agronomy

Editorial

Special Issue "Pretreatment and Bioconversion of Crop Residues II"—Introduction to the Collection

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Abstract: Bioconversion in biorefineries is a way to valorize residues from agriculture and food processing. Pretreatment is an important step in the bioconversion of lignocellulosic materials, including crop residues. This Special Issue includes nine articles on several pretreatment and bioconversion approaches applied to different agricultural residues and food-processing by-products. The materials addressed in this collection cover straw from wheat, rye, and miscanthus, olive tree pruning residue, almond shells and husks, avocado waste, sweet sorghum bagasse, soybean meal, and residues of non-edible oilseeds.

Keywords: pretreatment; bioconversion; crop residues; lignocellulosic biomass

Citation: Martín, C.; Castro, E. Special Issue "Pretreatment and Bioconversion of Crop Residues II"—Introduction to the Collection. *Agronomy* **2024**, *14*, 962. https://doi.org/10.3390/agronomy14050962

Received: 26 April 2024
Accepted: 30 April 2024
Published: 3 May 2024

1. Introduction

The expansion of the agricultural sector as a consequence of the population increase leads to an increased generation of crop wastes and agro-industrial residues. Management of the large amounts of residues generated by harvesting cereals [1] and other Gramineae, legumes, tubers and root crops [2], edible tree fruits and nuts [3], and non-food agricultural products [4] poses significant challenges [5]. A common management strategy is to use crop residues for energy generation or to burn them directly in the field. However, large-scale burning causes air pollution [6] and contributes to the deterioration of soil health [7].

As an alternative to disposal by direct burning, the bioconversion of crop residues to advanced biofuels, platform chemicals, and other products represents the possibility of technical development, reduction of import dependence, and job creation. Waste materials from agriculture and residual streams from crop processing are renewable and cost-effective feedstocks for biorefineries [8]. Bioconversion of agriculture-related residues can help cope with their accumulation and thus contribute to a sustainable economy [9].

As typical examples of lignocellulosic biomass [10], crop residues are composed of cellulose, hemicelluloses, and lignin. The general process of lignocellulosic biomass bioconversion into products of interest consists of three fundamental stages: pretreatment, enzymatic saccharification, and fermentation [11]. Pretreatment is directed at partially decomposing the lignocellulosic matrix to facilitate access to enzymes, which deconstruct cellulose and hemicelluloses by saccharification [12]. The resulting sugars are then converted into the desired products via fermentation. Pretreatment is a key stage in the overall process, and its effectiveness is feedstock-dependent [13]. Therefore, investigating pretreatment approaches that efficiently address materials of different natures is crucial for developing methods suited for the commercial bioprocessing of crop residues.

2. This Issue

This Special Issue is a continuation of a previously started series on different pretreatment and bioconversion approaches applied to crop residues [8]. The current collection features a review article and eight original research papers that present crucial aspects of pretreatment for various crop residues, as well as other key elements of the conversion process, such as economic and environmental factors and the production of enzymes.

In a review article, Castro et al. [14] provide an outlook on the pretreatment of non-edible oilseed residues to enhance their bioconversion. The study is pertinent considering that non-edible oils are a sustainable feedstock for biodiesel production [15], in contrast to the first-generation biodiesel from edible oilseeds, such as palm, sunflower, and rapeseed. Most of these residues are disposed of by burning or are used in a suboptimal way. Bioconversion via the sugar platform route, anaerobic digestion, or enzyme production enables the transformation of these residues into advanced biofuels and high-added value products.

Barley straw, as a feedstock for ethanol production, is the focus of the work presented by Díaz et al. [16]. Based on steam explosion pretreatment, the authors revealed that up to 194 kg of ethanol can be produced from 1 ton of dilute phosphoric acid-soaked barley straw. Operational conditions include moderate temperature (160 °C for 30 min), enzymatic hydrolysis, and co-fermentation by ethanologenic *Escherichia coli*.

