Waste2Value

INTERNATIONAL CONGRESS

ABSTRACT BOOK

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Title

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TABLE OF CONTENTS

PREAMBLE

The Organizing Committee, coordinated by ADDLAP – Dão, Lafões and Alto Paiva Development Association and IPV – Polytechnic Institute of Viseu, has the great pleasure to welcome all participants in the Virtual Waste2Value International Congress, to be held on 17th of November 2021.

The Congress will allow the sharing of results obtained during the implementation of the Waste2Value project. This is also a time for sharing activities carried out and planned for the future, providing a space for exchange of experiences between researchers, productive sector and public entities with responsibilities in the sectors, among others.

A range of national and international researchers, industry and public authorities will address key elements of the discussion for a better use of biowaste and conversion into resources and strategies to be adopted that contribute to the implementation of more sustainable and circular agro-food value chains in Portugal.

The Waste2Value Operational Group of the National Rural Network is coordinated by ADDLAP and involves 9 partners, namely the Polytechnic Institute of Viseu, the University of Aveiro and 6 other business organizations from the Center of Portugal - Ancose, Ervital, Indumape, Ovargado, Silvex and Vasco Rocha Pinto.

Waste2Value welcomes your participation in the development of future research on key issues such as the circular economy and climate change, in line with the major challenges of the Circular Economy Action Plan, the European Green Deal and the Plan of Recovery and Resilience to achieve carbon neutrality of EU by 2050.

The Organizing Committee

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Dulcineia Ferreira Wessel, Polytechnic Institute of Viseu, Portugal
Jorge Oliveira, Polytechnic Institute of Viseu, Portugal
Manuel Brito, Polytechnic Institute of Viseu, Portugal

PROGRAM OVERVIEW

09:00h Open session: **Minister of Agriculture**

09:15h Plennary Lecture: **Project Waste2Value**

10:00h Keynote 01: ***Broccoli By-products as Source of Bioactive Ingredients – The Spin-off Experience*.**

Diego A. Moreno. Spanish National Research Council CEBAS-CSIC, Spain

10:20h Keynote 02: ***New Technologies for the Valorisation of Vegetable By-Products.***
Marta Oliván. Centro Tecnológico Agroalimentario, Spain

10:40h **Oral Communications**

13:15h Lunch

14:15h **Pitch Communications**

15:00h **Poster session**

15:40h Keynote 03: ***Novamont Integrated Biorefinery: Developing Low Impact Value Chains***
Stefano Facco, Novamont Spa, Italy

16:00h Round Table: ***How Circular Economy Benefits Business***
| Moderation: Maria Custódia Correia, National Rural Network, Portugal

Inocêncio Amorim - Produção Distribuição Hortícola Litoral, Lda

Jaime Piçarra - Associação Portuguesa dos Industriais de Alimentos Compostos para Animais

Pedro Ribeiro - Federação Portuguesa das Associações Avícolas

Fernando Rocha - Ibero Massa Florestal, S.A.

17:30h Global Debate

18:00h Closing Session: **President IPV, President ESAV, President ADDLAP**

SCIENTIFIC PROGRAM

KEYNOTES LECTURE

[KN01] BROCCOLI BY-PRODUCTS AS SOURCE OF BIOACTIVE INGREDIENTS – THE SPIN-OFF EXPERIENCE

Diego A. Moreno; Raúl Domínguez-Perles; Cristina García-Viguera
Spanish National Research Council, CEBAS-CSIC, SPAIN

[KN02] NEW TECHNOLOGIES FOR THE VALORISATION OF VEGETABLE BY-PRODUCTS

Marta Oliván
Centro Tecnológico Agroalimentario, SPAIN

[KN03] NOVAMONT INTEGRATED BIOREFINERY: DEVELOPING LOW IMPACT VALUE CHAINS

Rosa Puigmont
NOVAMONT SPA, Italy

ORAL COMMUNICATION

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

[O01] UPCYCLING CICHORIUM CROP WASTE INTO FUNCTIONAL FOOD INGREDIENTS

Bart Van Droogenbroeck; Anna Twarogowska
ILVO - Research Institute for Agriculture, Fisheries and Food, Belgium

[O02] CIRCULAR ECONOMY IN WINE SECTOR: VALORIZATION OF DIFFERENT GRAPE BUNCH FRACTIONS (SKINS, SEEDS AND STEMS) AND VINE LEAVES FOR INFUSIONS PRODUCTION

A.C. Correia; M. Esperanza-Valdés; A.M. Jordão
Polytechinc Institute of Viseu, Agrarian School, Portugal

[O03] IMPACT OF OPUNTIA FICUS-INDICA FLOUR ON THE PHYSICO-CHEMICAL PROPERTIES OF WHITE BREAD

Ricardo M. Ferreira; Artur S. Silva; Jorge A. Saraiva; Susana M. Cardoso
LAQV-REQUIMTE, Departament of Chemistry, University of Aveiro, Portugal

[O04] ANTIMICROBIAL EFFECTS OF BLACKBERRY AND JUNIPERUS BY-PRODUCTS: IN VITRO STUDY OF THEIR EFFECTS WITH BIO-PROTECTING STRAINS ON PATHOGEN AND AMINOBIOGENIC STRAINS

Giulia Tabanelli; Federica Barbieri; Vida Šimat; Danijela Skroza; Chiara Montanari
University of Bologna, Department of Agricultural and Food Sciences, Italy

SUSTAINABLE BIOMATERIALS

[O05] FUNCTIONALIZED WASTE CELLULOSE WITH ANTIMICROBIAL ACTIVITY

Maria Luisa Testa; Paola Alletto; Claudia Vineis; Valeria La Parola; Enzo Laurenti; Maria Laura Tummino

Instituto per lo Studio dei Materiali Nanostrutturati, ISMN-CNR, Italy

[O06] FROM SPENT COFFEE GROUNDS TO POLYSACCHARIDE-BASED MICROPARTICLES FOR PULMONARY INSULIN DELIVERY

Sara A. Valente; Guido R. Lopes; Lisete M. Silva; Margarida Almeida; Paula Ferreira; Manuel A. Coimbra; Cláudia P. Passos

LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

[O07] DEVELOPMENT OF ANTI-INFLAMMATORY STARCH-BASED FILMS USING POTATO AND TOMATO BYPRODUCT-DERIVED MOLECULES

Paloma Lopes; Joana Tulha; Catarina R. Almeida; Sílvia Petronilho; Idalina Gonçalves

CICECO, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal

[O08] BIOCHAR DERIVED FROM BEAN BY-PRODUCT AS A SUSTAINABLE SUPPORT OF ZINC OXIDE NANOPARTICLES TO PRODUCE ANTIMICROBIAL AND ELECTRICALLY CONDUCTIVE COMPOSITES

Zélia Alves; Nuno M. Ferreira; Gonçalo Figueiredo; Sónia Mendo; Cláudia Nunes; Paula Ferreira

CICECO, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal

GENERATING ENVIRONMENTAL BENEFITS

[O09] DEGRADATION OF CAFFEIC ACID BY UV-A-FENTON SYSTEM

Nuno Jorge; Ana R. Teixeira; José R. Fernandes; Ivo Oliveira; Berta Gonçalves; Marco S. Lucas; José A. Peres

University of Vigo, Spain

[O10] ENERGY STORAGE IN SUPERACTIVATED BIOCHAR FROM RICE WASTES

Chiara Milanese; Ilaria Frosi; Adele Papetti; Alessandro Girella; Vittorio Berbenni; Giacomo Magnani; Daniele Pontiroli; Mauro Riccò

University of Pavia, Department of Chemistry, Italy

[O11] FOOD BY-PRODUCTS AS ORGANIC COAGULANTS FOR WASTEWATER TREATMENT

Rita Beltrão Martins; Nuno Jorge; Anabela Raymundo; Ana I.R.N.A. Barros; José A. Peres

CITAB, University of Trás-os-Montes e Alto Douro, Portugal

WASTE MITIGATION SOLUTIONS

[O12] MODEL2BIO. MODELLING TOOL FOR GIVING VALUE TO AGRI-FOOD RESIDUAL STREAMS IN BIO-BASED INDUSTRIES

Tamara Fernández Arévalo
CEIT, Basque Research and Technology Alliance, Spain

[O13] FIGHTING WINERY WASTE: GIVING A SECOND LIFE

Irene Gouvinhas; Ana Isabel de Barros
CITAB, University of Trás-os-Montes e Alto Douro, Portugal

[O14] WINTER SAVORY AND LEMONGRASS BYPRODUCTS USED IN THE DEVELOPMENT OF ANTIMICROBIAL BIOPLASTICS

Mariana Vala; João Cruz; Sónia Ferreira; Paulo Brites; Pedro Teixeira; Isabel Henriques; Paula Ferreira, Elisabete Coelho, Idalina Gonçalves
CICECO, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal

PITCH COMMUNICATIONS

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

[PITCH01] UTILIZATION OF RICE MILLING BY-PRODUCTS

Neşe Yilmaz Tuncel, Necati Barış Tuncel
Çanakkale Onsekiz Mart University, Turkey

[PITCH02] VALORIZATION OF PINE NUT SKIN THROUGH MICROWAVE-ASSISTED EXTRACTION OF BIOACTIVE COMPOUNDS

Soraia P. Silva; Guido R. Lopes; Manuel A. Coimbra; Elisabete Coelho
LAQV - REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

[PITCH03] ASSESSMENT OF BIOMETHANE POTENTIAL PRODUCTION FROM MEDITERRANEAN FEEDSTOCKS CO-DIGESTION

Valenti F.; Selvaggi R.
University of Catania, Department Di3A, Italy

[PITCH04] HYDROLATES AS POTENTIAL BIOPRESERVATIVES IN FOOD

Annalisa Serio; Chiara Rossi; Francesca Maggio; Chiara Purgatorio; Clemencia Chaves Lopez; Antonello Paparella
University of Teramo, Faculty of Bioscience and Technology for Food, Agriculture and Environment, Italy

[PITCH05] ADD VALUE TO TOMATO AND POTATO BY-PRODUCTS

Marco Consumi; Gabriella Tamasi; Claudio Rossi
University of Siena, Department of Biotechnology, Chemistry and Pharmacy, Italy

SUSTAINABLE BIOMATERIALS

[PITCH06] REPURPOSING POTATO CHIPS INDUSTRY BYPRODUCTS IN THE ACTIVE BIOPLASTICS PRODUCTION

Ana Marta Peixoto; Sílvia Petronilho; Rosário Domingues; Fernando Nunes; Idalina Gonçalves; Manuel António Coimbra
LAQV - REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

[PITCH07] REUSING POTATO CHIPS INDUSTRY BYPRODUCTS IN THE DEVELOPMENT OF HYDROPHOBIC AND FLEXIBLE STARCH-BASED FILMS

André Oliveira; Silvia Petronilho; Rosário Domingues; Fernando Nunes; Idalina Gonçalves; Manuel A. Coimbra
LAQV - REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

[PITCH08] BIOCASCADING APPROACH IN THE AGRO-RESIDUES VALORIZATION: THE BIOCOMPOSITE PRODUCTION AS A PROLIFIC CONTRIBUTION TO THE CIRCULAR ECONOMY

Micaela Vannini; Laura Sisti; Paola Marchese; Grazia Totaro; Annamaria Celli
University of Bologna, Department of Civil, Chemical, Environmental, and Materials Engineering, Italy

[PITCH09] BREWER'S SPENT YEAST POLYSACCHARIDES FOR FOOD PACKAGING DEVELOPMENT

Sérgio Viduêdo; Sofia F. Reis; Cláudia Nunes; Elisabete Coelho; Manuel A. Coimbra
LAQV - REQUIMTE, University of Aveiro, Aveiro, Portugal

[PITCH10] CARDOON A SUSTAINABLE CULTURE WITH POTENTIAL FOR INNOVATIVE BIO-BASED PRODUCTS

Paulo Barracosa; Mariana Barracosa; Euclides Pires
Polytechinc Institute of Viseu, Agrarian School, Portugal

GENERATING ENVIRONMENTAL BENEFITS

[PITCH11] SHORT ROTATION COPPICES AS RENEWABLE ENERGY SOURCE: A PROFITABILITY ANALYSIS

Giuseppina Rizzo; Testa Riccardo; Schifani Giorgio; Giuseppina Migliore
Università degli Studi di Palermo, Palermo, Italy

WASTE MITIGATION SOLUTIONS

[PITCH12] VEGETATIVE PARTS OF HUMULUS LUPULUS L. AS A SOURCE OF HIGH-VALUE BIOACTIVE COMPOUNDS

Olívia R. Pereira; Maria João Sousa; Gleiciara Santos; Beatriz Gullón
CIMO,Instituto Politécnico de Bragança, Portugal

[PITCH13] WASTE ELIMINATION PROCESSES: FROM LEAN TO KAIZEN IN THIRD SECTOR ORGANIZATIONS

Ana Branca Carvalho; António Pinto; Carolina Cesário; Daniela Santos; Mariana Saraiva
CISeD, Polytechinc Institute of Viseu, Technology School of Lamego, Portugal

[PITCH14] VALORISATION OF CARDOON TO PRODUCE BIOCHAR WITH ADSORBENT PROPERTIES

Sónia S. Ferreira; Luís Rodrigues; Paula Ferreira; Elisabete Coelho; Manuel A. Coimbra
LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

POSTER

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

[P01] CORN COB (ZEA MAYS L.) AS A POTENTIAL SOURCE OF BIOACTIVE COMPOUNDS: COMPARISON OF DIFFERENT EXTRACTION METHODS

Ilaria Frosi; Chiara Milanese; Adele Papetti
University of Pavia, Drug Sciences Department, Italy

[P02] VALORIZATION OF BY-PRODUCTS FROM CRAFT BEERS INDUSTRY: PHYTOCHEMICAL CHARACTERIZATION OF SPENT GRAINS AND HOPS

Cristiana Breda; Irene Gouvinhas; Ana Barros
CITAB, University of Trás-os-Montes e Alto Douro, Portugal

[P03] HOW TO PROFIT FROM AN INDUSTRIAL BY-PRODUCT OF ELDERBERRY JUICE?

