retaste

rethink food waste

Athens, 6-8 May, 2021

Hellenic Mediterranean University

The RETASTE Conference was co-organized by Harokopio University

The RETASTE Conference was organized under the auspices of the Green Fund that offers sponsored participation to selected participants.

GREEN FUND

RETASTE:

Rethink Food Waste

Athens, Greece, May 6-8, 2021

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Table of Contents

The Mission of RETASTE 1
Scientific Committee 3
Organizing Committee 5
Keynote speakers 7
KEY: Keynote 21
Food - Waste - Circularity: Contradictions and challenges 22
Rethinking Food Waste Within the Concept of BioWEconomy to Support Green Recovery From the COVID-19 Pandemic 23
A Green Deal for the Planet: The Role of Frontier Science and Innovation in Delivering a Circular Economy – the Case of Food Waste 25
Towards a Sustainable, Circular Bioeconomy: the Role of Innovation, Practice and Policy 26
Boroume 28
Food Waste: Path to Change 29
Integrated Biorefinery Processes: the Role of Anaerobic Digestion 30
Valorization of Source-collected Household Food Waste at Municipality Level 32
PLW: Food Loss and Waste Prevention 33
Possibilities for the Prevention of Food Waste in the Hospitality Sector - Case Study of Hotels in Heraklion, Greece 34
Alternative Food Networks and Household Food Waste: Evidence from an Italian Case Study 36
The Importance of Setting Accurate Monitoring Procedures to Prevent Food Waste at Retail Stores 37
Household Food Waste in Romania - a Literature Review 38
Freshness Labelling as an Underestimated Factor Driving Food Waste 39
System of Date Labelling of Food from Polish Consumers' Perspective 40
Material Flow Analysis in The Agri-Food Sector: Evidence from The Italian Beef Supply System 41
Comparative Study of Food Waste in Homes in Two Metropolitan Areas: Guayaquil (Ecuador) Vs. Valencia (Spain) 42
Acceptance of a University Menu According to the Waste Assessment of the Comstock Visual Estimation Method 43
Sustainable Restaurants: Report of Experience of Sustainable Workshops in Community Restaurants 44
Evaluation of Sustainable Practices in Food Services 46
TASTE, DON'T WASTE. Instigating Food Waste Reduction at the Household Level Through Behaviour Change Theory 48
Consumer Perception of Date Labeling: An Analysis of Consumer Discard Behavior by Phrase-date Combinations 50
Consumer Behavior During the COVID-19 Pandemic: An Analysis of Food Purchasing and Management Behaviors in U.S. Households Through the Lens of Food System Resilience 51
Food Loss and Bargaining Power at the Producer-Retailer Interface: a Qualitative Assessment of Food Loss Drivers in Fruit and Vegetable Supply Chains in Germany 52
Exploring the Role of COVID-19 Pandemic in the Case of Domestic Food Waste Through the Theory of Planned Behaviour 54
The Contribution of Innovative and Intelligent Packaging to the Loss and Generation of Food Waste 55

The Portuguese Nitrogen Footprint, a Challenge in a Mediterranean Country 56
Food Waste Prevention in Practice 58
Methodologies for food waste quantification 59
Compositional Analysis of Household Avoidable Food Waste in Four European Countries 61
Best Practices for Food Waste Prevention 63
Quantification of retail food waste through the analysis of in-store data 65
Behavior of Greek Households on Food Waste Generation 66
Food Waste Prevention as a Key Tool for Resource Management in Montenegro 68
State of the Art of Food Waste Measurement: a Key Challenge to Support Prevention and Reduction 70
VAL: Valorization of Food Processing By-Products 71
Utilization of the Strained Yoghurt Whey by Incorporating or Converting into Food Products 72
Supercritical CO_2 Extraction of Oil from Arctic Char Side Streams 73
Utilization of Acid Whey Lactose Using Commercial and Innovative Biocatalysts for the Production of Galactooligosaccharides 75
Physicochemical Properties, Structure and Antioxidant Activity of Pectin from Persimmon (Diospyros kaki): Effect of Extraction Conditions. 77
Towards the Integral Waste Valorization of Three Relevant Mushrooms 79
Citrus Fruit Waste as a Nano-Factory for Super Paramagnetic Iron Oxide Nanoparticles: Decorator and Enhancer for Microbial Desulfurization Efficiency 80
Partial Substitution of Flour by Date Seed Powder into Cookies 81
The Sea Urchin Supply Chain and the Reuse of Waste for New Products. An Example of Circular Economy on Applications Deriving from Marine Collagen 82
High-Added Value Products Obtained from Freshwater Fish Waste Processing 84
Mixture Design Approach for Optimization of Complementary Food Formulation from Sorghum, Soybean, Karkade Seed and Premix for Better Nutritional and Sensory Qualities 86
Sustainable and Valuable Antioxidant Recovery from Winery Food Waste 87
Raw Earth-based Building Materials: an Exploration on Mechanical Behavior of Floridia Soil-based Adobes 89
Correlations Between Antioxidant Activity and Bioactive Compounds in Ethanolic Extracts of Pomegranate Peels and Seeds and Their Physicochemical Composition 90
Characterization of Biochar Derived from Agricultural Residues as Potential Adsorbent for Extracting Phytohormones in Waste Coconut Water 92
Recovery of Bioactive Compounds from Corn Water Stream by Grape Marc Hydrogel as Pre-treatment Before Membrane Processes 93
Infrared Spectroscopy as Tool for Evaluating The Effect Of pH in the Purification of Bioactive Compounds From Corn Steep Water 94
Effect of a Biosurfactant Extract Obtained From Corn Steep Liquor on the Wettability of Grape Surface 96
Effect of a Biosurfactant Extract Obtained From Corn Steep Liquor in The Properties of a Natural Orange Juice 97
Valorisation of Alginate Waste Streams from Industrial Extraction as Promising Source of Bioactive Compounds 99
Re-Use of Viticulture Waste: The Case of Unripe Grapes for the Development of

New Vegetal Foods Enriched with Phenols 100
Application of Hydrothermal Treatment for the Optimal Extraction of Phenols from Olive Mill Wastewater in Lesvos Island 102
Development of A High Added-Value Healthy Spread by Valorizing Olive Oil Production Residue 103
Polyphenolic Profile and Biopharmaceutical Potential of Istrian Malvasia Grape Skin Extract 105
Usage Potential of Vegetable Residue Streams 107
Bioactive Ingredients from Custard Apple By-products for Nutraceutical Applications 109
Green Extraction Strategies for Sea Urchins Waste Valorization 111
Revalorization of Mango Byproducts to Obtain Bioactive Ingredients for Developing High Added-value Cosmetic Products 113
Valorization of Sea Urchins Waste: Antioxidant Pigments Extraction Strategies 115
Valorization of Sea Urchin Wastes: Characterization of Marine Collagen Peptides 117
Extraction of Chlorophylls from Bioresidues of Daucus Carota L. (Carrots) Aerial Parts for Food Colorants Development 119
Nutritional Evaluation and Development of Anthocyanin-Rich Colouring Formulations From Bioresidues of Lonicera Caerulea L. Fruits 121
Blueberry Bagasse, a Bioactive Residue to Be Included in New Food Products 123
Prunus Spinosa L. Fruit Epicarp: Extraction of Compounds With Colouring Capacity for Food Application 125
Valorization of Sea Urchins Waste for Innovative Products and Diversified Supply Chains. A Multidisciplinary Research Project 127
Summer is Coming: How Heat and Sugar Affect Saccharomycopsis Fibuligera Biomass and Cell-Wall Fractions Production in Mussel Process Wastewaters as Culture Media? 129
The Sea Urchin Collagen, Recycled from the Food Industry Waste, is a Novel and Valuable Biomedical Resource 131
Removal of Organic Compounds Using Chemically Modified Mixtures of Olive Cake and Wheat Straw Under Batch Processing 133
Adsorption of Methylene Blue Dye from Aqueous Solutions onto Chemically Modified Apple Seeds (Malus Domestica) 134
Innovative Approach for Bioactive Compounds Extraction from Beetroot Crown (Beta Vulgaris L.) 135
UTL: Food Waste Utilization 136
Valorization of Coffee Brew By-products Via Recovery of High Nutritional Value Bioactive Ingredients and Their Incorporation into Bakery Products 137
Optimized Process of Lactic Acid Production from Food Waste 139
Production of Biodegradable Polymers from Food Waste 141
Prediction of Properties of Poly(L-lactic acid) with the Aid of Atomistic Molecular Dynamics Simulations 142
Production of Compostable Bio-Plastics from Food Waste: Design of Bench-scale Unit 143
Effect of Substrate Concentration and Retention Time on the Anaerobic Digestion of Food Waste for the Production of Valuable Chemicals 145
Studies on The Catalytic Activity of Materials Obtained from Waste in the Form of Coffee Grounds in Oxidation and Isomerization Reactions 146
Conversion of Food Waste to Levulinic Acid Utilising a Catalytic Membrane Reactor 147

