

SCALABLE TECHNOLOGIES FOR BIO URBAN WASTE RECOVERY

Innovation Action (IA) Project

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LEADING A REVOLUTION IN BIOWASTE RECYCLING

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