Cláudia M. B. Neves, Élia Fogeiro, António Pinto, Fernando Gonçalves, Dulcineia F. Wessel
Polytechnic Institute of Viseu, Agrarian School, Portugal

[P04] DOSE EFFECT OF SAVORY (*SATUREJA MONTANA*) FEED SUPPLEMENTATION IN SMALL INTESTINE MORPHOMETRY

Jorge Oliveira; Helena Vala; Catarina Coelho; Carla Garcia; Adelaide Perdigão; Dulcineia Wessel
CERNAS-IPV Research Centre, Polytechnic Institute of Viseu, Agrarian School, Portugal

[P05] CARDOON FEED SUPPLEMENTATION IN RABBITS: REFLECTIONS ABOUT A PUTATIVE IMMUNITARY EFFECT

Jorge Oliveira; Edite Teixeira-de-Lemos; Paulo Barracosa; Catarina Coelho; Dulcineia Wessel
CERNAS-IPV Research Centre, Polytechnic Institute of Viseu, Agrarian School, Portugal

[P06] SAVORY (SATUREJA MONTANA) BY-PRODUCT SUPPLEMENTATION IN BROILERS: EFFECT IN INTESTINAL ESCHERICHIA COLI AND ENTEROBACTERIACEAE POPULATIONS

Jorge Oliveira; António Pinto; Catarina Coelho; Adelaide Perdigão; Dulcineia Wessel
CERNAS-IPV Research Centre, Polytechnic Institute of Viseu, Agrarian School, Portugal

SUSTAINABLE BIOMATERIALS

[P07] COULD BE ARTHROSPIRA SP. A SUSTAINABLE SOURCE OF BIOACTIVE COMPOUNDS? EVIDENCE OF ANTIOXIDANT, ANTIGENOTOXIC AND CYTOPROTECTIVE PROPERTIES

Vera Castro; Ana Teixeira; Celina Parreira; Rui Oliveira; Alberto C.P. Dias
University of Minho, Portugal

WASTE MITIGATION SOLUTIONS

[P08] RESOURCE EFFICIENCY OPTIMISATION OF SECOND CLASS VEGETABLES VIA BIOREFINERY SOLUTIONS TO IMPROVE SUSTAINABILITY IN THE AGRIFOOD CHAIN AND CLIMATE CHANGE RESILIENCE : THE EUROPEAN PROJECT “DEMETER”

Carine Le Bourvellec
INRAE - National Research Institute for Agriculture, Food and Environment, France

[P09] AGRO-FOOD WASTE AS POTENTIAL NATURAL HERBICIDES IN SPRING-SUMMER CROPS

Sara Barbosa; Cristina Galhano; Rosa Guilherme; Paula Lorenzo
Polytechnic of Coimbra, Agrarian School, Portugal

[P10] EGGSHELLS AND POTATO WASHING SLURRIES AS RENEWABLE LIGHTWEIGHT FILLERS FOR POLYSTYRENE-BASED MATERIALS

Martins C.; Vallejo M.; Brites P.; Santos J.; Nunes C., Coimbra, M. A., Ferreira, P.; Gonçalves, I.
CICECO, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal

[P11] VEGETATIVE PARTS OF HOP AND BREWERIES BY-PRODUCTS: FROM WASTE TO COSMETIC

Olívia R. Pereira; Maria João Sousa; Gleiciara Santos
CIMO, Instituto Politécnico de Bragança, Portugal

[P12] MATRIX OF BIOWASTE IN THE CENTER REGION. WASTE2VALUE SURVEY RESULTS

Cristina A. Costa; Ana Catarina Ferreira; Maria José Nogueira; Dulcineia Wessel
Polytechnic Institute of Viseu, Agrarian School, Portugal

[P13] INTEGRATED VALORIZATION OF PINUS PINEA BY-PRODUCTS IN ADDED-VALUE APPLICATIONS

Élia Fogeiro; Cláudia M B Neves;, Susana M. Cardoso;, Dulcineia Ferreira Wessel
LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Portugal

[P14] FOCUS GROUPS TO ASSESS AGRI-FOOD BIOWASTE VALORIZATION PERCEPTION AMONG STAKEHOLDERS

Joana Neto; Ana Catarina Ferreira; Maria José Nogueira; Dulcineia Wessel; Cristina Parente; Cristina Amaro da Costa
Universidade do Porto, Faculdade de Ciências, Sustainable Agrifood Production Research Center, Vairão, Portugal

[P15] CATEGORIZATION OF FARM BY-PRODUCTS THROUGH PRELIMINARY RECOGNITION OF THEIR BIOACTIVE POTENTIAL

Manuel Brito; Ana Catarina Ferreira; Dulcineia F. Wessel
Polytechnique Institute of Viseu, Agrarian School, Portugal

[P16] DRYING OF BY-PRODUCTS FROM AGRICULTURAL PRODUCTION AND AGRI-FOOD INDUSTRY

Carlos Pereira; Alberto Castro; Pedro Cardão; Tânia Ferreira; Ana Tavares; Sérgio Lopes; Dulcineia Wessel
CISeD, Polytechnique Institute of Viseu, Technology and Management School, Portugal

KEYNOTES LECTURE

KN01 <

BROCCOLI BY-PRODUCTS AS SOURCE OF BIOACTIVE INGREDIENTS – THE SPIN-OFF EXPERIENCE

Diego A. Moreno[1(*)]; Raúl Domínguez-Perles[1]; Cristina García-Viguera[1]

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The agro-food production entails the disposal of vast amounts of solid residues, which is another serious environmental problem in developed and developing countries. The most widely implemented destination of agro-food wastes is disposal. Annually, billions of tons of agriculture residues are discarded and the possibilities to exploit them in practical ways intended to be incorporated in industrial scale-up processes of the added-value chain represents opportunities for innovation. For instance, broccoli by products (harvest remains) are responsible of important environmental problems, since more than 75% of the aerial biomass is discarded after harvest, mainly used as animal feedstuff or as a source of glucosinolate standards. However, the boosted broccoli crop productions for the growing international exports to Europe and Middle Asia, in the last few years makes unbearable to manage such amount of by-products generated every year. The development of a spin-off company to offer a pipeline of products for commercialization – Aquaporins & Ingredients SL, facilitated the effective transfer of technology from public R&D results to industry products, with a broad spectrum of applications in this global era of plants for food and health.

KN02 <

NEW TECHNOLOGIES FOR THE VALORISATION OF VEGETABLE BY-PRODUCTS

Marta Oliván[1] (*)

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Currently, the European food industry generates around 100 Mt of waste, leading to a serious environmental problem, which is driving the food industry towards a circular economy, looking for new ways of exploitation, such as the use of advanced technologies to improve the extraction of bioactive compounds. One of these is the microwave-assisted extraction (MAE), which causes rapid heating that breaks up the cells, favouring the diffusion of the compounds. Ctic Cita has used the microwave-assisted extraction to improve the extraction of by-products from vegetable waste, which are rich in health-related compounds and might present technological functions. To obtain the by-products, microwaves has been used at different powers 1000W (25%), 2000W (50%), 3000W (75%), and 4000W (100%) for different times. The physicochemical quantification is carried out by spectrophotometric analysis, checking whether the quantity of these compounds increases as the sample stabilises. The best results are obtained by increasing the power and shortening the times. Thanks to this work, it has been proven that compounds are found in the by-products stabilised by microwave.

KN03 <

NOVAMONT INTEGRATED BIOREFINERY: DEVELOPING LOW IMPACT VALUE CHAINS

Stefano Facco, Novamont Spa, Italy

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ORAL COMMUNICATION

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

O01 <

UPCYCLING CICHORIUM CROP WASTE INTO FUNCTIONAL FOOD INGREDIENTS

Bart Van Droogenbroeck[1(*)]; Anna Twarogowska[2]

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In Europe, crops from the Cichorium genus (Asteraceae) are economically important, especially in Belgium, the Netherlands, France, and Italy. The most valuable and well-known leafy vegetables on the European market are Belgian endive (*Cichorium intybus* var. *foliosum*), Radicchio rosso (*Cichorium intybus var*. *foliosum*) and endive (*Cichorium endivia*). At the same time, industrial chicory (Cichorium intybus var. sativum) is grown for the extraction of inulin. Unavoidably, food waste and by-products are generated during the production of the edible Belgian endive crop. White Belgian endive heads are forced during a 21 day period in the dark at 16–20 °C. Each year in the EU, approximately 300,000–400,000 tons of forced roots are produced but they currently have no high-value use, often with a fate as compost or animal feed. However, these forced roots are a very interesting feedstock for a biorefinery concept: they are available year-round and have an attractive chemical composition, being rich in sugars, dietary fibres (DF) and bioactive compounds such as phenolic compounds (PC) and sesquiterpenes lactones (SLs).

A simple, cost-efficient biorefinery process was set up to prepare dietary fibre powders from forced roots of the Belgian endive and to assess their potential as a fibre-rich functional food ingredient. Dietary fibre concentrates (DFC) that are low in sugar and neutral in taste are sought by the food industry to increase DF content and improve texture in food products. The chemical composition, bioactive compounds and dietary fibre profile of the obtained powders were characterised, and their functional properties were evaluated. Additionally, sugars and short-chain carbohydrates, phenolic acids and sesquiterpene lactones in the aqueous extracts were characterised to estimate its potential for further valorisation in food and drink applications.

As a control, non-treated forced roots powder (FRP) was tested. Water extraction significantly ($p < 0.05$) decreased the content of sugars, phenolic acids and sesquiterpene lactones (SL) in DFC. In contrast, total dietary fibre concentration (TDF) was higher in DFC (81.82 g/100 g DW) in comparison to FRP (49.04 g/100 g DW). DFC offers an excellent water holding capacity (WHC) of 14.71 g water/g DW and a swelling capacity (SWC) of 23.46 mL water/g DW, confirming its potential as a functional food ingredient. Application in a broad range of food products such as bakery and plant-based or hybrid meat burgers are currently investigated in collaboration with food industry.

O02 <

CIRCULAR ECONOMY IN WINE SECTOR: VALORIZATION OF DIFFERENT GRAPE BUNCH FRACTIONS (SKINS, SEEDS AND STEMS) AND VINE LEAVES FOR INFUSIONS PRODUCTION

A.C. Correia[1]; M. Esperanza-Valdés[2]; A.M. Jordão[1,3*]

[1] Polytechnic Institute of Viseu;

[2] Technological Institute of Food and Agriculture, CICYTEX - INTAEX Junta of Extremadura, Badajoz, Spain

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The valorization of agro-industrial waste represents one of the most important challenges of biotechnology research, contributing to the sustainability of the sector. Large amounts of grape bunch fractions (skins, seeds and stems) residues are produced annually during wine production. In addition, from the vineyards, vine leaves after grape harvest are often left on the vine itself or used namely as organic material for fertilization and not valorized.

In recent years, the consumption of teas and herbal infusions has increased in the world and created a new market opportunity for new entries to the herbal tea market. Herbal infusions can be prepared from a great diversity of edible, aromatic, and plant fractions. Thus, the potential use of grape bunch fractions or vine leaves for infusions production may be an interesting option for the habitual infusion consumers, opening up the range of options for this type of product and, at the same time, increasing the economical valorization of residues from winemaking process and from the vine plant itself. Moreover, these infusions may be a potential alternative source of bioactive compounds for the human diet, besides being caffeine-free infusions, which may be a further advantage because some consumers have some sensitivity to this compound found in teas. In recent years, we have been studying the possible valorization of winemaking residues and vine leaves through their use in infusions production. Thus, the present study describes the recent knowledge of the chemical composition of grape skin, seeds, stems and vine leaf infusions concerning different perspectives, such as their phenolic and amino acid profile, mineral composition and sensory description and evaluation. For this, row material from several red and white grape varieties from Portugal and Spain were used. Furthermore, some of the results obtained were compared with the “traditional” herbal infusions, namely chamomile and black tea.

Our results revealed that the infusions prepared with grape stems showed the highest total phenolic content (average value of 54.7 mg/L gallic acid eq.), followed by the infusions produced from skins (average value of 36.5 mg/L gallic acid eq.), vine leaves (average value of 26.07 mg/L gallic acid eq.) and seeds (average value of 25.1 mg/L gallic acid eq.). Ala, Gaba, Leu, and Phser were the most important amino acids in infusions of leaves. With respect to mineral composition, K, Ca and Na, were the three major mineral components quantified in the different vine leave infusions produced. Finally, for sensory evaluation the better scores were attributed to the infusions produced from vine leaves followed by the stems, skins and seeds infusions.

