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Circular bioeconomy in the sustainable biotransformation of agri-food residues and waste

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Abstract. This paper explores the potential of sustainable biotransformation of agri-food residues and waste into a spectrum of marketable ingredients for food and feed and other bio-based products (biochemicals, biomaterials) which is at the heart of the bioeconomy. With over 80% of land covered by farms or forests and marine areas supporting fisheries of global importance, the EU is largely self-sufficient in most agri-food, forestry and some marine products. Based on available data, it is estimated that the European bioeconomy has an annual turnover of around €2 trillion and employs over 22 million people, around 9% of the total EU workforce. Its sectors have a strong potential for innovation due to their connection to a wide range of sciences and technologies, as well as local knowledge. Given that the transition from non-renewable to renewable resources is an important innovation aspect of both the circular economy and the bioeconomy agenda, the exploitation of the synergy between the two concepts in ensuring a more productive and efficient use of resources is also evaluated. There is an uneven distribution of activities associated with the development of sustainable circular bioeconomy in EU member states, which has an unwanted impact on the achievement of both European and national objectives.

Keywords: bioeconomy, biotransformation, agri-food residues and waste, bio-based products

1. Introduction

The circular bioeconomy is a relatively new concept that aims to promote sustainability and reduce waste in the production and consumption of goods and services. The main idea behind the circular bioeconomy is to create a closed-loop system where waste is minimized, resources are used more efficiently, and renewable resources are used wherever possible (EEA Report No 8/2018, European Commission, 2018).

Today, many governments and organizations around the world are adopting circular bioeconomy policies as part of their efforts to combat climate change and promote sustainable development. The key elements of these policies include:

- Reducing waste - implementing policies and initiatives that reduce waste generation and promote waste recycling, composting, and reuse.
- Using renewable resources, such as biomass, bioenergy, and bioplastics instead of non-renewable resources such as fossil fuels.
- Promoting sustainable production and consumption - encouraging the production and consumption of goods and services that are sustainable, resource-efficient, and environmentally friendly.
- Fostering innovation and research - investing in research and development to support the development of new technologies, processes, and products that promote the circular bioeconomy.

Examples of countries that adopted the policy documents in biotransformation field are: Germany (National Research Strategy for Bioeconomy 2030,2011; National Strategy for Policy in Bioeconomy, 2014; National Strategy for Bioeconomy, 2020), Netherlands (Groene Groei, 2012; 2013), Finland (The Finnish Bioeconomy Strategy, 2022), Spain (Estrategia española de Bioeconomía Horizonte 2030, 2016), Italy (Italian Bioeconomy Strategy – BIT, 2017; Italian Bioeconomy Strategy – BIT II, 2019), France (A bioeconomy strategy for France: 2018-2020 Action plan, 2018).

In 2012, the European Commission launched its first Bioeconomy Strategy, a research and innovation agenda aimed at improving the sustainable exploitation of bioresurces. The strategy was expected to act through existing policies, while urging Member States, public and private stakeholders to collaborate more closely to develop markets and competitiveness in the bioeconomy sectors in accordance with the following main objectives: 1) Ensuring food and nutritional security; 2) Managing natural resources in a sustainable way; 3) Reducing dependence on non-renewable resources; 4) Mitigation and adaptation to climate change; 5) Strengthening European competitiveness and job creation;

A comprehensive review of the 2012 European Bioeconomy Strategy concluded that it was a success, particularly in terms of mobilizing research and innovation, stimulating private investment, developing new value chains, promoting the adoption of national bioeconomy strategies and stakeholder engagement. On the other hand, the review also recommended adapting

the original five objectives and related actions to better use the potential of the bioeconomy to meet current and future EU priorities.

The CBE Joint Undertaking (CBE JU) is a €2 billion public-private partnership between the EU, represented by the European Commission (EC) and the Bio-based Industries Consortium. It was established within Horizon Europe, the EU research and innovation program for the period 2021-2031. Although the CBE JU is not a direct continuation of the Bio-Based Industries Joint Undertaking (BBI JU), it builds on the achievements of the previous partnership and aims to address its shortcomings.