TFM: Technology in Food Waste Management 148
Rethinking Food Waste in the Industry 4.0 era: A Review of Blockchain Research in the Food Supply Chain 149
GIS-based Model for Assessing New Suitable By-products for Renewable Energy Production Within the Context of Circular Bio-economy 151
Effective Tools to Reduce Domestic Food Waste: Bio-Based Dual Sensors Devices for Naked-Eye Freshness Monitoring of High-Protein Foods 152
How to Control Milk Freshness at Home: Multi-Purpose Colorimetric Sensor to Face Milk Waste and Health Issue 154
E-Tongue Based on Metallo-Porphyrins for Histamine Evaluation 156
ICC Initiative: Transformation of The City of Corfu Into a Smart, Green and Sustainable City 157
Managing Household Food Waste with the FoodSaveShare Mobile App 158
Remote Monitoring and Management of In-vessel Composting 160
AWP: Awareness and Prevention 162
Investigating the Ethical Dilemma of Food Waste in Long-Term Care Facilities 163
Comparing the Effect of Price, Regional and Environmental References on the Willingness to Purchase Sub-optimal, Regional Dairy Products in Germany 164
Children's Food Waste Behaviour Between Concept-Based Education, Peers, and Family Influence. Insights from Primary School Canteens in Northern Italy 165
sObres Mestres - Pop-up Food Waste Restaurant 167
"Save Our Food": A Pilot Food Waste Project in Cyprus 168
A 4D Approach to Food Waste Prevention - The "Healthy Little Eaters" Case Study 169
Intelligent and Sustainable Food Packaging in a Circular Economy and Consumers Changing Needs 171
The "A2UFood Training Kit": A Path to Food Wastage Reduction 173
The Profile of People Claiming Food and Material Support Benefits Due to Extreme Poverty: Data from the Region of Crete 175
F4F: Food for Feed 176
Effects of Dietary Dried Food Waste Addition to Broiler Diets on Growth Performance and Haematological Parameters 177
Performance and Meat Quality as Affected by the Dietary Inclusion of Food Waste in Fattening Pigs 178
Reintroduction of Fruit and Vegetable Waste in the Food Supply Chain: From Their Bioconversion to Earthworm Meal as Protein Source 179
The Potential of Some Underutilized Plants for Food and Nutrition Security in Benishangul-Gumuz Regional State of Ethiopia 181
The Effects of The Dietary Inclusion of Dried Food Residues on The Fecal Microbiota of Cats 183
The Effects of Dried Food Residues in a Diet on the Apparent Nutrient Digestibility and Fecal Microbiota of Dogs 184
In Vitro Fermentation of Dried Food Residues Using Canine Fecal Inoculum 185
Fruit and Vegetable Waste: Strategies for a Possible Reintroduction as Feed Ingredient 187
Characterisation and Quantification of Food Waste in the Greek Hospitality Sector 189
Microbiological Characterisation of Food Residuals Amended Animal Feed Using

a Solar Drying Process 190
The Environmental Impacts of Transforming Food Waste to Animal Feed via Solar Drying 191
Microbiological and Chemical Composition of Animal Feed Produced from Cheese Whey and Vegetable Residues Following Thermal Drying Rate 192
Solar Drying of Food Waste as a Feed Production Process: Experience from the Three Operational Periods of the F4F Pilot Unit 194
Innovative and Operational Infrastructure for the Implementation of Research and Development Actions in Waste Management within the Circular Economy Framework 196
LIFE Food-4-Feed: Context, Experience and Future Prospects 198
POL: Policy Perspective 199
Food Waste in Insular Communities in the Framework of Green Deal Strategy 200
Introducing Pay as You Throw System and Autonomous Composting Units for Biowaste Management in Municipality of Probistip 201
Autonomous Home Composting Units for Urban Areas in Greece: the case study of Municipality of Rhodes 203
A Legal Approach to Food Waste: Critical Analysis of The European Union's Regulation on Food Waste 204
CIRCULAR (Chain for Innovative ReCycling): a case study on the juridical complexity of circular economy in the food sector 205
W2E: Waste to Energy 206
Biochemical Methane Potential (BMP) of Quince Waste 207
Hydrothermal Liquefaction of Mixed Food and Plastic Waste From Supermarkets 208
Anaerobic Co-digestion of Coffee Wastes with Other Organic Substrates: A Mixture Experimental Design 210
Assessing the Effects of Spent Coffee Grounds on Dry Anaerobic Digestion of Kitchen Waste 211
Conversion of Used Cooking Oil Into Biofuel as Alternative and Renewable Energy 212
Assessment of Tomato Peels Suitable for Producing Biomethane Within the Context of Circular Economy: A GIS-Based Model Analysis 213
Quantifying the Future Energy and Nutrient Recovery Potential of the Organic Fraction of Municipal Solid Waste 215
Waste-To-Fuel: Life Cycle Assessment of Hydrothermal Liquefaction of Household Food Waste 216
Developing Dry Anaerobic Bioreactors Aiming in Optimum Utilization of Mediterranean Agro-waste for Energy Production 217
Biofuels from Hydrothermal Liquefaction of Food Waste: The Impact of Feedstock Composition on Process Economics 219
Utilization of Olive Mill Wastewater with Domestic Wastewater for the Production of Biogas and Microalgal Biomass 221
Solar Drying Method as a Pre-Treatment: Investigation of Biogas Production with Solar Dried Mixtures of Agricultural and Organic Residues 223
A Holistic Approach for the Treatment of Agro-Industrial Wastewater and Food Waste by Combining Anaerobic-Aerobic Sequential System and Photocatalysis 225
FWS: Food Waste as Soil Amendment 227
Closing the loop: Industrial Food and Agriculture Waste Valorization, the Case of Biosolarization 228

Suppressive Effect of Plant Diseases Using Coffee Grounds 230
Application of Fermented Spent Coffee Ground (SCG) With Inorganic Fertilizers in the Tea Fields and its Effects on the Nitrate Loading, Free Amino Acids and Cation Exchange Capacity 231
Phosphorus Forms Distribution in Various Composts 232
Coffee Grounds Potential Use for Small Scale Vegetable Production 234
Innovative Agricultural Practices to Increase Farm Sustainability - Tomato Production of Low Nitrogen Footprint 235
Decreasing Nitrogen Footprint of Vineyard Production 236
Modelling In-vessel Composting Under Difference Bulking Agents 237
Index 241

The Mission of RETASTE

The global food chain system is the single largest source of greenhouse gasses in the world, and the largest cause of biodiversity loss, terrestrial ecosystem destruction, freshwater consumption, and waterway pollution due to the mismanagement of biocides and nutrients. On top of these deficiencies, approximately 40% of all produced food is wasted throughout the farm to fork processes, while more than 900 million people remain undernourished.

Thus the margin for improvement of the global food chain system is huge, and may unlock pathways towards the stability of the Earth system and the future of humanity. Against this background, the **RETASTE** Conference initiates the dialogue for innovative solutions and optimization schemes that exploit significant opportunities for food waste reduction, reuse, and recycling at all stages of the food life cycle, as well as their scalability and commercial translatability. In parallel, **RETASTE** aims to address the social aspects of food waste issues, as well as to highlight ways to tackle social and perception barriers against reducing our environmental footprint, thus shifting the evolving future of social, market, and global megatrends.

Through the conservation of resources, the strengthening of the social fabric, and the development of new value chains, **RETASTE** supports the implementation of Circular Economy concept.

The audience of **RETASTE** includes academia, industry, and stakeholders, and is truly transdisciplinary as the topics of the conference dictate.

Join us to Rethink Food Waste!

The presidents of the RETASTE Organizing Committee,

Katia Lasaridi
Professor
Harokopio University

Thrassyvoulos Manios
Professor
Hellenic Mediterranean University

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9. SYNANI Katerina, Harokopio University

Keynote speakers

Maria Loizidou

Professor, School of Chemical Engineering National Technical University of Athens, Greece

Maria Loizidou obtained her PhD in chemical engineering focusing on the field of environmental protection at the University of London. She followed an academic career being Professor at the National Technical University of Athens in the School of Chemical Engineering and Head of the Unit of Environmental Science & Technology (www.uest.gr). Her efforts are continuous in the field of the environmental protection and human health, enhancing education, research technology and innovation. She has been scientific responsible for more than 175 environmental projects supporting competent authorities, municipalities and others (http://www.uest.gr/index.php/projects). She has more than 600 publications in international scientific journals (http://www.uest.gr/index.php/publications) and conferences and more than 8,100 citations (h-index: 52). Prof. Loizidou is the Head of the Scientific Committee of this series of conferences on Sustainable Waste Management bringing together academics, private and public sector, municipalities and regions, professionals from all continents. Prof. Loizidou won the first Green AWARD with the LIFE SOL-BRINE project that was voted as the best LIFE ENVIRONMENT project for the period 1992-2017 among more than 4,000 LIFE projects. She is also the Head of WtERT-Greece.

Gerasimos Lyberatos

Professor, School of Chemical Engineering National Technical University of Athens, Greece

Prof. Gerasimos Lyberatos is currently professor in the School of Chemical Engineering, National Technical university of Athens (since July 2011) and a collaborating faculty member of the Institute of Chemical Engineering and High Temperature Chemical Processes (Foundation of Research and Technology Hellas). He obtained his B.S. at M.I.T. and his M.S. and Ph.D. at CALTECH (USA) and served as Assistant, and Associate Professor at the University of Florida. In 1990 he joined the University of Patras as an Associate Professor and in 1993 became a Full Professor. His research interests are in Biochemical Engineering and Environmental Technologies. He has over 150 publications in International refereed Journals, and over 220 participations in International Conferences, 9 Chapters in books and two books. He has supervised 25 PhD theses and 15 M.S. theses. He has organized two International Conferences. Prof. Lyberatos is Editor of the Journal of Hazardous Materials (Elsevier), Associate Editor of Waste and Biomass Valorization (Springer) and is also heading a graduate programme on “Waste Management” in the Hellenic Open University.