All of these results will be important to improving the knowledge about the quality of infusions produced from different fractions of grapes and vine leaves, and contribute to improve the economical valorization of products derived from vines and grapes.

O03 <

IMPACT OF OPUNTIA FICUS-INDICA PEEL FLOUR ON THE PHYSICO-CHEMICAL PROPERTIES OF WHITE BREAD

Ricardo M. Ferreira[1,*]; Artur S. Silva[1]; Jorge A. Saraiva[1]; Susana M. Cardoso[1]

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Bread is consumed worldwide with an average consumption of 26.6 kg per person per year and annual sales revenue of USD 437.2 billion1. However, the consumption of white bread is associated with a high glycemic index (GI) and is also a major source of salt in the diet. So, due to the increasing public health concerns, efforts are being made to develop nutritionally fortified breads with both lower glycemic index capacity and health-promoting properties. Recently, the substitution of wheat flour for other, fruit and vegetable, flours has been tested to improve wheat bread quality2,3. In this work, the dried peel of *Opuntia ficus-indica*, ie a subproduct of prickly pear juice production, was used as an ingredient to produce fortified bread. The addition of 25% of prickly pear (red, orange, and white cultivars) peel flours in wheat breads was investigated and compared to the addition of 25% oat flour and to the use of wheat flour. After baking, the breads were milled and the contents of fiber, ash, protein, and total carbohydrates content were determined following the AOAC 2020 and the Dubois procedures, respectively. The antioxidant capacity of the bread extracts was accessed by the ABTS+●, NO●, SO●, DPPH● scavenging assays as well as the reducing power, whereas the total phenolic compounds (TPC) and total flavonoid concentration (TFC) were measured by the Folin–Ciocalteu and the Aluminium chloride methods, respectively. Additionally, the individual phenolic compounds and betalains in the prickly pear fortified breads were identified by UHPLC-DAD-ESI-MSn analysis. The addition of prickly pear flour resulted in a twofold increment of the ash and fiber content and a fourfold increase in the total carbohydrates while the percentage of protein decreased slightly. As for the antioxidant capacity, the addition of prickly pear peel flour allowed, for all the three cultivars tested and contrary to the control group, to have measurable and relatively high results for all the methods applied. Furthermore, it promoted an increase in phenolic levels of breads, particularly for piscidic acid, eucomic acid and isorhamnetin 3-O-rutinoside-rhamnoside. Globally, it was observed better overall results for both orange and white cultivars when compared to the red cultivar, since they have a higher fiber and protein content, as well as greater antioxidant capacity and TPC

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O04 <

ANTIMICROBIAL EFFECTS OF BLACKBERRY AND JUNIPERUS BY-PRODUCTS: IN VITRO STUDY OF THEIR EFFECTS WITH BIO-PROTECTING STRAINS ON PATHOGEN AND AMINOBIOGENIC STRAINS

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In this study the possible interactive effects between Lactic Acid Bacteria (LAB) bio-protective strains and bioactive extracts or essential oils obtained from blackberry and juniperus by-products were evaluated in culture media. In particular, the effects of supernatants of antimicrobial strains belonging to *Latilactobacillus sakei* or *Latilactobacillus curvatus* species on the growth of Listeria monocytogenes and amino-biogenic Enterococcus faecium alone or in combination with bioactive extracts/essential oils (added at sub-lethal concentrations) have been investigated. The samples were collected overtime to assess growth performances, culturability, viability, and in the case of aminobiogenic strains, biogenic amine accumulation. The cell deactivation or growth kinetics have been modelled via Gompertz equation to predict parameters as maximum growth rate or lag phase duration or maximum cell growth in different conditions. Moreover, samples were analysed by flow cytometry (FCM) to monitor the physiological state of target microorganism cells subjected to stresses and investigate the mechanisms of antimicrobial action of bio-protective strains and bioactive extracts/essential oils against the target microorganisms at cellular level. The data showed that the essential oils were able to delay the growth of *Listeria monocytogenes*, allowing to reach maximum cell loads lower than 99-99.9% compared to the control (i.e., growth in the absence of antimicrobic compounds). The use of extract permitted to have a reduction of pathogen growth, except for blackberry extract, which had scarce effect on cells. Bioprotective culture supernatants had a strain dependent effect on target cell growth kinetics. To better investigate this issue, samples were collected for FCM analysis. The dual staining procedure confirmed the presence of injured and dead cells in the samples added with the extract or essential oils. A similar trend was highlighted for Ent. faecium strain and the delay in cell growth was reflected in biogenic amine production. In fact, the juniperus extracts determined a reduced accumulation of these compounds during incubation while the addition of blackberry essential oils allowed a scarce production of tyramine. These results showed promising potential of the application of blackberry and juniperus by-products essential oils or extracts, also in combination with bio-protecting culture supernatants. Further investigations will be necessary to better study their possible interactions and to optimize their use in food matrices.

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O05 <

FUNCTIONALIZED WASTE CELLULOSE WITH ANTIMICROBIAL ACTIVITY

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Soybean hulls are one of the main by-products of soybean crushing and they are usually destined to become a putrescible waste. In a previous study, exhausted soybean hulls after the extraction of soybean peroxidase (an enzyme used for different applications) were employed as adsorbents of aqueous metal contaminants for water remediation [1]. In this work, such waste of soybean hulls were subjected to an acid-base treatment to isolate cellulose. The obtained material was functionalized with amino propyl groups [2] for the achievement of new sustainable materials with antimicrobial properties. For comparison purpose, analogous materials were synthesized starting from commercial cellulose. The amino-functionalization process resulted effective, since the antimicrobial activity of all the modified celluloses -tested by preliminary trials following the ASTM E 2149-2013 procedure- was outstanding against both Gram positive and Gram-negative bacteria. Particular attention was paid to the efficiency and sustainability of all the chemical processes with the use of waste materials, green solvents and sustainable procedures. The physical-chemical features of the samples were analyzed by several techniques such as electron scanning microscopy, infrared spectroscopy, thermogravimetry, differential scanning calorimetry. Preliminary results showed as the different synthetic procedures and the different starting cellulose samples influenced both the thermal stability and the microstructural order.

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O06 <

FROM SPENT COFFEE GROUNDS TO POLYSACCHARIDE-BASED MICROPARTICLES FOR PULMONARY INSULIN DELIVERY

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Spent coffee grounds (SCG) are by products from espresso coffee preparation. SCG are still rich in polysaccharides, such as galactomannans (GM) and arabinogalactans (AG). As biocompatible and biodegradable molecules, GM and AG are promising vehicles for insulin delivery. Insulin is a protein highly susceptible to degradation, requiring carriers to maintain stability during powder preparation. Insulin may be administered via the pulmonary route, a non-invasive alternative to injections [1]. In this study, GM- and AG-based microparticles capable of carrying, protecting, and delivering insulin were developed. GM and AG were extracted from SCG by the eco-friendly technology Microwave Assisted Extraction (MAE), at 150 ºC and 180 ºC, respectively [2]. The extracts were ultrafiltered (5 kDa) to isolate the high molecular weight material. The samples were assessed for their sugar composition and spray dried with insulin (10% w/w). The resulting microparticles were assessed for their size and morphology using scanning electron microscopy. Insulin release kinetics were evaluated by HPLC. Sugar analysis confirmed the occurrence of GM-rich and AG-rich fractions. Both GM- and AG-based microparticles presented sizes between 1-5 µm, a prerequisite for achieving alveolar deposition, and raisin-like morphologies. GM-based microparticles released insulin in a continuous and gradual manner, while insulin release from AG-based microparticles presented a sigmoid release profile, suggesting that the insulin release is dependent on the polysaccharide carrier. Both types of microparticles released around 86% of their insulin content during the 60 min tested. Our results demonstrate that GM and AG can be used to form microparticles able to carry insulin, which showed to have promising features for its efficient delivery via the pulmonary route. These results thus demonstrate the applicability of coffee waste in the development of pharmaceutical formulations.

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O07 <

DEVELOPMENT OF ANTI-INFLAMMATORY STARCH-BASED FILMS USING POTATO AND TOMATO BYPRODUCT-DERIVED MOLECULES

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Agrifood byproducts are often discarded or delegated to low-value applications despite being rich in valuable molecules that can be used for new products development, such as sustainable and functional wound dressings. Currently, wound dressings are mainly made of non-biodegradable plastics that are environmentally unsustainable. As alternative, the use of natural polymers with primary food application has been considered, raising ethical and societal issues.

Agrifood by products-derived molecules can help overcome this dilemma. In this work, potato and tomato by products were used to develop biobased materials with anti-inflammatory properties with interest for wound healing application, following a circular concept. The influence of different concentrations (1%, 5%, and 10% w/w in relation to starch dry weight) of tomato pomace-derived aqueous extract (TE) on physicochemical, mechanical, and anti-inflammatory properties of starch-based films was studied. TE showed a protein, sugar, and phenolic content of 14.7%, 15.2%, and 2.8%, respectively, and 19% of radical scavenging activity per mg of extract. TE conferred a yellowish coloration to starch-based films, maintaining their transparency. Films' rigidity and traction resistance decreased up to 58% and 50%, respectively, while their stretchability increased up to 36%, at 10%TE, thus becoming more flexible. TE also originated starch-based films with hydrophobic and hydrophilic surfaces, with water contact angles ranging from 68˚ up to 111˚, and lower water solubility (-33% with 5%TE) than the pristine materials. Finally, 10% TE/starch-based films had a maximum anti-inflammatory activity of 48%, decreasing the secretion of tumor necrosis factor α (TNF-α) by THP-1 cells stimulated for 24h with bacterial lipopolysaccharide (LPS). As such, potato- and tomato pomace-derived molecules allowed to develop anti-inflammatory biobased films, offering an opportunity for their valorisation through the development of active biobased wound dressings.

Acknowledgements

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O08 <

BIOCHAR DERIVED FROM BEAN BY-PRODUCT AS A SUSTAINABLE SUPPORT OF ZINC OXIDE NANOPARTICLES TO PRODUCE ANTIMICROBIAL AND ELECTRICALLY CONDUCTIVE COMPOSITES

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Biomass waste is a carbon-rich and renewable source with high potential for producing graphene-like materials, such as biochars. These materials can become green substitutes of carbon structures derived from graphite that normally require time-consuming and expensive methodologies [1]. In this work, biochars produced by the pyrolysis of kidney bean pods were functionalized with zinc oxide particles to produce active and electrically conductive composites for food packaging materials. At an early stage, several experiments were carried out to investigate the effect of the pyrolysis temperature, residence time, and time of air oxidation on biochar properties. The specific surface area (SBET) of biochars improved, mainly, with the increase of the pyrolysis temperature and with a short time of air oxidation, while the graphitization degree and electrical conductivity (EC) significantly reduced with increasing the time of air oxidation. Secondly, the biochar with the highest SBET and the biochar with the highest EC were used as support to produce zinc oxide nanoparticles by a green solvothermal methodology. The produced biochar-ZnO composites demonstrated greater SBET and EC properties than the ZnO composites supported onto the graphene sheets (ZnO-rGO). Furthermore, both biochar-ZnO composites showed antibacterial activity similar to that of ZnO-rGO, but greater than that of pristine ZnO particles. Therefore, it can be inferred that biochar derived from bean by-products is a sustainable alternative of graphene sheets to produce active and electrically conductive ZnO composites.

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GENERATING ENVIRONMENTAL BENEFITS

O09 <

DEGRADATION OF CAFFEIC ACID BY UV-A-FENTON SYSTEM

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Among the agro-industrial wastewaters, the winery wastewater is considered toxic to the environment due to the presence of high content of polyphenols [1]. The caffeic acid (CA) is considered to be one of the most refractory phenolic compounds to biologic degradation, because it exhibits high toxicity and antibacterial activity and represents a risk to human health when exposed to concentrations of 1.3 g/L. To the best of our knowledge no study has ever been performed on the degradation of CA by UV-A-Fenton process, therefore, the aim of this work is (1) optimize the UV-A-Fenton process, (2) evaluate the energy consumption and operational cost of CA degradation and (3) study the phytotoxicity effect of the treated wastewater. The concentration of CA was determined by Ultra-High-Performance Liquid Chromatography (UHPLC) using a C18 reverse phase column (250 × 4.6 mm, 5 µm) with a flowrate of 1 mL min-1 at 25.0 ºC. Experiments were performed in a self-designed lab-scale reactor with 500 mL of capacity employing a UV-A LEDs system was composed by 12 Indium Gallium Nitride (LnGaN) LEDs lamps with a λmax = 365 nm. The results showed that under the best experimental conditions, as follows: [CA] = 5.5x10-4 mol/L, [H2O2] = 22x10-4 mol/L, [Fe2+] = 1.1x10-4 mol/L, pH = 3.0, agitation 350 rpm, temperature = 298 K, radiation UV-A, IUV = 32.7 W/m2, t = 15 min it was achieved a CA removal of 99.9%, with a pseudo first-order kinetic rate of 0.695 min-1. The values of the electric energy per order (EEO) = 7.227 kWh m-3 order-1 and specific applied energy (ESAE) = 13.140 kWh mol-1 order-1 were obtained under the best experimental conditions, with low operational cost (0.599 €/m3). Performance of phytotoxicity tests showed that caffeic acid and UV-A-Fenton process can exercise phytotoxicity effect in onion seeds with low germination index (50.4 and 25.8%), however, tests performed in tomato and radish seeds showed high germination index values after UV-A-Fenton process (149.1 and 94.9%, respectively). **In conclusion,** this work provides an important insight into the application of UV-A-Fenton process in the removal of CA contaminant, especially for wastewater reuse

O10 <

ENERGY STORAGE IN SUPERACTIVATED BIOCHAR FROM RICE WASTES

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Recently biochar, the carbon side-product in the pyrolysis/gasification of residual waste biomasses, started to receive a widespread attention in the field of the electrical energy-storage, thanks to its hierarchical porous structure inherited from biomass precursors, its excellent chemical and electrochemical stability, high conductivity, high surface area and inexpensiveness. In particular, biochar converted to activated carbon (SSA > 1000m2/g) through a chemical activation with KOH appears now to be a new cost-effective and environmentally-friendly carbon material with great application prospect in the field of energy-storage applications.