The scope of CBE JU is supported by the updated EU Bioeconomy Strategy (2018), in line with the objectives of the European Green Deal. It aims to facilitate major contributions to the EU's climate goals by providing innovative bio-based solutions and paving the way for Europe to become the first climate-neutral continent by 2050; protecting and increasing biodiversity; combating pollution; reducing dependence on fossil resources; and implementing a just transition. The partnership funds projects of great excellence that promote the joint efforts of actors in different sections of the bio-based value chain, while reducing the risk of such cooperations.

Sustainable biotransformation of agri-food residues and waste into a spectrum of marketable ingredients has the potential to provide a range of benefits to both the food and feed industries. By utilizing otherwise discarded materials, this process can help to reduce waste and minimize the strain on natural resources. Furthermore, the resulting ingredients can be used to improve the sustainability and cost-effectiveness of food and feed production (Ria Millati, 2018).

2. Biotransformation

Biotransformation is the process by which microorganisms, such as bacteria and fungi, convert waste materials into valuable products. This process can be used to transform a wide variety of agri-food residues and waste, including food processing by-products, agricultural waste, and food waste. The biotransformation of food processing by-products, such as fruit and vegetable peels and seeds, can result in the production of valuable ingredients such as dietary fibers, antioxidants, and bioactive compounds.

The biotransformation of straw and other plant residues can result in the production of ingredients such as enzymes and other bioproducts. Food waste can be biotransformed into ingredients such as protein-rich animal feed, biofuels, and other energy sources.

3. Sustainable biotransformation

One of the key benefits of sustainable biotransformation is its potential to reduce waste and minimize the strain on natural resources. By utilizing waste materials that would otherwise be discarded, this process helps to conserve valuable resources and reduce the environmental impact of food and feed production. Furthermore, biotransformation can also help to improve the sustainability of food and feed production by reducing the need for synthetic inputs and promoting the use of renewable resources.

Another benefit of sustainable biotransformation is its potential to improve the cost-effectiveness of food and feed production. By utilizing waste materials as inputs, this process can help to reduce the cost of production and make food and feed production more affordable for consumers. Furthermore, the resulting ingredients can be sold at a premium, providing a source of additional income for food and feed producers.

The potential market for the ingredients produced through sustainable biotransformation is significant. There is a growing demand for natural and sustainable ingredients in the food and feed industries, and the ingredients produced through biotransformation can meet this demand. Te ingredients produced through biotransformation can be used to improve the nutritional profile of food and feed products, making them more appealing to consumers.

The sustainable biotransformation of agri-food residues and waste into a spectrum of marketable ingredients has the potential to provide a range of benefits to both the food and feed industries. By utilizing otherwise discarded materials, this process can help to reduce waste and minimize the strain on natural resources, while also improving the sustainability and cost-effectiveness of food and feed production. Furthermore, the potential market for the ingredients produced through sustainable biotransformation is significant, making it an attractive opportunity for both food and feed producers and consumers.

4. Bio-based products: biochemicals and biomaterials

Sustainable biotransformation of agri-food residues and waste into other bio-based products, such as biochemicals and biomaterials, holds great potential for reducing waste, creating new market opportunities, and promoting sustainable economic growth. Agri-food residues and waste, including by-products from agriculture, food processing, and consumer waste, are a significant source of organic matter that can be transformed into valuable bio-based products through various biotransformation processes.

The biotransformation of agri-food residues and waste into biochemicals, such as biofuels, bio-plastics, and organic acids, has the potential to reduce the dependence on non-renewable resources and to create new market opportunities. Biochemicals can be used as substitutes for traditional petrochemical-based products in a variety of applications, including energy, transportation, and packaging. The production of biochemicals from agri-food residues and waste can help to reduce greenhouse gas emissions and to promote sustainable economic growth by creating new jobs and markets.