Katia Lasaridi

Professor, Head of the Department of Geography, Harokopio University

Katia Lazaridis is Professor and Head of the Department of Geography at Harokopio University, where she teaches environmental management issues. She studied physics at the University of Athens and received her M.Sc. in environmental pollution control and Ph.D. in Environmental Engineering, from the University of Leeds (UK). She deals with environmental management and technology issues with emphasis on solid waste management, olive waste treatment, industrial ecology, environmental safety and environmental decision support systems (EDSS).

Thrassyvoulos Manios

Vice-Rector, Hellenic Mediterranean University, Heraklion, Greece

Thrassyvoulos Manios is Professor at the Department of Agriculture, Hellenic Mediterranean University and Vice-Rector of Finance, Planning and Development of the Institute. With a degree in Agricultural Biology and Biotechnology (Agricultural University of Athens), Chemical Engineering (University of Patras) and a Doctoral -Degree in Environmental Engineering (University of Leeds), his research interests include management and treatment of biowaste and wastewater. To date he has more than 85 publications in international scientific journals, 150 presentations in international conferences, and has managed more than 35 research projects, funded with over 10 million euros.

Charis M. Galanakis

R&I Director, Galanakis Laboratories, Greece
Adjunct Professor, King Saud University, Saudi Arabia
Director, Food Waste Recovery Group, Austria

Dr. Galanakis is a multi-/inter-disciplinary scientist and a Highly Cited Researcher (Clarivate Web of Science, 2019) with experience in the food and environmental science and technology, innovation and sustainability, industry and academia. He has defined the new term and discipline of "Food Waste Recovery", and established the biggest open innovation network worldwide in the particular field. He is an Adjunct Professor of King Saud University (Saudi Arabia) in Agricultural Sciences, and the Research and Innovation Director of Galanakis Laboratories L.P., with over 20 years of career in analyzing wine, food, beverages, and environmental samples as well as at the consulting of related industries and local producers. Since 2014, he works as a freelance expert for different bodies and projects (>30 calls) including European Commission, World Intellectual Property Organization, European Bank for Reconstruction and Development, and Australian Research Council among others. He has published >200 scientific documents, including >45 research articles, reviews, and monographs in ISI Scientific Journals, book chapters, technical briefs, and conference presentations. He has edited >45 multi-author contributing books in the broad field of food, bioresource, and environmental science and technology, and given >35 invited speeches.

Eleni Zika

Strategic Adviser, European Research Council Executive Agency

Eleni Zika is a strategic adviser at the European Research Council (ERC) and an active promoter of the development of a sustainable circular bioeconomy in Europe. Over the last 20 years, Dr. Zika has been active in science policy and strategy development, focusing particularly on innovation. Her areas of interest also include biotech, personalised medicine, public health and sustainability. She was the first Head of Programme of the Bio-Based Industries Joint Undertaking (BBI JU), a 3.7 billion Euros partnership between the EU and the industry, aiming to sustainably convert biological residues and waste into greener products for various applications in different sectors. Dr. Zika has previously served as Head of Sector for Fundamental Life Sciences at the ERC and in the EU's Joint Research Centre. Before joining the EU institutions, she was responsible for international policy at the UK Medical Research Council. She is a Christine Mirzayan Science and Technology Policy Fellow of the US National Academies and holds a PhD in Genetics and Molecular Biology from the University of North Carolina at Chapel Hill.

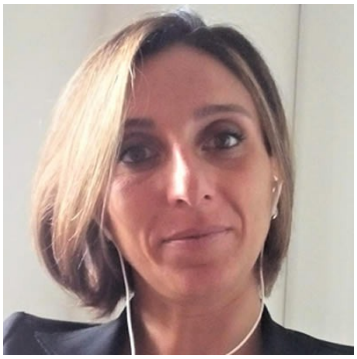
Alexia Macheras

Head of Communication and Sustainability, AB Vassilopoulos

Alexia Macheras has been working at AB Vassilopoulos (member of Ahold Delhaize) as Head of Communication and Sustainability for the past 15 years. In charge of the company's Sustainability Strategy of which one of its main pillars focuses on Food insecurity and Food waste salvation in Greece. "Trofima Agapis" is AB Vassilopoulos main Food Salvation & Donation program and has been awarded as Best CSR Strategy at the Retail Business awards. She also coordinates External and Internal Corporate communication activities at local and group level. Previously to that she worked for ten years in advertising agencies such as Publicis, UpSet! and Lowe Athens, on accounts such as L'OREAL, VODAFONE, DIXONS and UNILEVER etc. Born in Athens, Alexia Macheras is half French half-Greek, she has studied Law at the University Paris II-Assas and has BA in International Relations from American University of Paris.

Clara Cicatiello

Assistant Professor, Department for Innovation in Biological Systems, Food and Forestry, University of Tuscia



General information Born in 1983 in Napoli (Italy), graduates in Agricultural Science at University of Tuscia (Viterbo), then completes a Ph.D. in Economics and Local Development, defending her dissertation in 2012. From 2012 to 2017 works as Research Assistant at the Department of Economics and Management of University of Tuscia. In these years she develops research and teaching skills in the field of economics applied to the food sector. In May 2017 moves to Department for Innovation in Biological, Agro-Food and Forest Systems, as Assistant Professor in Agricultural Economics and lecturer of Food Marketing. In 2020 she is the coordinator of a consortium of 27 partners submitting a proposal for an H2020 Innovation Action on food waste prevention; the project, entitled LOWINFOOD, is funded with 5.5 million € by the European Commission, starting in November 2020. Author of 79papers on international journals, mainly in the topics of sustainable food chains and food waste. **Current position (since May 2017)** Assistant Professor at Department for Innovation in Biological Systems, Food and Forestry, University of Tuscia, Viterbo, Italy **Research interests** In the beginning of the career she focused her research on the study of short food supply chains, conducting empirical surveys on farmers and customers participating to these chains, for a total of 2,000+ interviews. She has expertise in sustainability indicators design and calculation; for the doctoral dissertation, she developed a model to measure the sustainability performance of food chains encompassing nearly 100 indicators and resulting in an optimization model supporting local policy choices. In the last years, her research became more closely focused on the issue of food waste. She was responsible for the first national assessment of food waste in the retail sector under the project REDUCE, funded by the Italian Ministry of Environment. She coordinates the H2020 Innovation Action LOWINFOOD, funded under the RUR-07-2020 call. In 2016 and 2019 she also worked with FAO Department of Forestry to support the socio-economic evaluation of initiatives against desertification in Africa.

Marta Gomez San Juan

Strategic project advisor on sustainable and circular bioeconomy, FAO

Ms Gomez San Juan is an Agricultural and Biosystems engineer in the Office of Climate, Biodiversity and Environment, at the Food and Agriculture Organization of the United Nations (FAO) headquarters in Rome, Italy. She currently acts as strategic advisor to the FAO's project on circular bioeconomy in agri-food systems. Marta works with policy-makers to develop national and regional bioeconomy strategies and develops knowledge products on sustainable and circular bioeconomy. She also supports the coordination of the 'International Sustainable Bioeconomy Working Group', a knowledge-exchange platform focused on sustainable transformation of agri-food systems, including through bio-innovations, policies and practices. The Working Group and the FAO project were created after 62 Ministers of Agriculture at the Global Forum for Food and Agriculture in 2015 called FAO to coordinate international work on sustainable bioeconomy.

Christina Marouli

Associate Professor, Environmental Studies, Deree – American College of Greece; Monitoring expert, NEEMO EEIG

Dr. Christina Marouli has studied biochemistry (B.A.), Urban and environmental policy (M.A.) and sociology (PhD) in the United States, with a specialisation on the urban environment, health and social inequalities. She has been the recipient of a Fulbright award during which she collaborated with a Turkish professor from Bogazici University and did research on multicultural environmental education programmes. Her research interests include sustainable – healthy – smart cities, food waste, Education for Sustainability and education for behavioural and social change, and environmental health. She is Associate Professor at the Environmental Studies B.Sc. program of DEREE - the American College of Greece, where she also founded and directed (for 7 years) the Center of Excellence for Sustainability. In addition, she has extensive experience as a consultant and a free-lance researcher on environmental and occupational safety health issues in the private sector, as well as an expert of EU funded environmental projects (under LIFE or Urban Innovative Action initiatives). She has worked with NGOs focusing on women's and children's issues (i.e. Director of Save the Children, Greece; responsible for development education programmes at the YWCA, Greece), while she was a co-founder of the Emergency Research Center (NGO).

Alexander Theodoridis

Co-Founder, Chief Food Saving Warrior, Boroume

Alexander is one of the co-founders and the director of NGO Boroume (“We Can”), a leading food saving organization of Greece which since 2012 has saved & offered more than 40 million portions of food from thousands of donors to over 600 charities all over Greece and has been awarded with the European Citizenship Award 2017 by the European Parliament. He has extensive experience in both the private and public sector, is a Marshall Memorial Fund Fellow and has received scholarships from the Friedrich Ebert Stiftung and the DAAD (German Academic Exchange Service). He holds degrees from the Ludwig-Maximilians-University of Munich (1996-2000, Magister Artium, Political Science, Economics, International Law) and the London School of Economics (2000-2001, MSc International Relations).