We report here on the preparation of novel hierarchically-porous super-activated carbon materials originating from biochar derived by the pyrolysis of poultry litter (PL) and of rice waste (bran RB and husk RH). The chemical activation process proved to be efficient to remove the majority of impurities other than carbon, stabilizing highly porous hierarchical structures with local graphene-like morphology. The porous compounds obtained by PL and mixtures of RH + RB demonstrated to behave as excellent electrode materials for high-performance symmetric supercapacitors (SCs), reaching high specific capacitance up to 230 F/g. On the contrary, the material obtained by RB, having specific surface area up to 5000 m2/g, shows a very good hydrogen storage ability, adsorbing up to 4.5 wt % of hydrogen in around 20 seconds at -196°C and around 1.5 wt% at room temperature. Work is in progress to optimize the pyrolysis and activation conditions and to improve the performance of the materials by decoration with transition metals. The availability, the biocompatibility and the inexpensiveness of the starting materials suggest possible large-scale applications for such devices, for example in the field of transportation or in renewable energy-grids, but also in the field of bio-medicine.

O11<

FOOD BY-PRODUCTS AS ORGANIC COAGULANTS FOR WASTEWATER TREATMENT

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Nowadays with the European Green Deal and the Environment protection daily goals, food industry has been forced to rethink and apply new strategies to reach more sustainable processes. The wastewater treatment, in particular, is a step in food production chain, where the use of by-products can be an approach to environment-friendly solutions [1]. Several studies revealed good results with natural coagulants applied in wastewater treatment [2]. In the present work, an elderberry wastewater was treated by coagulation-flocculation-decantation process (CFD), with the aim of (1) application of four by-products from food production as organic coagulants powder (OCP) from chestnut urchin, acorn skin, olive leaves, and grape stem, and (2) compare its efficiency with ferrous sulfate.

The CFD process was optimized by variation of different pH (3, 5, 7, 9) and dosage (0.1, 0.5, 1.0, 2.0 g L−1). The results showed higher removal rate at pH 3.0 for OCPs and pH 5.0 for ferrous sulfate. Under the experimental conditions, as follows: rapid mix 150 rpm/ 3 min, slow mix 20 rpm/ 20 min, sedimentation time 12 h, and with application of 0.1, 0.5, 0.5, 0.5 and 0.1 g L-1 it was 1observed a turbidity removal of 85.8, 82.0, 76.0, 81.9 and 74.9 %, respectively, total suspended solids (TSS) removal of 35.5, 30.5, 26.6, 33.6 and 0.0 %, respectively and a total organic carbon (TOC) removal of 0.0, 15.2, 0.0, 0.0, and 20.1 %, respectively. The high turbidity and TSS removal were observed due to the release of cationic proteins present in the coagulants, which reacted with the negatively charged colloids present in the wastewater. The low TOC removal observed after CFD process with OCPs were due to the presence of organic carbon compounds, as observed by the Fourier-transform infrared spectroscopy (FTIR) spectra. Finally, the sludge volume was measured (14.5, 12.5, 24.5, 16.8, 34.5 mL L−1, respectively), and the results showed that a higher volume of water was recovered with application of OCPs. In conclusion OCPs are a promising technology for wastewater treatment.

WASTE MITIGATION SOLUTIONS

O12 <

MODEL2BIO. MODELLING TOOL FOR GIVING VALUE TO AGRI-FOOD RESIDUAL STREAMS IN BIO-BASED INDUSTRIES

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The agri-food industry generates around 50% of global waste, of which only 36% is recycled, although the potential recovery could be as high as 60%. These residual streams can be used as feedstock for the bio-based industry, provided that the composition, logistics and volume are carefully analysed. The European project MODEL2BIO (H2020-BBI-JTI-2019. No 887191) aims to create a Decision Support System (DSS) for managing residual streams produced in agri-food companies. This will be an innovative concept that using predictive models will be able to select the best ways for valorising these streams considering their composition, seasonality, and industry location among other factors. This innovative MODEL2BIO-DSS tool is based on the interconnection of three complementary elements (simulation module, optimisation algorithm and LCA module). The simulation module is able to predict the mass fluxes for any bio-based residual stream alternatives using a set of compatible model libraries describing the agri-food production lines, the intermediate processes (storage, mixing, separation and transport) and the final valorisation in the bioprocesses. All libraries use the same Components Vector according to the Plant-Wide Modelling (PWM) methodology (Grau et al., 2007; Fernández-Arévalo et al., 2014). The PWM methodology is a systematic and rigorous methodology for constructing mathematical models able to describe the whole systems as complex as required in each case study. This approach facilitates the mass, charge and energy continuity throughout the whole system. The Optimisation algorithm is able to select automatically the bio-based residual stream alternatives that minimise a global cost function previously defined using the mathematical models constructed. Finally, the LCA module estimates the environmental, economic and social impacts associated with any bio-based residual stream alternative using an LCA methodology. The main advantage of the tool is the possibility of giving a holistic solution or prioritisation. Although there are many commercial programs for the simulation of industrial processes, these are mainly based on the analysis of specific facilities, and not on broader analyses with various industries, in which logistics plays a key role. Model2Bio will simulate the entire value chain providing recommendations from a holistic perspective (technical, economic, environmental and social), with the prioritisation of the valorisation possibilities through technical-economic criteria and the final decision through holistic criteria. This will provide a new concept for waste management.

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O13 <

FIGHTING WINERY WASTE: GIVING A SECOND LIFE

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The increase of the population and the climate changes are two of the major critical challenges that the population suffers worldwide, and that requires urgent intervention/answers to keep the availability of sustainable and health promoting food sources for most of the world population. Therefore, it becomes important to search for alternative, functional and sustainable food sources, as well as new added value for traditional food matrices and by-products, that contributes to the circular economy by minimizing waste of valuable resources in the limits of environmental protection. Circular economy allows to integrate agricultural wastes and non-marketable products by means of innovative technologies/practices, as phytochemically abundant functional food or natural substitute to the synthetic health/beauty products.

Given the relevance of the winemaking companies, particularly at Douro region, and the amount of underexploited wastes produced, the development of innovative applications for these organic materials is necessary. In the last years, our research group works revealed the presence of bioactive compounds in winery by-products (WBPs), namely a variety of polyphenols and stilbenes that contribute to remarkable biological activities such as anti-inflammatory, antioxidant and antibacterial, among others. Most recently, a preliminary study developed by the team demonstrated the WBPs extracts capacity to inhibit the growth of some foot wound ulcers bacteria through disc diffusion and minimum inhibitory concentration (MIC) assays, as well as some anti-aging enzymes, revealing that WBPs are valuable candidates as wound healing agents and to prevent some aging processes, respectively.

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O14 <

WINTER SAVORY AND LEMONGRASS BYPRODUCTS USED IN THE DEVELOPMENT OF ANTIMICROBIAL BIOPLASTICS

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Winter savory (WS) and lemongrass (L) are aromatic plants often used for gastronomic and medicinal purposes, whose industrial processing originates stems/leaves that are often wasted and together valuable molecules, such as essential oils, are lost. On the other hand, the need of developing eco-friendly active packaging materials that allow to extend the foodstuff's shelf-life is of major concern. In this work, it was hypothesized that WS and L-derived essential oils and the whole byproducts can be used in the development of antimicrobial bioplastics. The influence of WS and L-derived essential oils and the grinded byproducts on the physicochemical, mechanical, and antimicrobial properties of a bioplastic formulation was studied. From WS and L byproducts were obtained ca. 0.34% ad 1.32% essential oils-rich in carvacrol (ca. 90%) and citral (ca. 89%), respectively, with antimicrobial activity against Staphylococcus aureus. When incorporated into a bioplastic formulation, WS and L-derived essential oils conferred a slightly yellowish coloration to the bioplastics, although barely perceivable at the human eye ($\Delta E < 3$) and decreased the film's surface wettability, without interfering with the material's mechanical performance, except for films containing L-derived essential oils that showed a lower traction resistance than the pristine materials. On the other hand, grinded WS and L byproducts conferred a brownish coloration to the bioplastics; also decreased the film's surface wettability; and increased the material's rigidity. Both bioplastics containing WS and L-derived essential oils or grinded WS and L byproducts inhibited the Staphylococcus aureus growth, thus acquiring antimicrobial properties, being this effect more pronounced when the grinded byproducts were used. Overall, WS and L byproducts revealed to be a great source of antimicrobial molecules with potential to be used in the development of active bioplastics, opening an opportunity for their valorisation.

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PITCH

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

PITCH01 <

UTILIZATION OF RICE MILLING BY-PRODUCTS

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During the commercial milling process, paddy rice is transformed into many fractions. Approximately, 56–58% of white rice, 10–12% of broken rice, 18–20% of husk and 10–12% of rice bran is obtained as a result of the milling process (Kahlon, 2009). In other words, about 40 % of the milled paddy constitutes products other than white rice. The milling process starts with removing the husk or hull to produce brown rice which is also called “cargo”. Husk has a woody structure and not for use as food. Rice husks are often burned to produce energy. Brown rice, which can be considered as whole grain, is composed of starchy endosperm, germ and bran including aleurone. Brown rice kernels may vary in terms of maturity. Although harvest starts when the grains are generally mature, individual kernel maturity may vary widely and hence, immature rice grains are always formed to some extent. Despite being whole grains as their mature counterparts, immature rice grains are thinner and have a greenish or chalky appearance. In order to meet the consumer demands, brown rice is further milled to produce white rice and rice bran, which is the most valuable by-product of rice milling industry, occurs as a result of this polishing step. Composite rice bran may include many fractions such as germ, and broken rice kernels depending on the process. Rice bran and rice germ is also the source of rice bran oil which is another valuable by-product of the process. In conclusion, immature rice grain, rice bran, rice germ, and rice bran oil are the main by-products of rice milling industry. These by-products are generally evaluated as animal feed due to the rancidity problem caused mainly by lipase enzymes. Intact kernel is stable because the deteriorative enzymes and their substrates are physically located in separate zones. However, during milling lipases meet fat and causes hydrolysis of fat to free fatty acids and glycerol which results in rancid flavor and soapy taste in a very short time. On the other hand, these by-products comprise valuable bioactive compounds such as tocopherols, gamma-oryzanol, B group vitamins, minerals, dietary fiber, phenolics and antioxidants and have the potential to be used as value-added commodities in food, nutraceutical, and cosmetic industries when handled and processed accordingly. Some information about characterization and stabilization of rice milling by-products was reviewed.

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PITCH02 <

VALORIZATION OF PINE NUT SKIN THROUGH MICROWAVE-ASSISTED EXTRACTION OF BIOACTIVE COMPOUNDS

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Pine nut skin (PNS) is a by-product with an annual volume of approximately 550 metric tons worldwide [1]. PNS is easily recovered at the nut processing mill, has low moisture content and low density, reducing the costs associated with drying, transportation, and storage. PNS is currently used for heat production, however, the extraction of value-added compounds may allow its use as a functional food ingredient, enabling its valorization. To valorize PNS in the industry, low-cost and time-saving extraction methods must be employed. Microwave-assisted extraction (MAE) allows to attain high temperatures and is considered a green extraction methodology, due to the reduction of extraction time, solvent, and energy consumption [2]. Within this work, the MAE procedure was optimized to extract phenolic compounds from PNS. A full factorial design was used to estimate optimum extraction conditions, namely temperature (120, 150, 180 °C), time (1, 5.5, 10 min), and the ratio of sample mass to volume (w/v) (1, 2, 3 g to 60 mL) on the yield (% w/w), total phenolic content (TPC), and ABTS (free radical scavenging capacity).The three evaluated responses were significantly affected by the temperature, with a higher yield, TPC, and ABTS being obtained at 180 °C. Besides, the yield was affected negatively by w/v, and by the interaction between time and temperature. The interaction between time and w/v was significant on ABTS, which increased with time when the w/v was low and decreased with time when the w/v was high. Thus, the condition giving the best results for the three responses, simultaneously, was 180 °C, 1 min, and 1 g skins, which resulted in 18.8 % (yield), 229.1 mg gallic acid equivalent/g skins (TPC), and 310.5 mg ascorbic acid equivalent/g skins (ABTS).This work demonstrated that PNS could be valorized as a natural source of phenolic compounds, for the food and cosmetic industries.

