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Editorial

Advances in Food, Bioproducts and Natural Byproducts for a Sustainable Future: From Conventional to Innovative Processes

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The world population is expected to reach almost 10,000 million in 2050, which entails the need to focus on sustainability and its three pillars: the economy, the environment, and society. Within this context, it is necessary to use our resources efficiently; for instance, we will need to produce much more food using less land and while polluting less to optimize the production of biomass from diversified resources, along with its subsequent conversion, fractionation, and processing. To achieve this, new approaches and processes, with special emphasis from a biotechnological perspective, may need to be implemented to move towards a circular model that will confer environmental sustainability. Global projections of food losses constitute an abundant pool of complex carbohydrates, proteins, lipids, and functional compounds. Hence, the deployment of food waste streams as raw materials will encompass the formulation of added-value products that will be ideally reintroduced in the food supply chain to close the loop.

Therefore, the analysis and optimization of any food and bioproduct process, as well as the development of innovative and emerging food and by-product processing methods, are important as a necessity for the sustainable transition to a bioeconomy era. The valorization, bioprocessing, and biorefining of food-industry-based streams, the role of industrial microorganisms, the isolation of high-added-value compounds, applications of the resulting bio-based chemicals in food manufacturing, novel food formulations, economic policies for food waste management, along with sustainability or techno-economic assessment of processing methods constitute subject areas that need to be addressed. More specifically, bioprocess design to valorize food-industry waste and by-product streams should be initiated by characterizing the composition of the onset raw material with the aim of identifying the target end-products, whereas the generation of multiple high-added-value products is a prerequisite for cost-effective processes to establish economic sustainability. On top of that, the feasibility of innovative processes could be sustained by encompassing food applications, driven by the constantly emerging consumers' demand for functional foods and beverages with enhanced nutritional value. Equally, a growing awareness for bio-based and natural food components is being developed, thereby imposing challenges on the substitution of chemically derived ingredients with their natural counterparts.

In this context, many non-exclusive methods are possible, through which we can approach the general and specific objectives outlined in the previous paragraphs. The papers collected in this book could show some examples that can help to achieve a bioeconomy. The topics they address could be classified under several non-exclusive headings, including the following:

- Use of by-products and/or raw materials that are currently not used sufficiently;
- Waste management;

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- Improvement and optimization of existing bioprocesses;
- Development of new processes and products;
- New potentials of traditional products;
- Deepening in the basic aspects behind each product and process.

The interest in the development of molecules with biomedical interest is a topic of great current interest, an example of which is addressed in [1], a publication in which the extraction of Agglutinin is sought from wheat germ, a by-product of the flour-making industry of this cereal. Agglutinin is a molecule with cytotoxic properties that can find very interesting applications in anti-cancer treatments.

The interest in health promotes the search for functional ingredients in different raw materials, in particular, in relatively unknown fruits, many of them tropical, given that these seem to be a very interesting source of phenolic compounds, pectin. and other compounds. An example of this is addressed in the publication [2], in which the possibilities of using the pulp, seed, and peel of the jackfruit are analyzed. In this way, not only would the use of this large fruit, which can weigh up to 40 kg, be optimized or improved, but at the same time, the sources and types of functional ingredients for the pharmaceutical and food industries be increased.

On the other hand, it is not possible to forget because of both resource optimization and environmental reasons the problem of residues. Specifically, those from the agri-food industry have great potential for their use, since they are considered to be a very important source of multiple compounds: food dyes, antioxidants, anti-inflammatory, immunoactive, analgesic, antimicrobial, and other types. In this context, the publications [3,4] address the study of the use of eggplant residues and olive mill wastewater, respectively, as resources that offer many of these possibilities at the same time, as it would reduce its environmental impact.

The interest in a better use of our renewable resources, together with the development of new products, attracts the attention of many researchers. For example, the development of foams, taking into account the multiple applications of these materials, can be an interesting objective, in particular for the food industry, since they can be used as matrices for food or for the development of materials intended for to food packaging. In the publication [5], the possibilities of using starch, cellulose, and proteins from various plants for this purpose are analyzed. On the other hand, the publication [6], also addresses the possibility of developing new products, in this case, new beverages fermented from renewable resources, specifically, molasses mixed with certain medicinal plants. The effect of the culture medium and two lactic acid bacteria has been studied, both separately and together, on some of the properties of the product obtained, e.g., the content of polyphenols, sugars, aromatic compounds and antioxidant capacity.