Constantinos Stathopoulos

Vice Dean of College of Food and Agriculture, Professor of Food Technology, United Arab Emirates University

Costas Stathopoulos is a Professor of Food Technology and Vice Dean of the College of Food and Agriculture in the UAE University. He has extensive international experience having worked in academia and research in the UK, Ireland, Thailand, Australia, South Korea and the UAE, always in the broader field of food science and technology. His research focus for more than ten years is on the utilisation of waste and by-products from primary and secondary food production. Prof. Stathopoulos has more than 100 publications in peer reviewed journals and has had his work presented in more than 60 international conferences. Prof. Stathopoulos has secured more than 20 competitive research grants with a total value in excess of 5 million euro. He is a Fellow of the Institute of Food Science and Technology (UK), and Expert Advisor for the International Tropical Fruit Network, a member of the Scientific Advisory Committee of PETET, a Life Member of the Society of Dairy Technology (SDT) and a member of the International Society for Horticultural Science. He is an adjunct Professor for the University of Canberra (Australia), and sits on the Editorial Board of several international peer reviewed journals.

KEY: Keynote

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Food - Waste - Circularity: Contradictions and challenges

Christina Marouli

Environmental Studies, Deree - American College of Greece; Neemo EEIG- LIFE Monitoring Team

Abstract

Circular economy is a goal of sustainability efforts in the EU and worldwide (e.g. UN SDGs). To achieve circularity, we need to consider the whole life cycle of a product and rethink the relation between resource – product – waste. This is a challenge in contemporary societies, but even more so for food waste management. This presentation will discuss food waste management for circularity and based on the experiences of some EU funded projects, will highlight contradictions and challenges faced at several levels – culture, policy, administration / bureaucracy, economy and physical space – aiming to provide some insights for policy making.

Keywords: food waste, circularity, challenges

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Rethinking Food Waste Within the Concept of BioWEconomy to Support Green Recovery From the COVID-19 Pandemic

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Abstract

The spread of the COVID-19 pandemic has generated a health crisis and repetitive lockdowns that disrupted different economic and societal segments. The world has placed hope on the vaccination progress to bring back the socio-economic “normal,” and herein we will explore how the bioeconomy can enhance the resilience and sustainability of bio-based, food, and energy systems in the post-pandemic era. The pandemic occurred in a time when the EU policy agenda was taking a powerfully transformative shape: The European Green Deal, committed to foster sustainable development and achieving the targets of the Paris climate agreement, has specified respective goals, tools, and timelines. Rather than deviating from this pathway, the COVID-19 crisis shows that a system change is needed. As the EU and the rest of the world begin to emerge from lockdowns and plan recovery, respective strategies, and contingency plans to manage further waves of the pandemic, attention must return to addressing the climate crisis and building resilience – and in that, the bioeconomy has a role to play. However, to be socially accepted widely, the bioeconomy needs to rely increasingly on 'circular' feedstocks from bio-based residues and wastes to reduce dependency on crops that compete with agriculture/food markets. Food waste represents a valuable option as it allows for producing a broad group of biobased products ranging from biofuels to bioplastics. Transformation also requires working with people in active roles, considering their capacities to think and speak about the transformation. This is why social aspects (e.g., culture, arts & fashion), but also biocities, rural bioeconomies & key sectors like tourism are of high importance. A circular, sustainable, and transformative BioWEconomy can mitigate severe & likely risks, e.g., food security, water crises & climate change.

Keywords: COVID-19, pandemic, bioeconomy, BioWEconomy

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A Green Deal for the Planet: The Role of Frontier Science and Innovation in Delivering a Circular Economy – the Case of Food Waste

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Abstract

The European Green Deal lays the foundation for making the EU's economy sustainable by turning climate challenges into opportunities for growth and prosperity. One of its key objectives is to turn Europe into the world's first climate-neutral continent by 2050. To this end, innovation will play a central by deploying, demonstrating and de-risking solutions while frontier and curiosity-driven science will continue to open new avenues of discovery that can further enhance climate action. This presentation will outline the opportunities offered within the European Commission's recently adopted framework program (Horizon Europe) to enable this transition, focusing in particular on actions for a circular bioeconomy. The presentation will also outline examples of research and business models currently funded by the EU in order to valorize food waste, thus contributing to a circular and resource-efficient economy.

Keywords: Green Deal, climate neutrality, circular bioeconomy

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Towards a Sustainable, Circular Bioeconomy: the Role of Innovation, Practice and Policy

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Abstract

The use of natural resources globally has tripled in the last 50 years, and could double again by 2060 if we continue business as usual. Our current linear system highly depends on finite, unsustainable resources, pushing the planet to its limits and increasing inequalities. Also, the demand for food and non-food biomass is increasing rapidly. Current agri-food systems do not capture the maximum value from biological resources to sustain the global population of tomorrow. Bioeconomy policies are part of national low-carbon, non-polluting growth strategies. Today, more than 60 countries have bioeconomy or bioscience related strategies, which aim to harness the power of biological resources, science and technology, and to address different global challenges; providing food, feed, wood-products and furniture, paper, bio-based textiles, bio-chemicals, bio-plastics, bio-pharmaceuticals and bio-energy for a growing population while preserving our natural resources. These strategies, often linked to circular economy programmes, can improve resource use efficiency and the conservation and regeneration of biological resources. While different countries have different systems of measurement, many have estimated that bioeconomy represents 5 - 10% of their national GDP. Agri-food systems transformation is a particularly powerful lever for achieving global goals. They occupy the biggest share of the bioeconomy, employing 1.2 billion people worldwide. They also hold important opportunities for discovery and innovation. For instance, microbiome research can support sustainable agri-food systems that inextricably link healthy soils, to healthy plants and animals, to healthy diets in humans and to a healthy planet. However, agri-food systems are also contributors of GHG emissions, natural resources degradation and social inequalities. This presentation will outline FAO’s work on bioeconomy, with a focus on how circular bioeconomy can support the transition to more sustainable food systems at three levels: innovation, policy and practice. Through knowledge products on bioeconomy, which include good practices, policies, tools and indicators, FAO provides guidance to leverage technological bio-innovations, together with institutional and social innovations. Circular bio-innovations and technology play a key role in the shift from an economy based on fossil resources to one based on renewable biological resources. For instance, bio-innovations such as biostimulants to improve plant health and protein produced from waste streams, can contribute to reducing the great problem of food loss and waste. Beyond the technology itself, science-based data and inclusive governance mechanisms are needed to make the right choices between different policy and investment scenarios of these bio-innovations. FAO works with policy-makers to develop coherent and sustainable bioeconomy

strategies and policies that exploit synergies and navigate trade-offs between the agri-food system and other parts of the economy that rely on biological resources. A set of 10 Aspirational Principles and 24 Criteria for Sustainable Bioeconomy has been developed to provide a framework that considers all dimensions of sustainability under bioeconomy strategies and monitoring systems.

Keywords: agri-food systems, bioeconomy

RETASTE Conference Abstracts
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Boroume

Alexander Theodoridis

Boroume, Zografou, Greece

Abstract

Boroume ("we can") started in 2012 as an innovative model of saving food and directly offering it to charities all over Greece and has since then developed a holistic approach regarding the reduction of food waste including food saving & awareness raising programs.

Keywords: we can

RETASTE Conference Abstracts
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Food Waste: Path to Change

Alexia Macheras

AB Vassilopoulos

Abstract

AB Vassilopoulos is a Greek Food Retailer with non-negotiable quality, exceptional service, and unique variety, that has rightfully earned a place at the table of every Greek household. Guided by our purpose, to give our best to make a difference in people's lives, we are always by the side of our over 2.2 million customers with courage, integrity, teamwork, care and humor. Through our network of more than 500 stores across the country & AB Eshop, we are present in every neighborhood across Greece. Where our people become your people, every day, ready to assist you with joy and passion and to offer a unique shopping experience to each one of you. In 2019 we decided to act on the issue of Food Waste and Plastics, aiming to reduce both by 50% by 2025. Five years in advance from the Sustainable Development Goal. But to achieve our 50% target by 2025, it was important to put together the resources, knowledge and expertise of different stakeholders. Therefore, we decided, together with the local NGO Boroume that fights food waste, to co-create the first Alliance for the Reduction of Food Waste in Greece, and to partner with suppliers, producers, catering, and institutions. Today the alliance counts 51 members and is under the auspice of the Ministry of Environment and Energy. Boroume has been a long-time ally since 2013, partnering for the salvation of our close to expiration date goods from our stores via the program Love Food. An initiative that is unique in Greece and that has saved millions of food portions. We also partnered with Harokopeio University with an 18-month study, to set a baseline and measure food waste across our entire supply chain. Our goal is to measure food waste created by our main suppliers, our own organization, and our customers. Finally, our partnership with WWF will help us train our internal stakeholders about our procedures and the best way to assess our progress, create guidelines to minimize waste across the whole supply chain and investigate alternatives for food waste transformation or salvation. We take food loss and food waste very seriously and it is only through strong and mutually beneficial partnerships that we will be able to achieve our 50% goal, 5 years in advance. We chose partners with which we share a same vision and willingness for change. We have set concrete goals and targets. We will also need to be flexible and pragmatic because the road might be bumpy. But we have the will for change and transparency.

