Green Hydrolysis for Proteins Extraction from Black Soldier Fly (BSF) and its Use for Bioplastics Production

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- **BSF larvae used to bioconvert organic waste into proteins, lipids and chitin.**
- **Superheated water is utilized to intensify the extraction of proteins from BSF larvae.**
- **Bioplastics obtained from BSF proteins/polyvinyl alcohol blends.**

Introduction

Hermetia illucens. also known as Black Soldier Fly (BSF), is an insect of the Diptera order that is currently widespread and cosmopolitan and is often bred in pilot plants. BLS larvae have the great ability to bioconvert unused nutrients left in organic waste into lipids, proteins, and chitin which could be extracted to produce bio-based materials for technical applications.

In our study, proteins were extracted from defatted BSF larvae using superheated water, as a technique to intensify the protein extraction. Superheated water is a green solvent and it can be used as a replacement for existing solvents. Superheated water is defined as the liquid water under pressure in the range of atmospheric boiling point 100 °C and critical temperature 374 °C. It is highly effective in terms of hydrolysis or dissolution of proteins to get oligopeptides. Further advantages of using superheated water for protein extraction are that the proteins are extracted in water medium only at neutral pH and are sterilized so that they can be used without any further purification [1].

Proteins extracted were mixed with polyvinyl alcohol (PVA) in different proportions to obtain bioplastics. The term bioplastics refers to materials that possess a bio-based origin, i.e., the derivation, at least in part, from renewable resources and/or biodegradability i.e. the ability to degrade in natural environments or under specific industrial conditions.

Traditional plastics, such as low-density polyethylene (LDPE), are widely used in agriculture for uses such as mulching or covering greenhouses. Although appreciated for their low cost and good mechanical and optical performance, during the degradation process, they break down into microscopic fragments that remain in the soil, making them impossible to remove. A solution can be found with the development of alternative materials such as bioplastics, designed not only to degrade completely without leaving harmful residues but also to release nutrients that enrich the soil and support crop growth [2].

Methods

Proteins were extracted from defatted BSF larvae using a pressurized reactor with superheated water as a solvent at an optimized condition of temperature 160 °C, time 1 h, material to liquor ratio 1:20. The extraction yield was calculated as the weight of proteins in aqueous solution on the dry weight of the defatted larvae. The solid part was separated from the liquid by filtration and centrifugation. Two solutions of protein and PVA in water were prepared at the same concentrations. Two solutions were mixed at 60 °C for one hour in a thermostated bath to obtain solutions of 100% PVA / 0% protein, 90% PVA / 10% protein, 70% PVA / 30% protein, 50% PVA / 50% protein, 30% PVA / 70% protein, 10% PVA / 90% protein, 0% PVA / 100% protein. The solutions were cast into plastic containers and allowed to dry to obtain the respective films.

Results and discussion

The protein extraction yield was 45,51 % w/w. Tests at higher temperatures (180°C, 1 h) gave similar results so it was decided to use the temperature of 160°C for1 h to save energy and not increase protein hydrolysis obtaining lower molecular weights. From the FT-IR spectrum, it can be seen that the absorptions of the water extracted phase consist mainly of the amide absorptions characteristic of the proteins (see Figure 1).

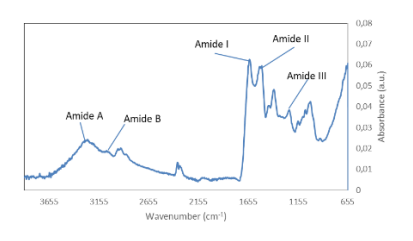

Figure 1. FT-IR spectrum of proteins extracted from BSF

Films produced by mixing BSF-extracted proteins with PVA are homogeneous and retain up to 70% protein intact.

Figure 2. Biodegradable films (from right to left in PVA/BSF protein percentages: 100/0, 90/10, 70/30, 50/50, 30/70, 10/90, 0/100).

Films show good dynamometric characteristics. Tensile strength and elastic modulus decrease with increasing protein fraction, while elongation at break increases.

Conclusions

BSF larvae fed with organic waste were biorefined to extract proteins with an environmentally friendly treatment using only water. The proteins have been used to produce bioplastics for applications for packaging and mulching films as they degrade in the soil releasing organic nitrogen.

Acknowledgements

The authors thank for the financial support of the project HI-Tech "Hermetia illucens biofactory: from waste to high value technological products"(PRIN 2022 ¬ D.D. MUR n.104 02/02/2022, Italy).

References

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