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FACULTY OF AGRONOMY ČAČAK

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2nd INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY

14–15 March 2024

Faculty of Agronomy in Čačak, University of Kragujevac, Serbia

- PROCEEDINGS -

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PREFACE

"From the mouth of my immortal teacher Pasteur, I heard these words:
It is true that science is international, but every scientist must be a man who in his scientific work is warmed by love for the people from which he sprang and to whom he owes all his strength".

Prof. Dr. Milan Jovanović Batut (1847-1940)"
The first dean of the Faculty of Medicine in Belgrade

Agricultural science and agriculture as a profession monitor and study changes occurring in this area, point out problems in agricultural practice, and find solutions. The Faculty of Agronomy in Čačak, in addition to educating students, 29y traditionally organizes the Symposium on Biotechnology (SYMBIOTECH) every year. The main goal is to acquaint the wider scientific and professional public with the results of the latest scientific research, and bring together domestic and foreign scientists in the fields of primary agricultural production, food processing, and environmental protection. We work tirelessly in pursuit of excellence.

At the 2nd International Symposium on Biotechnology, a total of 80 papers were presented in the 7 sections: Field, Vegetable and Forage Crops, Pomology and Viticulture, Livestock Production, Plant Protection, Food Safety and the Environment, Food Technology, Nutritionism, and Applied Chemistry.

We owe great gratitude to the **Ministry of Science, Technological Development and Innovation of the Republic of Serbia** and the **City of Čačak** for their traditional financial support and patronage of SYMBIOTECH24. We thank companies, entrepreneurs, stakeholders and all long-time friends of the Faculty of Agriculture for their material and organizational support.

In Čačak, March 2024

Faculty of Agronomy in Čačak
University of Kragujevac

is organizing

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2nd International Symposium on Biotechnology

29th Symposium on Biotechnology with International Participation

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Faculty of Agronomy, Čačak, Republic of Serbia

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Section: Applied Chemistry

Section: Nutritionism

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BIODEGRADABILITY ASSESSMENT OF CORN STOVER REINFORCED COMPOSITE MATERIALS WITH DIFFERENT MATRIX

Marijana Ponjavić [1], Jelena Milovanović [1], Jasmina Nikodinović-Runić [1]
Nikola Đurašković [2], Nedeljko Tica [2], Irena Živković [3]

Abstract: In this paper, the biodegradability of three SferiCorn™ biocomposites was investigated. Corn stover prepared through eco-friendly washing and grinding to short fibers was used as reinforcement. Three different biopolymers, corn starch, alginate and poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV), were used as matrices. The biodegradability of prepared composites was investigated in a simulated soil burial test and the samples were characterized in terms of weight loss and morphological changes. It was shown that biodegradability can be tuned by biopolymers used as matrices. Changes in the surface morphology after biodegradation of tested samples were confirmed using scanning electron microscopy (SEM).

Keywords: corn stover composites, bio-polymer matrix, biodegradability, composting

Introduction

Agricultural waste, often referred to as agri-waste, is the byproduct generated from various agricultural activities. It includes residues, byproducts, and non-food parts of crops that are left behind after harvest or processing (Duque-Acevedo et al., 2020). Agro-waste can be substantial, and its management is crucial for environmental sustainability (Phiri R. Et al., 2024). Corn stover composite refers to a material that is produced by combining corn stover, which is the residual biomass left in the field after corn harvest, with a matrix material to create a composite material with enhanced properties (Mohammed A. A., 2022). Utilizing corn stover in composite materials is a

[1]University of Belgrade, Institute of Molecular Genetics and Genetic Engineering, Vojvode Stepe 444a, 11042, Belgrade, Serbia (mponjavic@imgge.bg.ac.rs)
[2]Sferikon Design & Inovations, Put dr Goldmana 1A/12 21208 Sremska Kamenica, Serbia (sferikon@outlook.com)
[3]University of Arts in Belgrade, Faculty of Applied Arts, Kralja Petra 4, 11000 Belgrade, Serbia (irena.zivkovic@fpu.bg.ac.rs)