Keywords: reduction, retail

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Integrated Biorefinery Processes: the Role of Anaerobic Digestion

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Abstract

Circular economy and bioeconomy are the policies adopted as a response to the unsustainable use of natural resources. It is argued that implementation of these concepts in tandem, through a systemic approach including design principles and process integration, would ensure resource efficiency and sustainability. Biorefineries could stand as a strong link between these policy agendas that present common objectives and areas of intervention. A biorefinery produces a spectrum of marketable products in order to maximise its economic sustainability and aims to "zero waste". A variety of different biorefinery configurations have been developed. Anaerobic digestion has a special position in a biorefinery as one of the most established technological processes for converting biomass to value-added or bulk end-products in the context of circularity. Anaerobic digestion can be included in integrated biorefineries where innovative bio-materials and renewable energy may be produced. The anaerobic digestion process can be included in a biorefinery concept either as a final disposal step or as the core process unit. A review of the integrated anaerobic biorefineries is presented, evaluating their potential significance. An analysis of various types of anaerobic biorefineries has been developed, including both pilot and large-scale applications. Future directions are highlighted. The current state of knowledge was collected, presented and it was then synthesized under the concept of an integrated biorefinery. A biorefinery should produce a spectrum of marketable products in order to maximise its economic sustainability and to aim for “zero waste”. A variety of different biorefinery configurations has been developed. Biorefineries may be configured around a large volume product to maximise economies of scale and to allow the successful utilisation of all inputs with the integration of process operations. Integrated biorefineries that include anaerobic digestion systems were studied as case studies revealing the wide spectrum of input feedstocks, technological configurations and variety of end-products. Biorefineries that use food waste, restaurant waste, organic fraction of municipal solid waste, agricultural residues, microalgae were studied and the synergistic effect of anaerobic digestion with biofuel production processes was highlighted, since the perspective of anaerobic digestion as a process unit for the valorization of residual streams (stillage, pretreatment effluents etc.) was validated. Nutrient recovery from digestate could further boost the incorporation of anaerobic digestion systems in sustainable biorefineries. Case studies that presented the digestate valorization through the production of compost, inorganic fertilizers (N, K), PHAs and clean water set anaerobic digestion process in line with the strategy of resource efficiency. It is evident that the biogas plant has a special place in a biorefinery

as one of the major facilities for converting biomass to high-value or bulk products in the circular economy. Solutions involving biogas can be part of a dynamic innovation culture where apart from conventional end-products (biogas, digestate), novel materials may be produced. The flexibility of the anaerobic digestion system and its ability to digest a multitude of organic feedstocks, while producing a significant range of products ensures the role of anaerobic digestion and biogas in the circular economy. Nevertheless, the viability of each integrated biorefinery should be assessed in terms of technoeconomic and environmental sustainability. Key techno-economic factors include feedstocks, energy, capital and operational costs, the products utilization and market availability.

Keywords: Anaerobic digestion, Bioeconomy, Biorefinery, Circular Economy

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Valorization of Source-collected Household Food Waste at Municipality Level

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Abstract

According to FAO, every year, 1.6 billion tons of "primary product equivalents" of food are wasted. This implies a food wastage carbon footprint is 3.3 billion tons of CO_2 equivalent of GHG released into the atmosphere, 250,000 m^3 of water being used to produce food that is lost or wasted and 1.4 billion hectares of land - 28% of the world's agricultural area - being used to produce food that is wasted. The biodegradable MSW is the most promising, in terms of valorization opportunities, and at the same time the less exploited fraction of MSW. Food waste is the biggest fraction of the biodegradable MSW. In the framework of Waste4Think, a Horizon 2020 project, NTUA have developed at pilot scale separate collection and valorization of Household Food Waste (HFW) in the Municipality of Halandri. Household food waste was collected at the source from approximately 250 households (800 inhabitants) using brown bins that could only be used by properly informed citizens that had access with a key. Over a period of 3 years, excellent quality food waste (less than 2% impurities) was collected. The food waste was dried and shredded to produce FORBI (a food residue biomass product) with the following advantages: It has 1/4 to 1/5 the weight of food waste, implying reduced transportation costs It has low-moisture and may be stored for prolonged periods of time without deterioration, it Is homogeneous, it does not emit odors and may be used for producing fuels, energy and other products. 8 alternative valorization possibilities were examined at NTUA, namely Gaseous Biofuels (Methane, Hydrogen, Hythane), Liquid Biofuels (Bioethanol), Compost, Solid biofuels (pellets), alternative fuel for the cement industry, Direct production of Electricity (microbial fuel cell technology), Adsorbent and Animal Feed. Among them the production of bioCNG, compost and AF for the cement industry proved higher TRL and were further investigated. A pilot plant was built for production of bioCNG from FORBI and the generated fuel was used for properly modified waste collection trucks, in a circular economy approach. The collection scheme was expanded for a whole municipal section of 8,000 people and within 6 months diverted 43% of food waste from landfilling. A whole plan has been made for extending the whole approach for the Municipality.

Keywords: Waste4Think, biodegradable MSW

PLW: Food Loss and Waste Prevention

Prevention is at the cornerstone of sustainability. It is universally regarded as the best waste management option. The food waste reduction potential through prevention is huge - some reports speak about 70% - and it is spread throughout the value chain: the supermarkets, the hospitality sector, even our households. Prevention largely depends on consumer behavior; therefore, it is something dynamic – for this reason, the COVID-19 pandemic may also have had its impact on food waste production.

Case studies presented in the RETASTE Session on Food Loss and Waste Prevention span from the Mediterranean, Montenegro, Romania, Poland, Germany, and even across the Atlantic in the United States, and Ecuador.

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Possibilities for the Prevention of Food Waste in the Hospitality Sector - Case Study of Hotels in Heraklion, Greece

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Abstract

For Greece with a population of 10.5 million, it is estimated that more than 25 million tourists visit the country each year. Additionally, an extra number of 5 million domestic tourists are estimated (OECD, 2016). According to a study conducted in the region of Crete by Gidarakos et al. (2006), food waste is the main fraction of the municipal solid waste during the high tourism season, most of it arising in hospitality units. This fact provides an excellent opportunity for implementing kitchen based waste prevention systems. Large volumes of food, handled by professionals, with an explicit desire to reduce the amount of food that is thrown away, not just for environmental, but mostly for economic reasons. In order to reduce the amount of food waste, it is essential to know where, why and how much food is discarded. For this aim the "RESOURCEMANAGER-FOOD" (RMF) is applied in different hospitality units in Heraklion, Crete, Greece. The RMF is a hardware-software tool for the recording, analysis and reduction of food waste. By including evaluation parameters like costs or greenhouse emissions, the user gets direct feedback about the impacts of the discarded food, which rises awareness towards this issue. The measurement of the food waste quantities in different categories, as well as the reasons for the discard are conducted with the RMF by the kitchen staff. After analysis and evaluation, the kitchen managers receive feedback about the avoidance potential and possible reduction measures. The daily food waste generation due to overproduction show that some hotels generate many times more food waste per guest than others. When it comes to the composition of food waste, the hotels have in common that a large amount of the total food waste is salad, mainly mixed salad. Furthermore, the main courses and supplements are a large part, as well. A comparison of the plate leftovers per guest between the main restaurant (buffet style) in one hotel and the *a la carte* restaurant in two others showed that the amount of plate leftovers per guest is significantly lower in the buffet style restaurant. The measurements showed the daily food waste generation, the food categories with highest saving potential and theoretical possibilities to reduce food waste. The practical implementation of reduction measures is the responsibility of the hotels. They decide to what extent they want to and are able to implement these actions.

Keywords: food waste, prevention, hospitality sector, digital tool

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Alternative Food Networks and Household Food Waste: Evidence from an Italian Case Study

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Abstract

Food waste reduction is an important component of the EU action for waste management and one of the sub-goals highlighted in the SDG 12. Its importance has been growing rapidly since 2008, with about 3,000 scientific papers published in the past 11 years. Of these studies, many have identified consumer behavior as a significant cause of food waste. Therefore, policy actions have focused largely on communication campaigns and donations, and less on sustainable production. Large retailers and final consumers are the most blamed and targeted for any intervention at policy level. Despite the growing number of publications, literature has not assessed the waste reduction potential of alternative food networks on the food consumption side. For this purpose, our preliminary study – testing a food waste quantification methodology in the municipality of Pavia – focused on a sample of 24 households that adhere to Community Supported Agriculture or are active in local environmental associations, i.e. are active or aware of alternative food networks. A waste compositional analysis provided a weekly food waste quantity that was almost half any previous result obtained with the same methodology in Italy (573 VS 1058 g/family/week). The methodology has been set up based on the framework established in the Annex III of the Delegated Decision of the European Commission 2019/1597 of May, the 3rd 2019. Given the small sample size, the external validity of these results should be explored in further studies. Nevertheless, our preliminary results show that policy makers should take into account the role of alternative food networks in the strategy to achieve the SDG 12.3, thus revising the approach currently practiced in the sector.