The search for new products and applications for existing ones is not limited to the study of the use of by-products, residues, or other renewable resources. The possibilities offered by consolidated products are also considered, such as in the case of sourdoughs, see [7]. This is a complex system in which, from the microbial point of view, fundamentally yeasts and lactic acid bacteria can be found. Although they have traditionally been used to improve the sensory, textural, and other properties of bread and other baked products, new potentials linked to the production of products with higher added-value that are healthier and more natural are being studied, for example, related to the formation of exopolysaccharides and antifungal compounds, all this while using new raw materials that allow optimal flours to be obtained without the problems of allergies and intolerances that are occurring at the moment.

The improvement and optimization of existing processes, as well as the development of new ones, is of great importance in the context of the general objectives indicated earlier. The optimization of any process implies an adequate use of all the material and energy resources that it consumes; therefore, it is possible to increase productivity and reduce the environmental footprint that it supposes. When dealing with an increase in the world population while trying to reduce the impact that population has on the planet, this is of

great importance. Examples of studies that we could classify in this context can be found in other publications of this book. For example, [8,9] deal with the study and modeling of an alternative way of working in the acetification stage of the wine vinegar bioprocess, a product with multiple uses and great importance: For instance, it is a high-quality condiment. For another example, see the publication [10], which deals with the study of the influence of operational variables, temperature, and time on the properties and durability of the processing of another food, sous vide chicken breast fillets; this case is an example of the need to optimize processing conditions in order to reduce the generation of waste from food that has already been prepared and not consumed. Another example that shows the interest in optimizing the use of raw materials could be the one presented in the publication [11], in which the resistance of paper against moisture and oil is analyzed after coating with Poly (-3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) and Polycaprolactone (PCL). The work shows the possibilities and interest in the development of recyclable cellulosic materials that are in contact with food, helping to maintain it.

On the other hand, another topic of interest is related to the development of new processes for obtaining products that are already on the market, or products similar to some already existing ones, but with various advantages in terms of new uses, the use of other raw materials to obtain them or increase the productivity and/or efficiency of the new process. For example, in the publication [12], an interesting topic related to the production of bacterial cellulose is addressed; unlike the cellulose of vegetal origin, this product has a series of properties, among which its high purity, its water-retention capacity, its mechanical resistance, and its biocompatibility can be highlighted, which make it very attractive for various uses. However, the main problem for its development is related to the high production costs. The selection of new producing species could contribute to reduce these costs and the development of specific processes; for this reason, a search for new bacterial species with high cellulose production capability is carried out, Kombucha being one of the most interesting niches where this type of bacteria could be found. Although Kombucha is the result of the activity of a complex microbiota, its bacterial fraction is mainly made up of bacteria of the *Komagataeibacter* genus. Another matter of interest is related to enzymatic processes in which, instead of working with microorganisms, enzymes are previously obtained that, after purification, are used to carry out very specific reactions; in this way, the selectivity of the biotransformations that are intended is much higher, not as it happens in the work with microorganisms. In this context, in order to reuse enzymes as much as possible, a recurring theme is the possibility of immobilizing them on supports and, in this way, being able to retain them. Publication [13] analyzes the behavior of pectinolytic enzymes immobilized on Nylon.

On the other hand, every day, more work is conducted on the development of crops when, for whatever reason, there is no adequate natural environment (terrain, lighting, etc.). In this sense, the use of LED lighting to replace natural light is very interesting. The publications [14,15] address an example of this topic, specifically, the germination and growth of *Ocimum Basilicum* is analyzed, in the absence of natural light, depending on the type of LED light, the fertilizers that are used, the distance between plants, and other aspects. The optimization of the operating conditions of plant growth can be of great interest for various applications.

Finally, the publication [16], in the context of winemaking, deals with an example of the studies that are increasingly important for food production, knowing the processes at their most basic, molecular scale. The current availability of powerful analysis techniques makes it possible to identify, in complex samples, the basic molecules involved in the metabolisms responsible for the biotransformations behind the bioprocesses with which we produce many of our foods or with which we carry out other types of biotransformations. This knowledge is essential to optimize the transformations that are carried out and to improve the quality of the products obtained.