The biotransformation of agri-food residues and waste into biomaterials, such as biocomposites, bio-based fibers, and bio-based packaging materials, can help to reduce waste and promote sustainable economic growth by creating new market opportunities. Biomaterials are made from renewable resources and are biodegradable,

making them a more sustainable alternative to traditional petrochemical-based materials. The use of biomaterials can help to reduce the environmental impact of resource extraction.

The biotransformation of agri-food residues and waste into bio-based products requires significant investments in research, development, and infrastructure.The sustainable biotransformation of agri-food residues and waste into other bio-based products, such as biochemicals and biomaterials, holds great potential for reducing waste, creating new market opportunities, and promoting sustainable economic growth.

5. Synergy between the circular economy and bioeconomy

The circular economy and bioeconomy are two interrelated concepts that aim to ensure a more productive and efficient use of resources. The circular economy focuses on reducing waste and emissions by closing the loop on resource use, while the bioeconomy aims to create a sustainable and renewable economy based on biological resources. Both concepts share a common goal of promoting resource efficiency and sustainability, and they complement each other in many ways.

The circular economy and bioeconomy are complementary in their approach to resource use. The circular economy emphasizes the importance of reducing waste by keeping resources in use for as long as possible, while the bioeconomy emphasizes the importance of utilizing renewable biological resources to replace finite and non-renewable resources.

The circular economy approach to resource use can help to reduce waste by promoting the reuse and recycling of materials, while the bioeconomy approach can help to reduce the use of non-renewable resources by promoting the use of renewable biological resources

The synergy between the circular economy and bioeconomy can also help to increase productivity and efficiency. The circular economy approach to resource use can help to improve the efficiency of resource use by reducing waste and promoting the reuse of resources. At the same time, the bioeconomy approach can help to increase the efficiency of resource use by promoting the use of renewable biological resources that can be produced in a more sustainable and efficient manner.

The circular economy approach to resource use can help to create new business models and revenue streams by promoting the reuse and recycling of resources. At the same time, the bioeconomy approach can help to create new economic opportunities by promoting the development and commercialization of new biological products and technologies.

By combining these approaches, it is possible to create:

- a more sustainable and economically dynamic system for resource use that delivers benefits to society;
- a more efficient and sustainable system for resource use that maximizes the value of resources at every stage of the value chain;
- a more sustainable and efficient system for resource use that minimizes waste and reduces the impact on the environment.
- a more productive and efficient system for resource use that delivers greater value to society;

The circular bioeconomy can also help to promote regional and rural development. By promoting the use of renewable biological resources and reducing waste, it is possible to create new economic opportunities in rural and regional areas. This can help to create jobs and stimulate economic growth in these areas, and promote more sustainable and equitable development.

6. Transition from non-renewable to renewable resources

The transition from non-renewable to renewable resources is a critical step towards a more sustainable and environmentally friendly future. Non-renewable resources, such as fossil fuels and minerals, are finite and will eventually run out. On the other hand, renewable resources, such as solar, wind, and biomass, can be replenished over time and are considered more sustainable. The shift from non-renewable to renewable resources is necessary to reduce the negative impact of resource extraction on the environment and to ensure a secure and reliable supply of energy and materials for future generations.

The transition from non-renewable to renewable resources is being driven by a combination of technological advances, government policies, and changing consumer preferences. The cost of renewable energy technologies, such as solar and wind, has fallen dramatically in recent years, making them increasingly competitive with traditional fossil fuels. At the same time, governments around the world are implementing policies and incentives to promote the adoption of renewable energy and to reduce the use of non-renewable resources.