Keywords: Household food waste, Quantification, EU methodology, Alternative food networks, SDG 12.3

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The Importance of Setting Accurate Monitoring Procedures to Prevent Food Waste at Retail Stores

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Abstract

In the retail industry, the generation of food waste is linked to unsold products or items that for various reasons are not accepted by consumers. According to most studies, the share of food waste at stores is estimated between 1% and 2%, but food waste represents a significant commercial issue for retailers, due to low margins and high costs for in-store operations. It is also considered an ethical issue, regarded with increasing attention by the public opinion. In the context of a national study of food waste assessment at different stages of the supply chain, the quantity of food waste produced by 13 supermarkets in Italy was monitored for 12 months. An improved recording routine was applied during the study period, including the standard bar-code recording plus a manual weighting and annotation of the waste of unpacked items that are usually disposed of without recording. By comparing the resulting data with those recorded before the beginning of the study, the existence of huge amounts of unrecorded food waste was disclosed, especially for fruits and vegetables, packed cold cuts and groceries. The rate of food waste on sales raised from 1.01% to 1.33% during the impremention of the improved recording routine, showing that food waste data available to store managers were not accurate before the study. Moreover, a significant decreasing trend of food waste was observed in the stores during the study period, suggesting that the implementation of a more accurate recording procedure can have a positive effect on the attention of the stores' staff and management towards food waste prevention. This was confirmed by interviews with store managers conducted at the end of the study period. Therefore, setting a careful monitoring of food waste in retail stores can be regarded as a first and key action of prevention, thus making managers more aware of the real quantity of food discarded and increasing their commitment on actions against food waste. The effort needed in terms of time and human resources to improve the recording operations is likely to be largely rewarded by a decrease in the rates of food waste.

Keywords: retail food waste, supermarket records, food waste prevention, in-store waste, unrecorded food waste

Acknowledgments: This research is a part of the project REDUCE, funded by the Italian Ministry of the Environment [RINDEC-2015-0000088] and coordinated by Alma Mater Studiorum University of Bologna. The general aim of the project is to contribute to reducing food waste at the national level, by quantifying food waste in Italy and proposing preventive measures to reduce food waste at different stages of the food chain.

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Household Food Waste in Romania - a Literature Review

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Abstract

Working on the issue of food waste allows having more sustainable societies, due to its economical, social and ecological impacts. From the entire chain, one of the main actors in terms of waste is the household. According to Stenmarck et al. (2016), 53% of waste at EU28 level is produced by households, with food being an important element of the total waste. The aim of the study is to evaluate the situation of household food waste in Romania, a country with big discrepancies in terms of incomes and amount of food wasted - the ninth highest level, according to EU statistics with 6,000 tonnes of food waste per day (European Parliament, 2018). The method used was the narrative review, and the choice of the household sector was determined by the availability and the number of studies on this topic. A consistent number of research articles, EU studies and reports, waste statistics and databases were consulted with the purpose of identifying the main results obtained on this topic and determining the theoretical framework for future studies about food waste consumer behaviour. The results of this literature study reveal that there is an increasing trend in terms of food waste per capita in Romania, in the last years. The main factor, which influences the food waste behaviour, at household level, is the lack of panning in the shopping process. This is due to the lack of knowledge and interest about food waste, but also to the absence of waste prevention campaigns. Other significant factors are the food storage habits, the way of preparing food and the routine. The waste composition shows an important share of food and organic waste at household level. More in-depth studies are necessary to provide the best knowledge in terms of households food waste behaviour and to identify the unsolved problems.

Keywords: Romanian consumer, food loss, trend, prevention, behavior

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Freshness Labelling as an Underestimated Factor Driving Food Waste

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Abstract

Freshness dates, next to sensory properties, provide consumers with information about the remaining shelf-life of food products. The aim of this study was to evaluate the influence of freshness labelling on a consumer rejection of food. A consumer sensory study was conducted among 180 participants from Poland. Eight different foods labelled with two date types (‘use by’ or ‘best before’) and four various freshness dates were examined. The freshness dates showed that the food product is either one day before the expiration date, expires on the day of evaluation or is one day or one month (three days in case of ‘use by’ samples) past the expiration date. The respondents had to assess if the product is suitable for consumption without tasting it. Despite the different dates, all of the samples of a particular product had the same freshness. The results showed that even fresh samples were rejected by 14.2-22.1% respondents. The suggested loss of freshness caused a significant increase in products’ rejection. The frequency of rejection differed between food categories. Nearly half of the participants rejected ‘use by’ food products overdue by one day. In case of ‘best before’ expired samples ca. 40% of the participants did not accept the samples one day and one month after expiration. Such behaviour shows that there is still much confusion about different kinds of labels, which ultimately lead people to interpret any date label as a ‘use by’ date, and therefore, they throw away all food items that ‘have expired’, although these items are actually still safe to eat. Moreover, the results proved that freshness labelling is the key element of the packaging that may lead to unnecessary discard of food increasing the total volume of waste. Therefore, it is important to educate consumers to better understand the meaning of certain date type and, on the other hand, educate producers to establish freshness dates basing on both scientific evidence and on consumer sensory studies.

Keywords: food waste, food labelling, date labelling, shelf-life dates, best before

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System of Date Labelling of Food from Polish Consumers' Perspective

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Abstract

The relationship between food waste and date labelling is still not enough understood. Unreasonable throwing away of edible overdue "best before" labelled foods contributes to growing mass of wasted food and to inefficient use of land, water, labour, and energy, as well to unnecessary emission of greenhouse gases. Confusion and misunderstanding of the shelf-life dates therefore can have indirect impact on environment. The aim of the present study was to examine how food consumers in Poland perceive the ease of dealing with shelf-life dates under UE regulations. A quantitative survey was conducted using the face-to-face interview method among consumers declaring the systematic purchase of foods. The selection of the research sample (n = 1,145) was carried out by the quota method which met the demand for maintaining the relative representativeness of the research population. The results showed that 94% of Polish consumers used to check the dates, the most of them take care about "use by" or "best before" dates during purchase and before consumption. 40% claimed that it happened to them that they have problems with finding the information, with only 20% declaring any problems with reading the dates. 40% of Polish consumers were not able to correctly interpret the ‘best before’ date. Respondents had also problems with food handling adequate to the type of shelf-life labelling ("use by" vs "best before"). Diagnosed problems highlighted the scale of the labelling-related problem in the global context of food waste and the need of constant education.

Keywords: Date labelling, food waste, use by, best before, shelf life

Acknowledgments: This study was supported by the National Science Centre (Narodowe Centrum Nauki), Poland [grant number 2017/27/B/HS4/00805].

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Material Flow Analysis in The Agri-Food Sector: Evidence from The Italian Beef Supply System

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Abstract

The Italian meat industry, accounting for more than 15% of the domestic agri-food value, represents a core business for the national economy, but requires huge amounts of natural resources and generates different typologies of waste. Indeed, as a part of the Farm to Fork Strategy, the European Commission aims to halve food waste by proposing legally binding targets by 2023 within circular models. The study proposes the Material Flow Analysis (MFA) methodology as a tool to measure and qualify resource and waste flows in the Italian beef system in each stage of the food supply chain, from agricultural to final consumption stage. In detail, MFA is applied to the entire Italian sector of beef (one-third of national slaughtered animals) consumed as packaged fresh product in 2020, during the Covid-19 pandemic. To collect data, bottom-up and top-down mixed approach are applied. Subsequently, MFA results are used to calculate the wastage-related losses in terms of embedded natural resources. The aim of the paper is to investigate how the beef industry can be enhanced through responsible production, acquisition, consumption and disposition, and how waste management can be effectively addressed and developed. In particular, the authors attempt to: (a) better understand the Italian beef supply chain metabolism, highlighting hidden and/or virtual material flows associated to the entire beef supply system; (b) promote households' education, suggesting awareness campaigns toward agri-food resilience and sustainability. In 2020, it results that the Italian meat industry slaughtered more than 1.15 Mt of bovine to produce approximately 0.29 Mt of fresh meat, 0.69 Mt of by-products and over 0.015 Mt of food waste at households, while 0.15 Mt of beef meat are destined to catering services and food industry (out-of-boundaries). In terms of hidden natural resources, it emerged that over 94 billion m^3 of water, approximately 101,000 TJ of energy and over 11,500 t of PET and PE trays are required to sustain the beef system. This research is one of the few studies proposing MFA methodology as a tool to assess hidden resources and waste flows in the agri-food sector. This analysis shows its utility in terms of natural resources and waste quanti-qualitative evaluation, hidden flows accounting, and development of new educational strategies toward food waste minimization and sustainability.