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PITCH03 <

ASSESSMENT OF BIOMETHANE POTENTIAL PRODUCTION FROM MEDITERRANEAN FEEDSTOCKS CO-DIGESTION

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There is a general consensus that climate change and global warming are the most imminent environmental issues the world is facing today. The goals fixed by the CO2-mitigation European policy are very challenging and encourage to move toward high recycling targets, paving the road from a linear to a circular economy as a real answer for the challenge of globalization. In this context, the biomasses are seen as one of the most dominant future renewable energy sources (Valenti et al., 2018). The agri-food chains generate by-products that represent a potential source of value for other companies and for the society. They constitute a reserve of compounds to be used and exploited through new production cycles, according to the principles of the circular economy (Selvaggi et al., 2018). Co-digestion of different feedstocks to produce biogas in anaerobic digesters, has been widely investigated for enhancing biogas production and recently has become an attractive economic and sustainable possibility for by-products and agricultural residues valorization. Only a few studies have reported that multiple feedstocks were used to carry out co-digestion. In this study the effects of mixing five Mediterranean feedstocks (citrus pulp, olive pomace, poultry manure, Italian sainfoin silage and opuntia fresh cladodes) on biogas production will be investigated by biomethane potential (BMP) test.BMP test as a simple lab-scale method has been widely used to evaluate digestibility of feedstocks and conclude the maximum methane yield of few combined feedstocks (Stromberg et al., 2015). This research will allow to screen the suitability and technical feasibility of some feedstock-mixtures analysed. The data obtained will provide the basis for subsequent pilot scale evaluation of anaerobic digesters fed with these feedstock-mixtures, with the aim of selecting the best feedstock-mixture for enhancing biogas production by reusing by-products and agricultural residues. The adopted approach and the obtained results could facilitate developing biogas production in Mediterranean area as well as in other regions characterised by diverse sources of organic residues.

PITCH04 <

HYDROLATES AS POTENTIAL BIOPRESERVATIVES IN FOOD

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Innovative, effective and environmental-friendly antimicrobial strategies are even more necessary in different fields, including food processing and preservation. In particular, consumers are increasingly oriented towards minimally processed food, without chemical preservatives and with a green image. Among the natural substances, the biological activity of essential oils is well documented, while less information is available about hydrolates, obtained as a residue or by-product from the distillation of the essential oils themselves. The antimicrobial activity of hydrolates depends on their chemical composition, which in many cases involves the presence, albeit in lesser quantities, of the same compounds characterizing the corresponding essential oils (eg carvacrol in Coridothymus capitatus hydrolate). The antimicrobial activity has been proven in vitro against pathogenic bacteria of food interest, such as Listeria monocytogenes and Salmonella spp., as well as against yeasts, and phytopathogenic molds such as Botrytis cinerea and Rhizoctonia solani. Hydrolates effectiveness is often dose-dependent and could determine a bacteriostatic effect in low concentrations, or a bactericidal effect in quantities higher than 0.50 ml/ml. Nevertheless, the most important results regard in situ applications. In particular, the hydrophilic characteristics of the hydrolates make them suitable for the decontamination of industrial surfaces (eg hydrosol of Satureja thymbra), and even for the removal of biofilms (Thymbra capitata against Salmonella spp.). They are effective also in washing and sanitizing of vegetables and fruit to delay post-harvest decay, as observed in citrus fruit, pears and carrots, without affecting the sensory characteristics of the products. T. capitatus hydrosol has been also proved to reduce L. monocytogenes count in rocket salad. In conclusion, the data available underline the effectiveness of hydrolates as antimicrobials and suggest to deepen the research in this field to optimize their application in food products.

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PITCH05 <

ADD VALUE TO TOMATO AND POTATO BY-PRODUCTS

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Tomatoes (*Lycopersicon esculentum*, L.) and potatoes (*Solanum tuberosum* L.) are among the most important worldwide agricultural crops due to their edible parts that are important ingredients in human diet. The first step after the crops consists of mechanical separation the ripe fruits from the unripe ones and from plants. At the end of the process the by-products are usually discharged. Although they do not represent a source of pollution, these may constitute a source of important bioactive compounds. Tomato plants and green tomatoes bio-synthesize tomatine as a defence against fungi and bacteria. The tomatine is a 1:10 mixture of two glycoalkaloids, α-tomatine and dehydrotomatine. The α-tomatine is a potential health promoting effects in cells, animals, and humans. Potato plants bio-synthesize solanesol, necessary to the plant in the immune response towards pathogens. There is an increasing demand for solanesol, since it is widely used in the cosmetic industry as an important intermediate for the synthesis of Q10 coenzyme.

Researches are mainly focused on the edible part of the plants but, the knowlege of the levels of bioactive molecules in the unedible plant and unripe fruits is fundamental to evaluate if the by-products can represet an opportunity to increase the vale of the agricoltural production.

Based on this idea several protcols of extraction and quantification via high performance liquid chromatography coupled with spectrofotometric and mass spectrometry detectors (HPLC-UV, HPLC-DAD/UV, HPLC-MS), were developped and validated to determine levels of glycoalkaloids in tomato and potato by-products. In particular, α-tomatine and dehydrotomatine in unripe tomato and tomato plant were quantified by reverse phase liquid chromatography, coupled with electrospray ionization triple quadrupole tandem mass spectrometry, RP-HPLC-ESI-QqQ-MS/MS. The glycoalkaloids were evaluated in industrial varieties of tomatoes at different ripening stages, commercial varieties of post-harvest ripened fruits, stored at different temperatures conditions. The content of the two glycoalkaloids was also analysed in green tomatoes thermally treated, simulating industrial processing conditions (boiling at 100 °C), and in industrial prototype products containing green tomatoes as ingredients. Thermal treatment does not seem to affect the total tomatine content. Finally, a particular attention was devoted to the determination of tomatine content in plant leaves (at different vegetation stages) and locular gel from fruits, as potential source of bioactive molecules.

The solanesol content was determined in potatoes leaves, collected at different vegetative stages of the plants. The results showed an exponential increase of solanesol content from 11.5 ± 0.2 mg/kg in the baby-leaves to 3681.1 ± 272.8 mg/kg at 144 days from the seeding. These values corresponded to the solanesol content detected in tobacco leaves, that are considered the main source of solanesol.

SUSTAINABLE BIOMATERIALS

PITCH06 <

REPURPOSING POTATO CHIPS INDUSTRY BYPRODUCTS IN THE ACTIVE BIOPLASTICS PRODUCTION

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Food industry byproducts, together with the perishable foodstuff's loss, have promoted environmental and societal concerns. Under a circular economy concept, these byproducts can be valued as a source of biomolecules, such as polysaccharides, proteins, lipids, phenolics, and melanoidins, to develop active biobased materials. Potato chips industry generates byproducts, such as starch-rich washing slurries and brownish frying residues, that have simply been landfilled. In this work, a brownish-derived extract (BrE) and starch, both recovered from potato chips processing, were mixed and gelatinized to form bio-based films. The influence of BrE (5%, 10%, and 15% w/w related to the dry starch weight) on optical, mechanical, physicochemical (solubility, wettability), and active (antioxidant and UV-protective) properties of the films was studied. The incorporation of BrE conferred a yellowish coloration to the starch-based films, while maintaining their transparency. When compared to the pristine films, the extract also improved ca. 2x the traction resistance and elasticity of the films, decreasing concomitantly their hydrophilicity on both surfaces (water contact angles increased ca. 15° and 20° at the upper and down film surfaces, respectively). Moreover, the incorporation of BrE during films production allowed to increase the starch-based films antioxidant activity (from ca. 24% to ca. 94% of ABTS•+ inhibition in 4 h). Besides, the films water solubility and UV protective properties were directly related to the BrE dosage: when compared to the pristine films, as high the BrE amount, lower the films' solubility in water, changing from 12% in the pristine samples to almost 0% in films containing 15% of BrE, and higher their UV radiation absorption capacity, mainly at UV-C and UV-A at 340 and 250 nm, respectively. Therefore, the brownish-derived extract revealed to contain molecules of interest to tune the performance of potato starch-based films, offering a new in-situ strategy to valorize potato chips industry byproducts.

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PITCH07 <

REUSING POTATO CHIPS INDUSTRY BYPRODUCTS IN THE DEVELOPMENT OF HYDROPHOBIC AND FLEXIBLE STARCH-BASED FILMS

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Starch currently stands as a promising candidate for the production of biodegradable films with useful gas barrier and thermoplastic capabilities. However, their hydrophilic and brittle nature stand out as drawbacks that limit their application range. To overcome these weaknesses, in this work it was hypothesized that starch can be hydrophobized and plasticized during the starch-based films production by transesterification. Spent frying oil (SFO) and potassium hydroxide (KOH) powder were used as a triacylglycerides source and alkaline catalyst, respectively, to promote the starch modification. Under a circular economy concept, starch and SFO were obtained from potato washing slurries and potato frying residues, respectively. Different ratios of SFO (w/w related to the dry starch weight) were tested. When compared to the pristine films, the incorporation of at least 15% SFO/KOH gave rise to transparent, hydrophobic (water contact angles of ca. 90º), stretchable (ca. 20x), and elastic (ca. 5x) starch-based films with improved tolerance to water conditions. These improved properties were not observed when the films were produced without the catalyst. FTIR and 1H NMR revealed structural differences among the produced films, suggesting that starch was modified with the SFO-derived fatty acids. Therefore, the incorporation of SFO and KOH during the films production revealed to be a promising strategy to develop bio-based materials with improved hydrophobicity and flexibility while valorizing the potato chips industry byproducts.

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PITCH08 <

BIOCASCADING APPROACH IN THE AGRO-RESIDUES VALORIZATION: THE BIOCOMPOSITE PRODUCTION AS A PROLIFIC CONTRIBUTION TO THE CIRCULAR ECONOMY

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The increasingly pressing demand of civil society to move towards the circular economy models drives the scientific community to explore new routes to fully valorise wastes in order to achieve the zero-waste objective. From this perspective, even the residues of agro-industrial processing must not be considered as a waste, the disposal of which involves an economic cost, but as a potential source of valuable products. Indeed, this kind of leftover biomasses and food production by-products can be particularly rich in proteins, carotenoids, polyphenols, caffeine, and fibres, which could find application in various sectors as food, nutraceuticals, cosmetics and packaging. Within the PROLIFIC project, a range of green and innovative processing technologies to recover significant amounts of the above-mentioned value-added compounds from industrial processing residues of legumes (seeds of peas, beans and chickpeas), fungi (cuttings and mycelia of different species) and coffee (silver skin residue and not compliant roasted seeds) has been tested and developed. The protein extraction has been performed by using environmentally friendly aqueous extraction (EFAE), enzyme-assisted extraction (EAE) and ultrasound-assisted (UAE) and microwave-assisted (MAE) extractions. The resultant residues have been further exploited by using supercritical CO2 extraction (SFE-CO2), subcritical water extraction (SWE) and alkali extraction to recover polyphenols, caffeine and fibres. The described biocascading approach allows actually collecting interesting compounds but also produces an ultimate fibrous waste, which, with the purpose to keep it into the circular economy loop, can be differently valorised. In fact, it is well-known the use of natural fibre residues as filler in polymeric matrices to prepare bio-composites, characterized by decreased costs but retained mechanical properties. Composites based on biodegradable and bio-sourced polymers have been successfully prepared by melt-mixing, with the extracted residues in different ratio but without any additive. All the materials are characterized by high thermal stability and in any case, the temperature of thermal degradation resulted far higher than the polymer processing temperatures. The addition of residues has not affected the crystallization and melting processes of the polymeric matrices. The tensile tests have shown an increment in the Young modulus and a decrement in both the strength and the elongation at break consistent with filler loadings. However, for a reduced amount of filler, the overall properties of the matrix have been retained. Then, the results demonstrate that also the ultimate agro-residues, after the extraction of high value molecules, can be successfully exploited. Finally, it is notable that the obtained material costs can be remarkably reduced and applications in different packaging sectors, such as cosmetic area and food industry, can be taken into consideration.

PITCH09 <

BREWER'S SPENT YEAST POLYSACCHARIDES FOR FOOD PACKAGING DEVELOPMENT

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Brewer's spent yeast (BSY) is an abundant, recyclable and inexpensive by-product of the brewing industry, being a source of valuable compounds, such as glucans and mannoproteins. These compounds are reported to have promising applications1 and can be solubilized from BSY by several extraction methods leading to extracts with different compositions which rule their applications. This work aims to evaluate the production of biomaterials with potential application as food packaging, using different aqueous extracts from BSY. Hot water and alkaline extracts (0.1M and 4M KOH) were tested in the production of films using the solvent casting method (drying at 25-35 °C during 16-24 h) and different percentages of plasticizer (glycerol) and crosslinker (genipin). Both hot water and 0.1M KOH extract films were produced but were highly hygroscopic (water contact angle of 49-87°) and would crack under heavy tension (Young's Modulus of 67 MPa, tensile strength of 2 MPa, elongation at break of 24 % for 0.1M KOH film), displaying a fragile nature. To improve this, sepiolite, a soft white clay mineral was used as a filler in different percentages. Films produced with sepiolite had a light greenish tint and a high resistance. Films with the 4M KOH alkaline extract (23 % of protein and 74 % total sugars with 22 mol% Rib, 30 mol% Glc and 48 mol% Man residues) showed better characteristics. These films were produced by solvent casting (drying at 35 °C during 16 h) using 20 mg sample/cm2, 50 % (w/w) glycerol, 0.2 % (w/v) genipin, and 3.5 % (w/v) sepiolite. The films showed a water contact angle of 52° and a Young's Modulus of 371 MPa, a tensile strength of 8 MPa and an elongation at break of 5 %, meaning that the film had still a hydrophilic nature, albeit being more rigid and strong, being able to be handled. These results show that films with different characteristics may be produced from different aqueous BSY extracts, allowing the production of films that can meet the requirements for a specific food packaging application.