sustainable approach as it repurposes agricultural waste, reduces environmental impact, and provides an alternative to synthetic composites materials (Suess T., 2013). Some common types of matrix materials used in corn stover composites are thermoplastic polyolefins from the recycling industry, such as polyethylene (Chun K. S. Et al., 2017), or polypropylene (Delgado-Aguilar M. et al., 2018) on one hand, or, on the other hand, polyvinyl alcohol very well known for its biodegradability (Yong K. J., 2022). A biodegradable and bio-based polymers such as polylactide acid (Qi Z., 2022), polycaprolactone (Wu C. S. and Liao, H. T. 2012), polyurethane (Kocak E. D. et al., 2023), natural resins such as soy-based resins (Pfister D. P. and Larock R. C. 2010), starch-based (Ibrahim M. I. J. et al. 2019) or lignin-based matrix (Yuan Y. et al., 2019) that enhances the eco-friendliness and sustainability of corn stover composites, can be used. Combining different polymers to create a hybrid matrix that optimizes properties such as strength, flexibility, and biodegradability, polymer blends are also a possible choice (Li R. et al. 2023). Among the very interesting polymers for the role of the matrix in corn stover composites are a family of biodegradable polyesters synthesized by a variety of microorganisms as intracellular carbon and energy storage compounds named polyhydroxyalkanoates (PHAs). PHAs are considered promising bioplastics due to their biodegradability, thermoplastic properties, and potential to replace conventional petroleum-based plastics in many applications, among which are thermoplastic matrices for composite materials (Sharma V. et al, 2021). PHAs are biodegradable and can be synthesized with various monomer compositions, leading to a range of materials with different physical and mechanical properties (McAdam B. et al., 2020). Due to their thermoplastic properties, can be processed using conventional plastic processing techniques such as extrusion, injection molding, and film blowing (Raturi G. et al., 2021). In this paper, the degradation possibilities of three SferiCorn™ biocomposite materials with corn stover ligno-cellulosic reinforcement and different polymer matrices are considered. The potential impact of the study extends to the realms of waste management, environmental sustainability, and the development of green alternatives to traditional synthetic composites.

Materials and methods

SferiCorn™ composites. Three types of SferiCorn™ composite materials with the same reinforcement and different matrices were made. The composition and properties of individual composites are given in Table 1. The structure of the composite is quasi-isotropic in all three tested kinds of samples.

Corn stover is provided from Agricultural Farm Marko Adžić from Vojvodina, Republic of Serbia, Corn Starch from Klas plus d.o.o. Republic of Srbija, and Sodium Alginate from Cenik Chemicals UK. Aonilex® X131A PHBH was supplied by Kaneka, Japan.

Table 1. Composition and the properties of prepared samples

Samples name	SferiCorn R	SferiCorn S	SferiCorn BioTP
Reinforcement	Ground corn stover		
Matrix	Starch 12.5%	Alginate 2%	Aonilex® X131A
Matrix/ reinforcement ratio	1:1	1:1	1:1
Areal density, kg/m2	1.4	0.9	4.1
Surface	Rough	Rough	Smooth

The production processes of SferiCorn™ composites are completely eco-friendly, including the corn stover washing process. All three composite materials were produced using different technological procedures, according to the requirements imposed by composite matrices.

Simulated soil burial biodegradation tests. Simulated soil burial biodegradation test was done following the procedure: compost and garden soil were mixed (1:1) and mixed with water (3:1) in a Petri dish (20 cm diameter, 3 cm hight) and the tested samples (rectangular shape, 1 x 1 cm^2) were buried at depth of 1 cm. Samples were incubated for 10 days and 17 days, and after predetermined time intervals samples were washed with water, and dried in a vacuum oven to achieve constant mass and the weight loss was calculated according to the equation (1):

$$Weight\ loss\ (\%) = (m_1 - m_0)/m_0 \times 100\ \%\ (1),$$

Where m_1 is remained mass after degradation and m_0 is the starting mass of the samples.

Scanning Electron Microscopy (SEM) analysis. The surface morphology of the control samples, but also changes in morphology after the biodegradation test in soil were investigated using scanning electron microscopy (SEM, JEOL JSM-6390LV JEOL USA Inc., Peabody, MA, USA) applying an accelerating voltage of 15 kV. Prior to the recording at various magnifications, all samples were fixed on supports and sputter-coated with a thin layer of gold.

Results and discussion

Weight loss after simulated soil burial biodegradation test. The biodegradation ability of the SferiCorn™ samples were quantified by measuring weight loss after predefined time intervals (Figure 1). After 10 days of degradation, a significant weight loss, of almost 80 %, was detected for the SferoCorn R sample, while the SferiCorn S composite with alginate appeared to be more stable under the testing conditions and lost more than 40 % of its mass. With the extension of the degradation time, samples were mostly disintegrated with a weight loss close to 100 % indicating that SferiCorn™ samples are highly compostable, biodegradable material. However, the composite of SferiCorn samples with PHBV showed better stability under the tested conditions with the weight loss of only a few percentages even after 17 days of composting, due to the presence of biopolymer PHBV.