Keywords: beef industry, material flow analysis, waste management

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Comparative Study of Food Waste in Homes in Two Metropolitan Areas: Guayaquil (Ecuador) Vs. Valencia (Spain)

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Abstract

The world generates 1.3 billion tons of food waste every year, which, in turn, generates economic losses equivalent to 940 billion dollars a year (FAO, 2013). However, this poses a particular challenge, since the lifestyle, consumption trends, and purchasing habits are in continuous change (Oláh et al., 2018). Here we compare the annual food waste of 120 families from two metropolitan areas, corresponding to the city of Guayaquil (Ecuador) vs. Valencia (Spain), 60 families from each city. Food waste is evaluated using questionnaires designed by the Ministry of Agriculture Fisheries and Food (MAPAMA, 2017), which collects information on the total waste content (kg/home/year). The total food waste content obtained in Guayaquil is 85.9 kg/home/year, and in Valencia it is 72.8 kg/home/year. While in Guayaquil, 78.3% of the waste generated by the families surveyed is avoidable and 21.7% is unavoidable, in Valencia it is 96% of the families surveyed generate avoidable waste and 4% of unavoidable waste. According to the criterion classification of avoidable waste, open and over-cooked foods account for 60.4% in Guayaquil, while in Valencia they account for 54% of the total, on the other hand, waste derived from unhealthy food, either due to expiration or poor conservation, in Guayaquil account for 39.6% while in Valencia they account for 46% of the total. The results show waste values in the range of those obtained in the household food waste quantification panel in Spain 2016 which was 71.2 kg/home/year, although some difference is observed between the two communities in the classification of this waste as avoidable or unavoidable.

Keywords: Household, food waste, quantification, awareness

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Acceptance of a University Menu According to the Waste Assessment of the Comstock Visual Estimation Method

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Abstract

It has been reported that food waste accounts for the largest land fill deposits, and an average annual loss of $100 billion. Because of the large size of Universities, food waste should be among the important issues for universities (Thapa et al., 2016). Alternatives to weighing food are visual estimation, i.e., direct observation by an experimenter, and photographic methods. Visual estimation has high reliability, requires less labor, less time, and less space, but requires trained observers (Brautigam et al., 2014). The purpose of this research was to amount of lunch plate waste and to collect information to raise awareness for the reduction of food waste in university dining halls, used by students as well as administrative and academic staff. For this research, the food waste at the Valencia University's dining halls in Valencia (Spain) was examined by visual estimation of waste on the trays using the Comstock method; 5-point scale: item 5: all; item 4: 3/4; item 3: ½; item 4: 1/4; and item 5: none (Comstock et al., 1981). A photography method was used to measure waste of starter, main course and dessert on 942 trays during one month by a trained nutritionist. No residue (item 0) was found in 90% (847) of desserts, in 83.5% (790) of the starters, and in 67.4% (635) of the main courses. Most of the residue, valued as a higher percentage of dishes with a higher amount of residue, was occurred in second dishes with the 16.8% (159) of item 1 (1 -25%) and 12.8% (121) of item 2 (26-50%), followed by the first dishes where 10.4% (98) were cataloged as item 1 (1-25%), and for desserts where 3.82% (36) shown an item 4 (76-100%) and it was almost entirely wasted. The menus offered in the catering service of the University of Valencia are well accepted by users, but it is necessary to investigate the reasons for the waste with an emphasis on the differences between first and second course, as well as to investigate why in the category of desserts there is a surprising percentage of item 4.

Keywords: Food Waste, Universities, Food Services, Consumer Waste, Spain.

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Sustainable Restaurants: Report of Experience of Sustainable Workshops in Community Restaurants

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Abstract

Sustainable restaurants are based on the implementation of environmental management. They are closely related to quality management through a set of instruments and programs, which aim to provide a process of organizational change and continuous improvement of the environmental quality of services, products, and services. Work environment in public or private restaurants, of any size, generating greater social, environmental, and economic impact while reducing environmental damage (Maynard et al., 2020). This study aimed to implement a sustainable development program that transforms community restaurants into sustainable units. This interventional study was carried out in 12 community restaurants in the Federal District/Brazil. The intervention plan was elaborated through workshops performed with food handlers, separated by themes related to sustainable development. The food services participated voluntarily and signed the Institutional Acceptance Term. There were two meetings in each of the twelve community restaurants, one for the situational diagnosis and recognition of the activities carried out in the food services and in the second meeting, the sustainable workshops were developed. The first meeting was based on applying a previously validated checklist on sustainable practices applied with the dietitians and the employees. In the second meeting, water conservation, energy efficiency and solid waste production's themes were worked on. The first theme was addressed using posters and awareness stickers spread on the site, in that same workshop, a dynamics on garbage production was developed, to which employees were invited to consume food and soon afterward the packaging of it becomes "garbage". So that there would be the impact of the rapid production of solid waste. Finally, a conversation was held with employees explaining how the worldwide production of waste is exacerbated, damaging the planet. Also, how we can improve the situation and become more sustainable, as well as what the role of each employee about the use of water and energy in a more sustainable way. Curiosity and knowledge about water, energy and solid waste production were identified, as well as positive evaluations of the interventions carried out. The sustainable workshops showed a positive effect on companies and employees' awareness in relation to sustainable practices.

Keywords: sustainability, restaurant, environmental management, awareness.

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Evaluation of Sustainable Practices in Food Services

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Abstract

Food services are establishments that carry out nutrition and food activities, aiming to provide nutritionally balanced and healthy meals and made with food safe for consumption. As a result, the demand for food services has increased, resulting in a large generation of solid waste and overuse of natural resources, thus making evident the need to raise awareness of meal production to adopt more sustainable practices in order to reduce impacts negative to the environment (Strasburg et al., 2017). This work aimed to investigate which sustainability practices are being carried out in food services. This was descriptive and transversal study carried out in 81 food services in the Federal District/Brazil, containing philanthropic institutions, hospitals, schools, community, commercial and institutional restaurants. The research was carried out using a validated checklist questionnaire. The food services participated voluntarily and signed the Institutional Acceptance Term. Concerning the percentage of sustainable activities carried out, commercial restaurants stood out with 37.2%, followed by community restaurants with 35.9%, since the least performing activities were restaurants in the hospital sector, but with no statistical difference between them ($p > 0.05$). Among the main results found on water supply, reservoir, and water use activities, 96.3% of the companies answered that their employees verify that taps are closed when they are not in use and that the company performs immediate repair when there is a leak. Regarding the use of energy, only 12.3% used some form of renewable energy. As for gas indicators, no company uses biogas (100%). Regarding menu and food waste, 90.1% of the food services have the majority of their meals containing healthy food, and 72.8% of the food services evaluate their food waste during the preparation and distribution of food. Concerning solid waste, 63% companies carry out separation of recyclable materials (selective collection). In the case of training on sustainability and preservation of the environment, only 34.6% of the employees' teams have already undergone environmental training on energy efficiency and water efficiency and social sustainability, and 44.4% of the food services have initiatives that promote education in healthy food for the local community. It was noted that the interest in the development of more sustainable practices in food services is of vital importance, and also that the dietitians becomes even more aware of his role concerning sustainability.

Keywords: sustainability, restaurant, environmental management, waste.

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Acknowledgments: Thanks to all restaurants, nutritionists and employees who participated in the study.

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TASTE, DON'T WASTE. Instigating Food Waste Reduction at the Household Level Through Behaviour Change Theory

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Abstract

Every year, millions of tonnes of food get wasted all across Europe, causing serious strains on the environment. As long as food goes to waste, the energy and resources used to produce, package, and transport the food go to waste as well. In terms of the UN Sustainable Development goals, reducing food waste can help tackle Goal 12.3, responsible consumption and production by aiming to halve global food waste by 2030. Therefore, within the European continent, several policies and actions are designed to tackle the issue of food waste both on the international level of the European Union as well as on the level of national and local governments. While food waste occurs at every stage from farm to fork, research has shown that, especially at the household level, the issue of food waste is problematic with domestic food waste accounting for 53.08% of all food waste produced in the European Union (Stenmarck et al., 2016). The following research, therefore, explores the awareness of food waste in households within five European countries (Belgium, Germany, Greece, Republic of Ireland, and the UK), and food waste prevention/reduction practices within the field of consumer behaviour before and during the COVID-19 lockdown. An online questionnaire was distributed to 250 respondents (50 for each country) from which data was analysed using behaviour change theory and the COM-B model (Michie et al., 2011). Across countries, the results show that the main reason for food waste is poor pre-shop planning by the participants. There also appeared to be a slight difference in shopping habits during the Covid-19 pandemic since respondents seemed to have more time to prepare shopping lists and were looking for foods that could last longer in order to postpone trips to grocery stores. Results of this survey can be used as a baseline for the creation of marketing tools based on behaviour change theory in order to help households in food waste prevention and reduction.

Keywords: household food waste, prevention, behaviour change theory, questionnaire study, Covid-19

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Consumer Perception of Date Labeling: An Analysis of Consumer Discard Behavior by Phrase-date Combinations

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Abstract

This paper studies how food date labeling impacts consumer discard behavior. Recently, to combat consumer confusion regarding date labels, food industry groups in the United States have proposed a standardized two-phrase date labeling system where foods with quality concerns are labeled differently than foods with safety concerns. In this study, the current environment in the United States where different phrases are used by product is compared to the proposed standardized system. In addition, the effect of an education campaign on both systems is examined. In a sensory laboratory experiment, total of 364 participants were presented with one of two sets of three products: 1) chicken, lettuce, and bread or 2) frozen chicken, milk, and cereal. Participants were able to see, handle, and smell the products before indicating whether they would keep or discard the product should it be in their home. A linear probability model is used to determine the effect of date label system and education on participants' stated discard behavior. The difference between the two date labeling schemes is often insignificant. The main effect of labeling on discard is driven not by the phrase but rather the date. If manufacturers switch to standardized phrases and extend the date on the label to agree with the standardized definition, unknowing consumers may continue to ignore the phrase unless an intense information campaign accompanies the change. Manufacturers could be conservative extending the date on the label, but this would counter the point of a standardized label system to reduce consumer confusion. Three national online surveys were conducted following the sensory laboratory experiment to assess the validity of an online survey measuring intended consumer discard as well as specific consumer interpretations of different phrases and dates on package labels.