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PITCH10 <

CARDOON A SUSTAINABLE CULTURE WITH POTENTIAL FOR INNOVATIVE BIO-BASED PRODUCTS

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Cardoon (*Cynara cardunculus* L.) is a multi-purpose and versatile Mediterranean crop, adapted to climate change with a wide spectrum of potential applications due its added value as a rich source of fibres, oils and bioactive compounds. The potential use of cardoon for biotechnological applications is due to its high content of bioactive compounds such as oligofructose inulin, caffeoylquinic acids, flavonoids, anthocyanins, sesquiterpenes lactones, triterpenes, fatty acids and aspartic proteases. Cardoon flower extract is a vegetable coagulant used exclusively in the manufacture of some Mediterranean PDO cheeses due to its extremely high concentration in cardosins. The characteristics and functions of cardoon biomass permits the development of innovative bio-based-products for biotechnological application in food and nutrition, pharmaceutics and cosmetics, plant protection and biocides, oils and energy, lignocellulose materials, and healthcare industries following the actual trends of a circular economy.

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GENERATING ENVIRONMENTAL BENEFITS

PITCH11 <

SHORT ROTATION COPPICES AS RENEWABLE ENERGY SOURCE: A PROFITABILITY ANALYSIS

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Introduction: The global warming and the increase in the demand for energy have led to the development of renewable resources to the detriment of the fossil fuels that contribute about 80% to the emission of greenhouse gases (GHGs), the main causes of climate change. Among the renewable energies, several studies have highlighted the numerous environmental benefits that characterize Short Rotation Coppices (SRCs) as biomass crops as they represent carbon-neutral species that reduce, among the other, the CO2 and NO2 emissions (Dahmen et al., 2019). The question that arises is: are these productions also sustainable from an economic point of view? Profitability, in fact, is a key factor for farmers' choices and represents the condicio sine qua non of their diffusion in the agricultural sector. This study aimed at responding to this question by evaluating the profitability of Paulownia, a SRC that rapidly spreading across Europe.

Materials and methods: Economic analysis has been performed in 2020 in a Southern Italian farm, where it has been introduced the Paulownia clone in vitro 112® (Paulownia elongata x fortunei) to obtain timber and biomass production (dual-use production) that has been compared with the hypothesis in which Paulownia is exclusively destined for biomass production. To evaluate the economic profitability of Paulownia, the discounted cash flow (DCF) method has been adopted (Blanc et al., 2019), by determining the annual gross margin (AGM). Finally, a sensitivity analysis for each surveyed crops has been performed, by varying sales price and yield.

Results and discussion: Economic analysis has highlighted an AGM value of 357.91 € ha-1 for dual-use production, against a value of 4.22 € ha-1 for biomass production. This is due to both the lowest planting density of SRC for dual-use production and its highest revenues for the greatest yield and the timber production. Finally, the sensitivity analysis denotes that SRC for exclusively biomass production appears to be an economically viable investment only with an increase in the woodchip price or biomass yield.

Conclusions: SRCs represent an opportunity for socio-economic development of some rural areas by avoiding exodus rural phenomena. They can play a key role in the creation of a sustainable biomass supply chain, thanks to their environmental benefits, contributing to the achievement of SDGs of 2030 Agenda, among which production of renewable energies, climate change mitigation and sustainable economic growth.

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WASTE MITIGATION SOLUTIONS

PITCH12 <

VEGETATIVE PARTS OF *HUMULUS LUPULUS* L. AS A SOURCE OF HIGH-VALUE BIOACTIVE COMPOUNDS

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Hop (*Humulus lupulus* L.), a member of the family Cannabaceae, is a hardy climbing perennial plant native to the northern hemisphere (1). It is a native plant and cultivated in the northern regions of Portugal and Galicia, having contributed for decades to the development of the regions. Large amounts of vegetal material such as leaves stems and small-caliber cones (hops) are discarded in the harvest process of hops for further use in brewing industry constituting an ecological and economical issue (2,3). This work aimed to optimize techniques for extracting phenolic compounds from samples of plant parts (leaves and stems) of spontaneous plants of *Humulus lupulus* from Bragança – Portugal. For that, solid-liquid extractions of vegetative parts of H. lupulus (1:10g) were performed with stirring, microwave at 30 minutes and 1 hour and using ultrasound using as extraction solvents water; ethanol: water: 50% (v/v); ethanol: water 80% (v/v). In addition, total phenolic compounds and total flavonoids were determined as well as some antioxidant assays were performed.

The H. lupulus extracted with a 50% hydroalcoholic solution in microwave was the richest in total phenolic compounds and total flavonoids, followed by the extraction with the same solvent under stirring. In agreement with these results, the same two extracts showed better antioxidant power either in FRAP assay (13.25±0.019 mg TE/g plant and 8.91±0.73 mg TE/g plant, respectively) as in ABTS+ (47.79±9.43 mg TE/g plant and 38.60±4.00 mg TE/g plant, respectively). The same extraction methods (microwave and stirring) but using the solvent ratio ethanol: water 80% (v/v) were also associated with a high number of phenolic compounds and flavonoids, which is in agreement with the values obtained in the antioxidant tests, especially regarding the extraction by stirring. The present work shows the potential interest of non-used parts of H. lupulus L. as source of high-value bioactive compounds.

Acknowledgments

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PITCH13 <

WASTE ELIMINATION PROCESSES: FROM LEAN TO KAIZEN IN THIRD SECTOR ORGANIZATIONS

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In a globalized world, the challenges are many for companies and organizations. To face these challenges, organizations need to increase their productivity in order to become more competitive. This need leads organizations to look for new management methodologies and techniques. All available methodologies and techniques are an aid in business management. The Lean philosophy focuses on process efficiency and its main objective is to offer maximum value using the least amount of resources possible. Therefore, it is necessary to completely eliminate all waste (activities that do not add any value) and focus on completing only the necessary work within a certain period, so you can establish a progress of the company's processes. This article analyze the concepts and principles of these methodologies and make a comparative study between them, identifying the aspects that distinguish them and the similarities found, as well as verifying their application in a third sector institution.

Third sector organizations are gaining more and more social weight, they increasingly need to achieve the much desired organizational sustainability and, for this purpose, they turn to management to perform a sustainable, effective, efficient, quality and transparent work. According to the previously developed concept of Lean Six Sigma, it was found that it is important for Third Sector Organizations, in particular, with regard to the sustainability of Organizations, as it is impactful in its various dimensions (financial, environmental and social) (Freitas; Costa and Ferraz, 2016). For this purpose, they created three pillars of organizational sustainability (financial, social and environmental pillar) and measured the influence of the implementation of Lean Six Sigma on these, having verified that the impacts are of greater magnitude in the financial and social pillar followed by the environmental pillar. The use and application of Lean and Six Sigma concepts in third sector organizations will allow for a better understanding and comparison of initial situations with the final results, in a context of improvements based on the elimination of waste and reduction of errors.

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PITCH14 <

VALORISATION OF CARDOON TO PRODUCE BIOCHAR WITH ADSORBENT PROPERTIES

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Cardoon flower is used in the production of goat and sheep cheese in the milk coagulation process [1]. Cardoon stems and leaves are usually leaved in the fields, generating a large amount of agricultural by-products. Nevertheless, these by-products represent a source of biomass to produce biochar with potential adsorbent properties [2]. Therefore, the production of biochar from cardoon can be used as a valorisation strategy. In this study, cardoon stems and leaves were pyrolyzed in the absence of oxygen at 550 ºC or 900 ºC. Each biochar was characterized for its pH, ashes, H, N, and C contents, particle size, surface area by BET analysis, and pore volume and size according BJH method. Adsorbent properties were evaluated against monensin A, a coccidiostat used as additive in poultry feed.

Pyrolysis of cardoon by-products yielded 14-35% of biochar with alkaline pH (10-12). The pyrolysis at 900ºC promoted higher surface area and pore volume, while promoting lower pore size. Biochar with higher surface area was able to adsorb 43.5 mg/g of monensin in comparison with the 5.1 mg/g adsorbed by commercial biochar. These results indicate that cardoon by-products can be valorised as biochar with monensin A adsorbent properties, being exploited towards reduction of water and soil contamination.

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POSTER

BY-PRODUCTS AS FOOD/FEED INGREDIENTS

P01 <

CORN COB (*ZEA MAYS* L.) AS A POTENTIAL SOURCE OF BIOACTIVE COMPOUNDS: COMPARISON OF DIFFERENT EXTRACTION METHODS

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The minimization and reutilization of food waste is extremely relevant nowadays. Following the guidelines of the European Commission on the long-term strategies for a sustainable development to support a circular economy [1], the aim of this research was to valorize corn cob (Zea mays L.), as a promising source of bioactive compounds possessing healthy properties [2]. Different extraction protocols were set-up, and a conventional method was compared to innovative approaches, also assisted by microwaves. The recovery of phenolic compounds was evaluated using different solvents, traditional hydro-alcoholic mixtures and innovative natural eutectic mixtures with the so-called deep eutectic solvents strategy [3]. The effect of different parameters on the extraction yield was studied using experimental designs and the composition of each extract was monitored by RP-HPLC-DAD. Polyphenols characterized by different chemical structure were present in corn cob extracts independently from both the extraction methods and the tested solvents. Results indicated that the highest extraction yields were generally obtained by means of the innovative microwave assisted extraction with traditional hydro-alcoholic mixtures. Reduced extraction time and therefore energy consumption were the main advantages of this technique with respect to the conventional approach, probably due to the formation of pores and fractures on the plant matrix induced by microwaves, as confirmed by scanning electron microscopy (SEM) analysis performed on corn cob before and after microwave irradiation. The best extract obtained from the previous investigation was characterized by LC-ESI-MS/MS. Different polyphenolic compounds known for their healthy properties are present, suggesting a promising bioactivity, that will be confirmed by further assays

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P02 <

VALORIZATION OF BY-PRODUCTS FROM CRAFT BEERS INDUSTRY: PHYTOCHEMICAL CHARACTERIZATION OF SPENT GRAINS AND HOPS

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Beer is one of the oldest alcoholic beverages produced and consumed in the world (Humia et al., 2020). Craft beers is a new concept introduced in the beer industry and its definition is not legally determined, however, most authors define it as a product that is produced using traditional practices and using traditional or innovative raw materials (Jaeger et al., 2020). The craft beer brewing generates substantial quantities of by-products, namely spent grains and spent hops. These by-products can be used for microalgae production, biofuel production, polyphenolic and antioxidative substances, etc (Petrón et al., 2021). Therefore, the present study determines the phenolic composition and antioxidant capacity of two different by-products of the craft beer industry, namely spent grains and spent hops. For each by-product the goal was to evaluate the phenolic composition and antioxidant capacity, and for that we performed the determination of the total polyphenolic, ortho-diphenols and flavonoids contents. The determination of antioxidant capacity was performed using the ABTS and DPPH methodologies. The results showed that there were significant differences in the content of phenolic compounds and antioxidant capacity of the analyzed by-products. Concerning total phenolic content, ortho-diphenols, and flavonoids, spent hops exhibited the highest concentration, with 8.63 ± 0.38 mg GA/g, 20.40 ± 0.67 mg GA/g, and 2.07 ± 0.13 mg CAT/g, respectively. Regarding the antioxidant capacity, spent hops was also the by-product that presented the highest antioxidant capacity for the two methods. Thus, these by-products represent sustainable and good alternative for bioactive compounds recovery and could be significantly useful in cosmetic, pharmaceutical and food industry.

Acknowledgements

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P03 <

HOW TO PROFIT FROM AN INDUSTRIAL BY-PRODUCT OF ELDERBERRY JUICE?

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Black elderberry (*Sambucus nigra* L.) is recognized for its high content of antioxidants mainly anthocyanins, flavonols, and other phenolic acids.[1] Cyanidin-3-O-glucoside and cyanidin-3-O-sambubioside are the main anthocyanins present and rutin is the most representative flavonol. Elderberry pomace, the by-product resulting from berries pressing in industrial juice processing represents 25-40% of total berry weight and has low economic value as it is conventionally used as animal feed or as an organic fertilizer. However, this by-product still contains considerable amounts of bioactive compounds that can be recovered to be used in the production of value-added ingredients and products bringing several opportunities in the food sector. Elderberry pomace can be a good source of natural colouring agents and antioxidants since anthocyanins pigments remain in pomace to a large extend representing 75-98% of total pomace.[2] Other phenolic compounds such as flavonols, phenolic acids and tannins, as well as, vitamins, provitamins, essential unsaturated fatty acids, dietary fiber and other valuable compounds can be found in pomace. These compounds have antioxidant, antimicrobial among other health-promoting properties and have potential to be used as preservatives and in the development of functional foods.[3]This work intends to provide an overview of the chemical composition of the pomace resulting from the industrial elderberry juice production, and to show how the industry can find benefits through the effective utilization of this by-product as source of bioactives, natural pigments and preservatives.