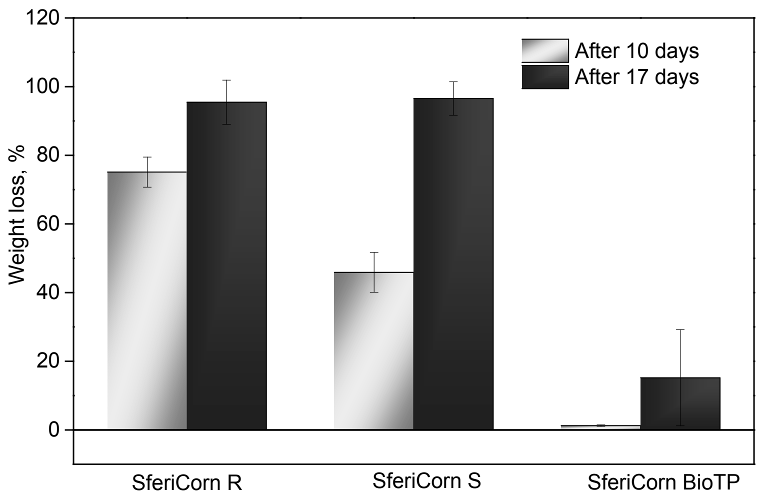

Figure 1. Weight loss of SferiCorn samples after 10 days and 17 days under composting.

SEM analysis. The surface morphology of the SferiCorn composite material before and after composting was evaluated by SEM analysis (Figure 2). Morphology of all SferiCorn control samples appeared porous with the most prominent porosity in the case of SferiCorn R, while its composites with alginate and PHBV possessed less porous and more compact morphology due to the presence of biopolymers. After the biodegradation of both 10 days and 17 days, beside remained pieces of compost were detected, the samples were remarkably disintegrated and the sponge-like morphology was less visible as a consequence of remarkable weight loss.

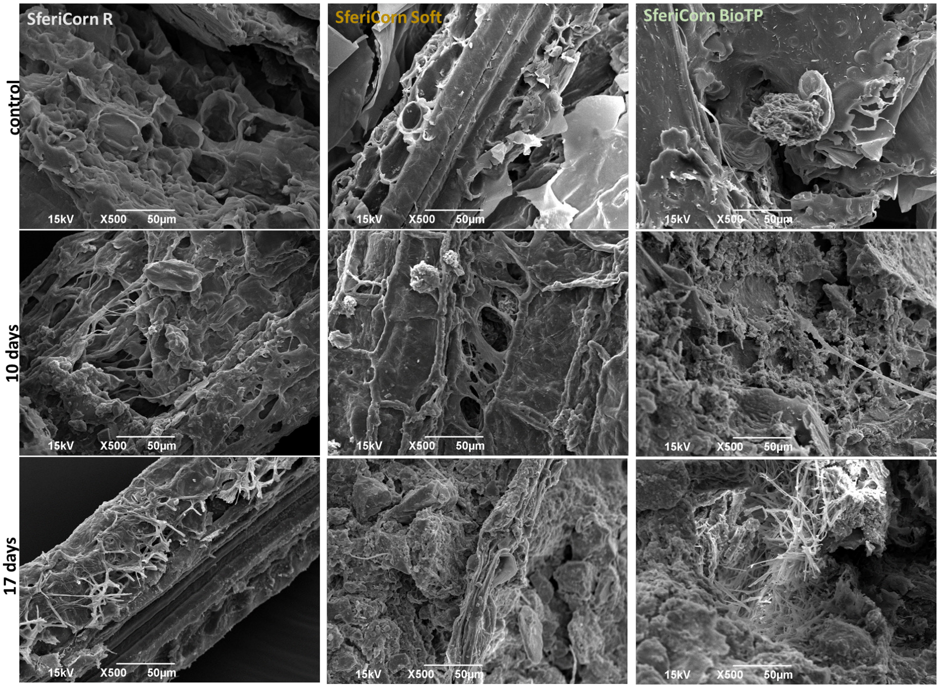

Figure 2. SEM analysis micrographs of the samples before and after biodegradation in soil after 10 days and 17 days (magnification of 500 times).

Conclusion

By analyzing the obtained results, it can be concluded that SferiCorn™ samples are highly compostable, biodegradable materials, but with different susceptibility to environmental degradation, tuned by the selected biopolymer. Therefore, the highest biodegradability was proved for the composite SferiCorn R, followed by SferiCorn S, while the SferiCorn BioTP showed the highest stability. SEM analysis of surface morphology of the SferiCorn samples before and after composting indicated a porous morphology that is most expressed in the case of SferiCorn R sample, while SferiCorn S and SferiCorn BioTP have a less porous and more compact morphology provided by the biopolymers used for composite production. After biodegradation, the samples apart of PHBV reinforced SferiCorn™ composite material, were significantly disintegrated and the sponge-like morphology was less visible as a consequence of notable weight loss. The versatility of SferiCorn™ composites extends to varied applications, contingent upon the chosen matrix. Specific properties imparted by different matrices result in tailored lifetimes, rendering each composite uniquely suited for specific applications.

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