The shift to renewable resources is also being driven by consumers, who are increasingly concerned about the environmental impact of resource extraction and are looking for more sustainable and eco-friendly alternatives. This has led to the growth of renewable energy markets, as well as the development of new technologies and products that utilize renewable resources. The transition from non-renewable to renewable resources is not without its challenges. Renewable energy sources are often intermittent and depend on weather conditions, making it difficult to ensure a consistent and reliable supply of energy. In addition, the shift from non-renewable to renewable resources requires significant investments in research, development, and infrastructure, which can be challenging for governments and businesses. The transition from non-renewable to renewable resources is an essential step towards a more sustainable future. By promoting the use of renewable resources and reducing the use of non-renewable resources, it is possible to reduce the negative impact of resource extraction on the environment, ensure a secure and reliable supply of energy and materials, and promote sustainable economic

growth. The shift to renewable resources is an ongoing process that requires continued investment, innovation, and cooperation between governments, businesses, and consumers.

7. Conclusion

The circular bioeconomy is essential for ensuring a more productive and efficient use of resources. By combining the circular economy approach to resource use with the bioeconomy approach, it is possible to create a more sustainable, efficient, and productive system for resource use that delivers greater value to society. The circular bioeconomy offer a unique opportunity to promote resource efficiency, reduce agri-food residues and waste, and create new economic opportunities, and should be embraced as complementary approaches to ensure a more sustainable and productive use of resources.

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References

A bioeconomy strategy for France: 2018-2020 Action plan, 2018, https://agriculture.gouv.fr/bioeconomy-strategy-france-2018-2020-action-plan

BIT Bioeconomy in Italy - A unique opportunity to reconnect

the ECONOMY, SOCIETY and the ENVIRONMENT, 2017, https://cnbbsv.palazzochigi.it/media/1768/bit1_en.pdf

BIT II Bioeconomy in Italy - A new Bioeconomy strategy for a sustainable Italy, 2019, https://cnbbsv.palazzochigi.it/media/1774/bit_en_2019_02.pdf

Estrategia española de Bioeconomía Horizonte 2030, 2016, https://www.juntadeandalucia.es/export/drupaljda/ESTRATEGIA_ESPANOLA_BIOECONOMIA.pdf

EEA Report No 8/2018. The circular economy and the bioeconomy – Partners in sustainability

European Commission, Directorate-General for Research and Innovation, A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment: updated bioeconomy strategy, Publications Office, 2018, https://data.europa.eu/doi/10.2777/792130

Groene Groei – Van biomassa naar business, 2012, https://edepot.wur.nl/196915

Groene Groei: voor een sterke, duurzame economie" aan, 2013, https://open.overheid.nl/documenten/ronl-archief-1aeba8d4-55b1-4a6c-b9b1-be0774aa9f99/pdf

National Bioeconomy Strategy, 2020, https://www.bmel.de/SharedDocs/Downloads/EN/Publications/national-bioeconomy-strategy.pdf?__blob=publicationFile&v=2

National Policy Strategy on Bioeconomy - Renewable resources and biotechnological processes as a basis for food, industry and energy, 2014, https://www.bioways.eu/download.php?f=62&l=en&key=c21c2ea7e095424f3545c66da7b98821

National Research Strategy BioEconomy 2030 - Our Route towards a biobased economy, 2011, https://www.pflanzenforschung.de/application/files/4415/7355/9025/German_bioeconomy_Strategy_2030.pdfRia Millati, Rochim Bakti Cahyono, Teguh Ariyanto, Istna Nafi Azzahrani, Rininta Utami Putri, Mohammad J. Taherzadeh, Chapter 1 - Agricultural, Industrial, Municipal, and Forest Wastes: An Overview, Editor(s): Mohammad J. Taherzadeh, Kim Bolton, Jonathan Wong, Ashok Pandey, Sustainable Resource Recovery and Zero Waste Approaches, Elsevier, 2019, 1-22, https://doi.org/10.1016/B978-0-444-64200-4.00001-3.

The Finnish Bioeconomy Strategy Sustainably towards higher value added, 2022, https://www.biotalous.fi/wp-content/uploads/2022/05/The-Finnish-Bioeconomy-Strategy-Sustainably-towards-higher-value-added-VN_2022_5.pdf