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P04 <

DOSE EFFECT OF SAVORY (*SATUREJA MONTANA*) FEED SUPPLEMENTATION IN SMALL INTESTINE MORPHOMETRY

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In general, the feed supplementation in broilers pretend achieve better performances in a more efficient way. The utilization of aromatic herbs, namely its by-products after the main agro-industrial use, is a strategy to modulate the gut ecosystem and maintain or reinforce the epithelial integrity. The utilization of raw powder stems by-product of aromatic herbs acts as a prebiotic form of supplementation in broilers. This physical form allows the protection of the cellular contents at the lower gut.
The aim of the current study was to evaluate the effect of different levels of savory feed supplementation in the jejunum morphology in broiler chickens, as a way to enhance productive performances.
One hundred and ninety-two Ross308 one-day old chicks were randomly distributed into sixteen pens, with twelve animals each. All animals were fed ad libitum with commercial feedstuffs in the control [C] group and with savory by-product supplementation in the treatment groups (10 [S1], 20 [S2] and 40 [S4] g/kg). The diets were randomly assigned to pens. At the end of the trial (35 days), two animals randomly selected from each pen, were sacrificed by cervical dislocation, slaughtered, plucked and eviscerated, for a total of 8 animals per treatment.
Samples collected were fixed in 10% neutral buffered formalin and processed for routine histopathological diagnosis with Haematoxylin and Eosin (HE). Morphometric variables were villus height (VH) from the top of the villus to the villus-crypt junction, villus width (VW) from side to side of the villi at its half height, and crypt depth (CD) from the base of the villus to the submucosa. Ten measures of all variables were taken in each animal. The villus height to villus width (VH:VW), the villus height to crypt depth (VH:CD) ratios and the villus surface area (VSA) was calculated ($\pi \times VW \times VH$). To analyze the influence of treatments on morphometric variables, one way analysis of variance with post hoc Tukey test through SPSS V26 software was used with a significance level of 0.05.
Regarding to VH, S1 and S4 revealed similar values (775.0±201.0 and 767.0±350.5 µm, respectively) and lower than control group (922.7±178.9 µm; $p<0.05$). Concerning VW, S4 group stood out the higher value ($p<0.05$). Both results reflect the lower values for VH:VW of supplemented groups in relation to the control one ($p<0.05$), presenting the S4 group the lowest mean value. CD presented lower mean value in S1 treatment ($p>0.05$). Spite the non-significant differences, the S1 group showed the high VH:CD mean value. The relative differences for specific variables mentioned above, attenuated the mean values of VSA composite variable for all groups ($p>0.05$), hypothesized that the different doses of supplementation don't influence the morphologic intestinal surface absorption. In general, the incorporation of savory in feed

was beneficial for intestinal morphology, showed by the morphometric values presented, namely the CD and the VH:CD ratio, reflecting higher productive performance, particularly in S1 group (data not shown).
In conclusion, the lower dosages of savory inclusion improved the intestinal morphometric parameters, being the worst results obtained from higher supplementary doses of savory.

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P05 <

CARDOON FEED SUPPLEMENTATION IN RABBITS: REFLECTIONS ABOUT A PUTATIVE IMMUNITARY EFFECT

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The inclusion of the by-products of cardoon in animal diets produced in the region of the plantation is an alternative feeding strategy that could enhance the sustainability of animal production while reducing the environmental burden and the economic cost associated with the disposal of these by-products. Moreover, the use of cardoon might allow the production of healthier animal. Rabbit animal models have been used in research studies not only to the mechanistic studies of human diseases but also to the development of therapeutic compounds, devices, or techniques for therapeutics.
The present study intended to hypothesize about putative effects in immunity of rabbits feed with cardoon.
Twenty male rabbits of the *Hyplus* strain, individually housed, were randomly distributed into two groups of 10 animals. One group with ad libitum fattening feedstuff (Control) and the other with the same food strategy plus 250 g of cardoon per day (Treatment). The study was conducted from weaning until 76 days of age. The rabbits were monitored for feed behavior. At the end of the experiment, 3 animals per group were slaughtered. Blood samples were taken for analysis and spleens were weighted. To evaluate the influence of cardoon intake on hematological parameters and spleen weight we performed the independent samples t-test with SPSS v26 and a significance level of 0.05 was considered.
The rabbits feed with cardoon diet presented a heavier spleen (0.61±0.03 g/Kg body weight (BW) vs 0.46±0.05 Kg/Kg BW; $p < 0.01$), and higher (but not significant) levels of total white blood cells, monocytes, and granulocytes (cells/L). The number of red blood cells and haemoglobin was also augmented but with a lower mean corpuscular volume ($p > 0.05$).
Considering the importance of the spleen in cellular immunity and humoral immunity, as well as in hemodynamic activities and even though no histological study was performed, the fact that in rabbits feed with cardoon spleen was heavier than their control group suggests more ability of cardoon to increase immunity as well as to ameliorate the production of red blood cells.
This preliminary study inspires to a reflection of the effects of cardoon ingestion on immunity. Nevertheless, more robust studies should be performed to consolidate these putative effects of cardoon on rabbits' immunity and to find out if this animal model is a suitable candidate to study the effect of cardoon consumption on human health.

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P06 <

SAVORY (*SATUREJA MONTANA*) BY-PRODUCT SUPPLEMENTATION IN BROILERS: EFFECT IN INTESTINAL *ESCHERICHIA COLI* AND ENTEROBACTERIACEAE POPULATIONS

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The valorization of agricultural and food industry by-products has been in the focus of investigation worldwide. Winter savory (*Satureja montana*) is an aromatic and medicinal plant also used as a spicy. Its extract is a good source of carvacrol and thymol, two compounds with several health benefits documented as anti-inflammatory, antioxidant, antimicrobial and antifungal (Movahhedkhah *et al.*, 2019). With the limitation of antibiotics use in animal production, plant-based products have gained interest as an alternative (Michiels *et al.*, 2010). Using this by-product in the raw physical form (only grinded) allows the protection of the cellular contents at the lower gut, allowing a greater potential use by bacteria. However, the mode of action of savory on the intestinal microbiota is not fully understood.
This study aims to investigate the effects of *Satureja montana* by-product powder supplementation on gut *Escherichia coli* and Enterobacteriaceae populations of broiler chickens. One hundred and ninety-two Ross 308 one-day old chicks were randomly assigned to four dietary treatments containing three replicates of 12 birds each. All animals were fed *ad libitum* with commercial feedstuffs. The treatments consist in a control group [C] and three groups supplemented with three different amount of winter savory by-product powder (10 [S1], 20 [S2] and 40 [S4] g/kg, respectively). At the end of the trial (35 days) 8 animals of each treatment were slaughtered. Four aseptic samples of intestinal content were collected by each treatment (mixture from two animals per pen) and frozen in sterile vials at -18 ºC. *Escherichia coli* and Enterobacteriaceae populations were evaluated according to the ISO: 166492-2/2001 and ISO: 21528-2/2004 standards, respectively. The results were expressed in Log CFU/ml (Logarithm of colony forming units per milliliter).
The results of this trial show a trend of decrease in both populations of bacteria between the treatment groups and the control groups ($p>0.05$) The essential oil of *Satureja montana* by-product has already shown good results in growth inhibition of *Echerichia coli* when evaluated *in vitro* for its antimicrobial activity (Santos *et al.*, 2019). Several studies indicate that carvacrol and thymol have bactericidal effects to pathogenic microorganisms, in particular to *Escherichia coli* (Chouhan *et al.*, 2017).
S1 was the treatment with the lowest number of colonies formed in both populations therefore, the amount of 10 mg of winter savory by-product powder was the most effective. These results were similar with those reported by Mozafari *et al.* (2018) for *E. coli*. The reduction of Enterobacteriaceae population and consequently *E. coli* population, might have been a result of the increase of commensal bacterial population, that play a protective role in gut structure

integrity and are the first line of defense against pathogenic bacteria as *E. coli*, avoiding the occurrence of dysbiosis.
Nevertheless, this study shows, at least, that the introduction of a new food supplement in the diet did not cause a deregulation or significant decrease in the intestinal microbiome of chickens. Thus, we understand as safe the use of savory by-product as supplementation in broiler chickens feed, indicating the dose of 10 g/Kg, with the most appropriate, regarding the size of the intestinal microbiome effects.

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SUSTAINABLE MATERIAL

P07 <

COULD BE ARTHROSPIRA SP. A SUSTAINABLE SOURCE OF BIOACTIVE COMPOUNDS? EVIDENCE OF ANTIOXIDANT, ANTIGENOTOXIC AND CYTOPROTECTIVE PROPERTIES

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Microalgae are a potential renewable and sustainable source of active molecules such as lipids, pigments, polysaccharides, among others [1]. Several species are cultivated at an industrial scale to produce valuable secondary metabolites for aquaculture, bio-fuel and biotechnology industries, like environment, food, cosmetic, nutraceutical, and pharmaceutical [2]. Nevertheless, it is a poorly-explored resource for drug discovery. Accordingly, the main goal of this study was show that microalgae are a source of bioactive compounds that can be used to discover and develop new drugs. To achieve that the antioxidant potential of hexane and methanolic extracts of Arthrospira sp. was evaluated, as well as the anti-genotoxic, cytotoxic and cytoprotective effects of these extracts. Results show that Arthrospira sp. acts as free radical scavenger of DPPH and superoxide radical, being hexane extracts the most promising, 68.4% and 38.3%, respectively. Moreover, hexane extracts revealed the best ability for iron chelation (22%). On the contrary, methanol extracts revealed the highest FRAP values (122 eq Fe2+ µM). Cell viability assay was performed using 25 mM H2O2 as the genotoxic agent in Sch. pombe. In the presence of H2O2, 750 µg/mL of hexane extract protected cells against oxidative damage, increasing cell viability by 56%, compared to the positive control (only H2O2). Hexane and methanolic extracts did not show cytotoxic effects in HepG2 cell line up to 500 µg/mL at 4 and 24 hours of incubation period, except for methanol extract that decreased cell viability at the highest concentration tested. Moreover, hexane extracts significantly increased cell viability of HepG2 cells when co-incubated (4 hours) with the oxidant agent t-BHP, revealing cytoprotective effects. Overall, our results indicate that Arthrospira sp. extracts reveals antioxidant properties. Additionally, hexane extracts seemed to show antigenotoxic potential, and cytoprotective properties, without cytotoxicity, being the most promising. This work highlights the Arthrospira sp. biomass as a sustainable and renewable source of bioactive compounds, which could create a larger impact on the future, contributing to a blue and green economy. Additionally, our findings support the introduction of these extracts in the food/feed, nutraceutical, cosmetic and pharmaceutical industries.

Acknowledgments

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WASTE MITIGATION SOLUTIONS

P08 <

RESOURCE EFFICIENCY OPTIMISATION OF SECOND CLASS VEGETABLES VIA BIOREFINERY SOLUTIONS TO IMPROVE SUSTAINABILITY IN THE AGRIFOOD CHAIN AND CLIMATE CHANGE RESILIENCE: THE EUROPEAN PROJECT "DEMETER"

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The overall objective of the European FACCE SURPLUS DEMETER project is to establish a more resilient vegetable supply chain by creating a secure and long-lasting sustainable relationship between the vegetable grower (agriculture, no greenhousing) and its customers in the first step of the agrifood chain. The specific objective of the project is to increase resource efficiency through valorisation of currently not valorised side streams via production of soups, juices and functional ingredients. The expected impacts of the DEMETER project are by valorisation of residues, second and third class vegetables, damaged vegetables, off cuts and peelings to reduce land, water, pesticides and fertilizers consumption and also food contamination. The DEMETER project will run for 2 years, with activities distributed along five work packages. WP1 will provide an overview on the state of the art on the available residues and waste streams to give the potential of agricultural residues, residues from primary processes and pomaces from juice production. In WP2, the characterisation of the different raw materials will be done to define necessary pre-treatments and processing steps. The residues as new materials will be processed and characterised in WP3. In order to calculate the financial viability and the environmental impact of the processing of soup, juice and functional ingredients, WP4 will carry out an economic and environmental assessment on each process. WP5 deals with the project management and dissemination activities.

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P09 <

AGRO-FOOD WASTE AS POTENTIAL NATURAL HERBICIDES IN SPRING-SUMMER CROPS

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Weeds are among the main enemies of crops significantly compromising yield. For this reason, synthetic chemical herbicides are generally used, although the known negative impacts they cause on the environment and on the human health. Thus, it is imperative to find potential alternative herbicides, sustainable and harmless to humans. It is also urgent to promote the Circular Economy, discovering new uses for waste, valuing them. Thus, the main objective of this research was to know the herbicidal potential of agro-food waste, spent coffee grounds (SCG), on weeds of spring-summer crops (lettuce and radish), produced under an Organic Farming system. For this, a field trial was carried out. SCG was incorporated into the soil of plots at a dose of 9 Mg ha-1. Soil without agro-food waste was considered as control. Both treatments were replicated four times. Seedlings of lettuce and radish were immediately planted in intermixed rows in plots after the incorporation of SCG. Two months after the field trial establishment, the following data were collected: the normalized difference vegetation index (NDVI) of plot vegetation; dry weed aboveground biomass identified as monocotyledons, dicotyledons, Cyperus spp., and total; and dry crop biomass identified as leaf, root and total). Results, properly statistically analyzed, showed that the incorporation of spent coffee grounds into the soil decreased the biomass of weeds, and promoted crops' development. Based on these results, spent coffee grounds could be considered as a potential alternative to synthetic chemical herbicides. Moreover, the growth stimulation of crops may indicate an additional fertilizing effect of the studied waste.