Wheat straw is an abundant crop residue with limited uses, and its valorization is desirable [17]. The work authored by Steffen et al. [18] proposes using wheat straw as a fiber source alternative for use in several paper applications. This could provide sufficient quantities of alternative products with acceptable quality for green applications. As a main conclusion, sodium carbonate-based pulping is perfectly suited for non-wood materials such as wheat straw. A broad range of pulp qualities can be produced from unbleached pulp for packaging to bleached pulps for graphical applications.

Olive tree pruning residues are another abundant and renewable lignocellulosic by-product, which is generally burned in the fields, but it has potential as a source of energy and chemicals [19]. Based on the high content of potentially fermentable carbohydrates in olive tree pruning biomass, Díaz et al. [20] propose using it as feedstock for producing a wide range of byproducts in a biorefinery context. The study assesses a sequential pretreatment with sulfuric acid and sodium hydroxide to maximize the release of sugars to be fermented into bioethanol.

López-Sandín et al. [21] report the production of second-generation ethanol from sweet sorghum bagasse using hydrothermal pretreatment. The pretreated material was further processed by pre-saccharification and simultaneous fermentation (PSSF). The study has a strong focus on the energy balance of the process. The results show that pretreatment severity played a key role in sugar release and energy consumption.

The residues from avocados are the object of an article co-authored by García-Vallejo et al. [22]. The potential introduction of small-scale biorefineries in rural areas as a sustainable alternative is presented. Four scenarios, based on experimental and simulation data, were evaluated according to technical, economic, environmental, and social aspects. A process producing animal feed, bioactive compounds, biogas, and fertilizer was selected as the best option for implementation in an avocado waste-based biorefinery in Caldas, Colombia.

In a different processing approach, following the thermochemical pathway, Carmo-Calado et al. [23] present a technical study of the gasification of almond shells and husks. The study includes a detailed technical-economic analysis of the in situ installation of a decentralized unit to produce electricity through a syngas generator, which would overcome the use of fossil fuels in the almond-processing industry. It was concluded that thermal gasification is a suitable technology for the recovery of lignocellulosic materials, with good economic viability for fixed-bed gasification systems.

Two articles cover studies on enzymes required for the bioconversion of crop residues. Osipov et al. [24] report the investigation of in-house enzyme preparations produced by recombinant strains of *Penicillium verruculosum*. The effects of different pretreatment methods on the enzymatic conversion of miscanthus straw by *P. verruculosum* preparations were investigated. Pretreatment with dilute sodium hydroxide was found to be the most effective method. Finally, Anderson et al. [25] report the immobilization of enzymes produced by *Aspergillus niger* for producing mannooligosaccharides from soybean meal. As a main conclusion, the authors state that the prebiotic potential of soybean meal-produced sugars on the growth and viability of probiotic bacteria is better than that of glucose. The study demonstrated the potential of immobilized mannanase for sustainable prebiotic production from mannan-containing agricultural feedstocks.

3. Conclusions

The set of studies compiled in this Special Issue, with their wide variety of techniques and raw materials, and a multi-perspective analytical approach, represent an advance in the knowledge on valorization of crop residues through bioconversion. However, we recognize the significant challenges that remain ahead. Continuing the current efforts is necessary for the worldwide development of the biorefinery business based on crop residues. The Guest Editors thank the authors who contributed to this Special Issue and hope that this collection will interest a wide range of readers.

Author Contributions: Conceptualization, C.M. and E.C.; methodology, C.M. and E.C.; writing—original draft preparation, E.C. and C.M.; writing—review and editing, C.M. and E.C. All authors have read and agreed to the published version of the manuscript.

Funding: Sparebankstiftelsen Hedmark (through project number 362001-10) and Bio4Energy strategic research environment (through project number 550080300) funded C.M. salary.

Acknowledgments: The Department of Biotechnology, Inland Norway University of Applied Sciences, and the Department of Chemical, Environmental and Materials Engineering, Universidad de Jaén, are thanked for their institutional support.

Conflicts of Interest: The authors declare no conflicts of interest.

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