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References

1. Balčiūnaitė-Murzienė, G.; Dzikaras, M. Wheat Germ Agglutinin—From Toxicity to Biomedical Applications. *Appl. Sci.* **2021**, *11*, 884. [CrossRef]
2. Cruz-Casillas, F.; García-Cayuela, T.; Rodriguez-Martinez, V. Application of Conventional and Non-Conventional Extraction Methods to Obtain Functional Ingredients from Jackfruit (*Artocarpus heterophyllus* Lam.) Tissues and By-Products. *Appl. Sci.* **2021**, *11*, 7303. [CrossRef]
3. Silva, G.; Pereira, E.; Melgar, B.; Stojković, D.; Sokovic, M.; Calhelha, R.; Pereira, C.; Abreu, R.; Ferreira, I.; Barros, L. Eggplant Fruit (*Solanum melongena* L.) and Bio-Residues as a Source of Nutrients, Bioactive Compounds, and Food Colorants, Using Innovative Food Technologies. *Appl. Sci.* **2021**, *11*, 151. [CrossRef]
4. Foti, P.; Romeo, F.; Russo, N.; Pino, A.; Vaccalluzzo, A.; Caggia, C.; Randazzo, C. Olive Mill Wastewater as Renewable Raw Materials to Generate High Added-Value Ingredients for Agro-Food Industries. *Appl. Sci.* **2021**, *11*, 7511. [CrossRef]
5. Jarpa-Parra, M.; Chen, L. Applications of Plant Polymer-Based Solid Foams: Current Trends in the Food Industry. *Appl. Sci.* **2021**, *11*, 9605. [CrossRef]
6. Gadhoumi, H.; Gullo, M.; De Vero, L.; Martinez-Rojas, E.; Saidani Tounsi, M.; Hayouni, E. Design of a New Fermented Beverage from Medicinal Plants and Organic Sugarcane Molasses via Lactic Fermentation. *Appl. Sci.* **2021**, *11*, 6089. [CrossRef]
7. De Vero, L.; Iosca, G.; Gullo, M.; Pulvirenti, A. Functional and Healthy Features of Conventional and Non-Conventional Sourdoughs. *Appl. Sci.* **2021**, *11*, 3694. [CrossRef]
8. Álvarez-Cáliz, C.; Santos-Dueñas, I.; Jiménez-Hornero, J.; García-García, I. Modelling of the Acetification Stage in the Production of Wine Vinegar by Use of Two Serial Bioreactors. *Appl. Sci.* **2020**, *10*, 9064. [CrossRef]
9. Álvarez-Cáliz, C.; Santos-Dueñas, I.; Jiménez-Hornero, J.; García-García, I. Optimization of the Acetification Stage in the Production of Wine Vinegar by Use of Two Serial Bioreactors. *Appl. Sci.* **2021**, *11*, 1217. [CrossRef]
10. Haghighi, H.; Belmonte, A.; Masino, F.; Minelli, G.; Lo Fiego, D.; Pulvirenti, A. Effect of Time and Temperature on Physicochemical and Microbiological Properties of Sous Vide Chicken Breast Fillets. *Appl. Sci.* **2021**, *11*, 3189. [CrossRef]
11. Lo Faro, E.; Menozzi, C.; Licciardello, F.; Fava, P. Improvement of Paper Resistance against Moisture and Oil by Coating with Poly(-3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) and Polycaprolactone (PCL). *Appl. Sci.* **2021**, *11*, 8058. [CrossRef]
12. La China, S.; De Vero, L.; Anguluri, K.; Brugnoli, M.; Mamlouk, D.; Gullo, M. Kombucha Tea as a Reservoir of Cellulose Producing Bacteria: Assessing Diversity among *Komagataeibacter* Isolates. *Appl. Sci.* **2021**, *11*, 1595. [CrossRef]
13. Ben-Othman, S.; Rinken, T. Immobilization of Pectinolytic Enzymes on Nylon 6/6 Carriers. *Appl. Sci.* **2021**, *11*, 4591. [CrossRef]
14. Barbi, S.; Barbieri, F.; Bertacchini, A.; Barbieri, L.; Montorsi, M. Effects of Different LED Light Recipes and NPK Fertilizers on Basil Cultivation for Automated and Integrated Horticulture Methods. *Appl. Sci.* **2021**, *11*, 2497. [CrossRef]
15. Barbi, S.; Barbieri, F.; Bertacchini, A.; Montorsi, M. Statistical Optimization of a Hyper Red, Deep Blue, and White LEDs Light Combination for Controlled Basil Horticulture. *Appl. Sci.* **2021**, *11*, 9279. [CrossRef]
16. González-Jiménez, M.; Mauricio, J.; Moreno-García, J.; Puig-Pujol, A.; Moreno, J.; García-Martínez, T. Differential Response of the Proteins Involved in Amino Acid Metabolism in Two *Saccharomyces cerevisiae* Strains during the Second Fermentation in a Sealed Bottle. *Appl. Sci.* **2021**, *11*, 12165. [CrossRef]