P10 <

EGGSHELLS AND POTATO WASHING SLURRIES AS RENEWABLE LIGHTWEIGHT FILLERS FOR POLYSTYRENE-BASED MATERIALS

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Agrifood byproducts are rich sources of valuable biomolecules that, during their disposal, are simply wasted, thus requiring strategies to efficiently be valorised. In this work, the feasibility of using calcium carbonate (CaCO3) recovered from eggshells (ES) and starch from potato washing slurries, two byproducts derived from egg and potato processing industries, was studied as renewable lightweight fillers for polystyrene (PS)-based plastics. ES-CaCO3 presented lower density (-2%) than commercial CaCO3 and when combined with starch, its density decreased in 12%. ES-CaCO3/starch-based fillers were successfully incorporated into PS-based plastics, conferring a yellowish coloration to the PS/commercial CaCO3-based plastics and decreasing in 6% their density and in 77% their rigidity. Therefore, eggshells and potato washing slurries revealed to be suitable sources of molecules for developing renewable lightweight fillers for plastics, giving an opportunity to reuse and valorise egg and potato agrifood byproducts.

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P11 <

VEGETATIVE PARTS OF HOP AND BREWERIES BY-PRODUCTS: FROM WASTE TO COSMETIC

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Hop (*Humulus lupulus* L.) is known worldwide as a raw material in beer production due its flavour and preservative values. The beneficial properties of the plant have been mostly associated to the female hop inflorescences (hops) which is also the part used in the brewing industry remaining the hop leaves, stalks, and smaller calibre flowers as an agricultural by-product and currently discarded as waste. Hop leaves are rich in flavanol glycosides (quercetin and kaempferol derivatives) (1). On the other hand, millions of tons of residues are produced in brewing process in which large quantities of by-products main in forms of spent grains and spent hops/ hot trub are produced, raising environmental and economic sustainability concerns (2). Herbal products have been used has ingredients for cosmetic formulations. Hop extracts has been used for skin aliments in loose skin, stretch marks, and sagging, preventing skin ageing (3). As the discarded parts of hop plants, and also the hop residues of brewing process are rich in different compounds it could be proposed as source of ingredients for cosmetic industry. In addition to that, the recovered of high-value bioactive compounds from the by-products or non-used parts of H. lupulus L. in brewing industry, has been a strategy emphasized by recent literature in order to solve this ecological and economical issue (2).

Acknowledgments

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P12 <

MATRIX OF BIOWASTE IN THE CENTER REGION. WASTE2VALUE SURVEY RESULTS

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The use of biowaste resulting from agricultural or agro-industry production, through its recovery, reuse, valorization, can help reduce the impacts generated by the sector, create alternatives to the use of scarce natural resources and, simultaneously, new products and activities with economic interest in various sectors, from food and feed, health, new materials for packaging, among many others. The term "biowaste" is used in this work with the meaning of by-product from agricultural and agro-industry activities. One of the biggest constraints to this use is related to the multiplicity of different by-products of agricultural and agro-industry activity, their dispersion in the territory, their seasonality and perishability. In this sense, the Waste2Value Operational Group, whose vision is the mitigation of agricultural and agro-industry by-products through recovery and reuse of these materials in innovative applications associated with public health concerns and use of environmentally sustainable practices, conducted a survey by questionnaire on the type, quantities and disposal of agricultural and agro-industry by-products in the Central Region of Portugal, including the specific interest in this theme, among relevant sectors and stakeholders, implemented in 2018/2019.

Sixty questionnaires were applied to companies in the Central Region of Portugal, in various agricultural and agro-industrial sectors (horticulture, olive growing, viticulture, arable crops, aromatic and medicinal crops, honey and other hive products, liqueurs and jams, meat, milk and derivatives). The surveyed companies were of small and medium size (between 1 and 60 workers), presenting several types of by-products that in some sectors are distributed throughout the year (e.g. horticulture, smoking, mushrooms), while in others are concentrated in specific periods (e.g. wine, olive oil, cereals).

As for the destination of the by-products, the largest use is related to the use in animal feed, free delivery or sale and composting. Incineration, delivery to landfill or for treatment, and distillation are also some of the destinations of the by-products identified.

About 40% of the surveyed companies are interested in investing in the recovery and valorization of by-products, and the main constraints to investment in these processes are related to the associated costs, legal issues associated with their use, available quantity and satisfaction with the destination currently given to them. Over 65% of companies are interested or very interested in participating and learning from the results of the Waste2Value project.

P13 <

INTEGRATED VALORIZATION OF PINUS PINEA BY-PRODUCTS IN ADDED-VALUE APPLICATIONS

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Pinus pinea L. is a coniferous tree native from the Mediterranean basin, with a scattered distribution from Portugal to Syria. Pine nut seeds are the primary product obtained from this crop, followed by timber and, to a lesser extent, resin, cones, nut shells and bark, used essentially to produce energy. In Portugal, the stone pine gained renewed importance over the last decades, with an 61% growth in forest area from 1995 to 2015, accounting for a total of 193000 ha. However, bark and resin collection are practices with progressively less relevance and the revenues from timber production have recently dropped. Furthermore, the yield of cone production is affected by cone pests and climatic inconstancy, leading to large variability in pine nut yield. Thus, the identification of opportunities for an integrated management of stone pine forests is of major importance, being in line with concerns regarding *P. pinea* forests sustainability.

Stone pine by-products are lignocellulosic materials (except for resin) composed of cellulose, hemicellulose, and lignin, with extractives with bioactive properties. These agroforestry by-products are rich in compounds of interest, namely terpenic and phenolic compounds, and sterols. Pine bark is an interesting source of polyphenols, once it contains a considerable amount of tannins and low content of polysaccharides and lignin1. Pine cones, needles and resin are obtained in considerable amounts from Stone pine forests (IFN6) and their essential oils are rich in monoterpenes, particularly limonene, α-pinene, and β-phellandrene2. Concerning the nut shells, although an average of 4128 tons are obtained per year in Portugal, studies concerning its valorization are scarce. Nonetheless, recent data suggests a richness of bioactive compounds that may favour the utilization of this by-product in added-value applications 3.

Pinus pinea by-products are currently under-valued. Their richness in bioactive compounds, together with the growing interest of the industry in the use of natural products, makes them promising materials to be used in a wide range of industrial sectors.

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P14 <

FOCUS GROUPS TO ASSESS AGRI-FOOD BIOWASTE VALORIZATION PERCEPTION AMONG STAKEHOLDERS

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The Waste2Value project is a joint strategy that brings together a wide range of partners from public institutions, universities, and companies, that aim to find solutions for biowaste recovery. The term "biowaste" is used in this work with the meaning of by-product from agricultural and agro-food industry activities. The application of a Focus Groups dynamic (FG) (as a collective interview)[1] intended identify agricultural and agroindustry by-products, and animal effluents, and potential users of its by-products, in the Portugal Center Region to understand: (i) the potential generators of agricultural and agroindustry by-products, their nature and destination; (ii) the perception of processed by-products by potential users (namely for livestock), the advantages and constraints of their adoption. It was also inferred the participants' degree of knowledge about biowaste management, and their willingness to collaborate as suppliers/users of biowasted-based raw materials, creating synergies to large-scale biowaste integration in the circular economy. Although biowaste valorization is not the core business of most biowaste-producing companies', it is a problem in the agro-industrial sector. From the managers' perspective, biowaste valorization poses a valid solution, whether through enhancement of composting practices, the production of new organic fertilizers, or the application of new solutions for transforming biowaste into valuable by-products. From the potential users' perspective compounds produced from organic by-products raise a set of concerns at the regulatory level, food safety, by-product homogeneity and availability, and profitability of enriched feeds. Thus, the strategy defined for the by-products treatment and incorporation (as additives/raw materials) determines how they may integrate the production systems. Even so, the historical importance of by-products for the animal industry is unanimous, and alternatives are urgently needed to allow producers to move through the demedicalization imposed by the EU[2]. Public agencies are pointed as key elements in the promotion of biowaste valorization acting as facilitators.

Keywords: by-products; biowaste; circular economy; collective interview.

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P15 <

CATEGORIZATION OF FARM BY-PRODUCTS THROUGH PRELIMINARY RECOGNITION OF THEIR BIOACTIVE POTENTIAL

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Annually one third of all the food produced is wasted leading to costs and negative environmental impact [1]. To mitigate these problems, some alternative uses are emerging, such as the recovery of phytochemical compounds with beneficial properties and the bioproduction of new added value products [2]. Phenolic compounds can be recovered from food by-products and were shown to possess antimicrobial and antioxidant capacities, being natural alternatives to food preservatives and helping reduce the risk of some chronic diseases [3].
Fourty-two agri-food by-products, distributed by 3 groups with equal number of samples: leafs (resulting from the vegetable “cleaning” and sorting process), “fleshy” (dense and bulky by-products), and aromatic herbs (leftovers resulting from sorting and cleaning), were analyzed by four different assays. For each by-product, three extracts were accessed. The total phenolic content (TPC) was assessed using an adaptation from the Folin-Ciocalteu method [3]. Flavonoid content (FC) assay was evaluated according to Alothman et al [4]. Antioxidant activity was assessed using two different methods: the radical ABTS+• inhibition and the DPPH• free radical scavenging analysis [5,6].
The analysis of differences of each parameter was evaluated between the groups using the Kruskal-Wallis tests (α=5%) and the agglomerative hierarchical clustering was used to group by-products in clusters based on their similarity.
It is worth mentioning Laurus nobilis, that registered the highest values in all the analyzed parameters, and Mentha piperita, Origanum majorana and Origanum vulgare. The aromatic herbs group stood out with the highest mean, median, minimum and maximum in all the assays and was the one with the highest variability (SD). In terms of TPC, FC, ABTS+• and DPPH•, there are statistically significant differences between the aromatic herbs and the remaining two groups ($p<0.001$). In the cluster analysis with the four parameters, the by-products were grouped into three clusters. From cluster analysis using only the TPC assay, four clusters were obtained, and the FC analysis suggested the establishment of three different clusters. For the antioxidant activity assays, the by-products were grouped into three cluster for the ABTS+• assay and two clusters for the DPPH• method.
Despite the antioxidant potential of aromatic herbs, leaf-based horticultural by-products could be an interesting source of added-value compounds. It was possible to assess that the grouping initially performed based on the agricultural characteristics of the by-products was different from the clusters obtained. It should be noted that only part of the aromatic herbs constituted their own cluster regardless of the parameters of TPC, FC and antioxidant activity evaluated in any of the analyzes performed.

Keywords: by-product; phenolic compounds; antioxidant activity; valorization; circular economy

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P16 <

DRYING OF BY-PRODUCTS FROM AGRICULTURAL PRODUCTION AND AGRI-FOOD INDUSTRY

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The agro-food industry generates huge amounts of by-products, from productive activity, to product processing and also in post-processing, namely food waste (FAO, 2012). One of the biggest causes of this waste are imperfections in weight or shape and the perishability of foods that make them unsuitable for commercialization.

These by-products are rich in various ingredients (fiber, bioactive compounds, mineral salts, etc.) and show great potential for their integration in different industries, such as pharmaceuticals, for example. However, due to their generally high water content, they suffer from rapid perishability. Therefore, taking advantage of the opportunities available for the valorization of these by-products depends on the use of conservation techniques.

This work aimed to evaluate the use of dehydration by indirect solar drying, as a conservation technique, to enable the sustainable use of by-products.

The species studied were selected with partner companies and supplied by them: spinach, lettuce, kale, onion skin, thyme, anise and apple pomace. The initial moisture contents of each species were determined. In a climatic chamber, drying curves were obtained and the influence of temperature and relative humidity of the drying air on the final composition of the product was evaluated. Field tests were carried out with two types of solar dryers to validate their effectiveness, optimize the operating parameters and assess the energy cost of the process. The dryers were equipped with an electrical auxiliary air heating system. All samples of by-products tested were subjected to chemical characterization analysis before and after drying.

The results showed the natural importance of drying temperature and the structure and morphology of each species. The increase in temperature leads to a decrease in the time to complete the process and in the equilibrium moisture content. The increase in temperature also has a negative influence on the nutritional content, namely in terms of protein, antioxidant activity and sugars (Catorze et al. 2021).

Field tests revealed that the dryer designated as “Big Bag” was not suitable for most species of by-products, in particular due to low drying effectiveness. The dryer designated as “AVATAR” proved to be effective, and the use of auxiliary electric heating is recommended to compensate for the absence of sun and thus prevent product deterioration due to the concentration of humidity caused by the cooling of the air. The use of solar energy as the main source of energy

contributed to the sustainability of the process, reducing the need for electrical energy by 35% (Catorze et al. 2021).

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