Keywords: Food waste, Date labeling, Food packaging, Information asymmetry, Consumer behavior

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Consumer Behavior During the COVID-19 Pandemic: An Analysis of Food Purchasing and Management Behaviors in U.S. Households Through the Lens of Food System Resilience

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Abstract

The COVID-19 pandemic has stimulated considerable interest in the resilience of the U.S. food system. Less attention has been paid to the resiliency characteristics of the final link in the food system – individual households. We use national survey data from July 2020 to understand the food acquisition, preparation, and management strategies that households implemented in response to the pandemic. We find a substantial increase in the amount of food prepared and consumed at home which scales with respondents' time availability, perceived risks of dining out, and pandemic-induced income disruption. We then identify several household responses to support this increase in home food consumption that are in line with practices suggested to enhance resiliency at other links in the food supply chain, including increased cold storage capacity and enhanced in-house capability via improved cooking and food management skills. We discuss how responses such as improved food skills can reduce the propagation of shocks through the supply chain by allowing greater flexibility and less waste, while actions such as increased home cold storage capacity could undermine system resilience by exacerbating bullwhip effects, i.e., amplifying consumer demand shocks that are propagated to upstream food supply chain actors.

Keywords: COVID-19 pandemic, Food management, Food waste, Cold storage

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Food Loss and Bargaining Power at the Producer-Retailer Interface: a Qualitative Assessment of Food Loss Drivers in Fruit and Vegetable Supply Chains in Germany

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Abstract

Food loss and waste are associated with an unnecessary consumption of natural resources, futile emissions of climate-relevant gases and preventable economic harm (Gustavsson et al. 2011). Against this backdrop the United Nations (UN) have set the reduction of food loss and waste on the political agenda by means of the Sustainable Development Goal (SDG) 12.3. In Germany, the National Strategy for Food Waste Reduction which aims to implement this goal relies almost exclusively on voluntary actions, where mainly individual actions are taken at each stage of the supply chain. This policy approach however neglects interactions between the stages of the supply chain. While current research on food loss and waste in industrialised countries focuses predominantly on the consumer end (e.g. Aschemann-Witzel et al. 2017), this study puts emphasis on early stages of the food supply chain from the field to the retailers' warehouses. By means of 22 qualitative expert interviews with producers as well as key persons of producer organisations and food retailers in Germany, it aims to identify major inter-stage drivers of food loss in early fresh fruit and vegetable supply chains. Moreover, the study examines how bargaining power imbalances lead to risk shifting behaviour and hence may result in food losses further up the supply chain. Results indicate that the manner, in which contractual terms and conditions, trading practices, ordering processes and communication along the supply chain is shaped, influences the extent of food loss. Bargaining power imbalances for instance become apparent in the form of unilateral imposition of quality specifications and promotions, absence of commitments to purchase and purchased quantities within contracts as well as short-notice ordering, which potentially enhance food loss amounts particularly at the producer level. It can be deduced that ongoing market concentration, integration and product differentiation in todays globalised agricultural value chains are highly entangled with food loss drivers and should not be neglected when designing food loss reduction policies targeting the producer-retailer interface.

Keywords: food loss, producer-retailer interface, fruit and vegetables, bargaining power, qualitative expert interviews

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Exploring the Role of COVID-19 Pandemic in the Case of Domestic Food Waste Through the Theory of Planned Behaviour

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Abstract

According to the recent Food Waste Index Report, 930 million tonnes of food are wasted globally, one-third of the food produced for human consumption. Despite the fact this is a global problem, scholars suggested that among all the supply chain, in developed countries most of the thrown away food occurs at household level where consumers waste more than the food service industry or stakeholders that are situated way earlier in the chain. The Covid-19 pandemic has rapidly and dramatically disrupted household behaviours in almost all areas and, among these, eating behaviours and daily food patterns have also been radically altered. Both food acquisition patterns and at home meal preparation have undergone significant changes compared to pre-COVID levels, changes that have potential and mixed effects in terms of food waste. The main aim of this study is to examine the possible moderator effect of COVID-19 concerns on two different behaviours linked with food waste reduction, namely using leftovers and reducing portion size, using the framework of the Theory of Planned Behaviour (Ajzen, 1991). So far, the behavioural measures used in the scientific literature referred generally to not wasting food, therefore in this paper two tangible and well-defined actions have been chosen, adhering strictly to the Theory. Data were collected via an online survey developed with the Qualtrics survey software using a snowball sampling procedure. A sample of n = 201 (59,7% female) individuals from Italy, mean (SD) age = 33.09 (12.06), completed the questionnaire. First results confirm the TPB relations for both behavioural measures and, in particular, it can be seen that the COVID-19 concern act as a moderator when the behavioural measure to contrast food waste considered is the reduction of portion size ($p<.05$). These results show that, since COVID-19 is changing the behaviours of individuals, identifying a specific role of COVID-19 on waste behaviour can help to better target policy choices and communication campaigns.

Keywords: TPB, food waste, moderation effect, COVID-19

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The Contribution of Innovative and Intelligent Packaging to the Loss and Generation of Food Waste

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Abstract

The constant changes in our consumer goods, at industrial level, at retail and distribution level, are important challenges for maintaining food safety and quality, but also for food waste and waste production. This background enables the packaging industry to offer innovative solutions that meet the changing demands of the food industry and consumers, as well as sustainable development. "Intelligent packaging" is defined as a packaging system that can perform intelligent functions - such as detecting, perceiving, recording or communicating - to support decisions and remedies, thus extending life, increasing safety and quality for improve, provide information and warn of potential problems. "Smart packaging" with additional functions, goes beyond protection, restriction and the provision of product information. In general, there are three basic technologies used for smart packaging: data carriers, pointers and sensors. As data carriers are the barcodes, QR Codes, and RFID tags. The indicators that can be used are the time-temperature indicators, freshness indicator, gas indicators. The sensors are divided into biosensors and gas sensors. However, not every application is useful or necessary to all factors. For every different food product type, we should examine, whether smart packaging is worth it or not. The use of such technology is meaningful only, if it really reduces food waste and offers benefits to the market.

Keywords: The contribution of innovative and intelligent packaging to the loss and generation of food waste.

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The Portuguese Nitrogen Footprint, a Challenge in a Mediterranean Country

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Abstract

The European Union (EU) agriculture is responsible for 80% of the total reactive nitrogen (N_r) emissions from all sources, especially animal-based food with beef and dairy products, for instance, responsible for 56% of EU's agricultural N_r emissions. Population growth and its individual dietary choices are intrinsically connected to the increase of N_r emissions. The Nitrogen Footprint concept was created to communicate the importance and the negative effects of nitrogen (N) to the general public. This concept needs to be disseminated worldwide to show how personal choices of consumption affect nitrogen pollution and become a serious problem to human health. In this regard, the N-footprint for Portugal was estimated and compared to other countries with different diets' patterns. Comparison between Portugal's diet and the recommended Mediterranean diet were also analysed. The N-footprint model is based on the N_r loss to the environment from food consumption and production, transport and housing consumptions. Virtual Nitrogen Factors (VNF) were estimated to each crop, animal and by-products. The VNF represent all N that was used in the food production process but is not contained in the final food product consumed. These factors allow us to estimate the N-footprint of food production. Preliminary results show a high N-footprint for food production followed by food consumption, transport and housing. A total of 25.46 kg N/cap/yr were achieved for Portugal's diet which is extremely high in protein meals – mostly meat, fish and eggs - further stimulating animal production and consequentially the increase of N-Footprint. In contrast, legumes also have a very high protein content but their N-footprint is very low due to its biological N fixation. Animal-based products have a much higher N-footprint compared to plant-based products: 15.08 and 4.37 kg N/cap/yr respectively. Portuguese N-footprint shows similar patterns to other EU countries. No significant differences were found. On the other hand, a decrease in the consumption footprint were highlighted when the Portugal's Mediterranean diet were analysed based on N recommendations. The Nitrogen Footprint is a valuable tool to increase awareness about our daily choices and promote the reduction of global N pollution.

Keywords: Mediterranean diet, nitrogen footprint, nitrogen loss, virtual nitrogen factor

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Food Waste Prevention in Practice

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Abstract

As the increasing amounts of food loss and waste and their economic, social, and environmental consequences are being recognized, a holistic approach for the management of the food supply chain is becoming a priority. On this background, an array of global targets, strategies and initiatives has been developed, piloted and, in some cases, widely implemented, with the aim to provide a basis for the improvement of the sustainability and circularity of the food supply chain. Indicatively, some of the policy and legally binding targets are: Target 12.3 of the UN Sustainable Development Goals, the Circular Economy Package of the European Union and the concept of the food waste hierarchy. All actors of the different stages of the food supply chain are responsible for food wastage. However, their share responsibility exhibits a wide geographic variation depending on the regional economic and social framework. Wastage generated at consumption level is much more higher in middle and high-income regions, and much lower in low-income regions. The sources of food wastage and the required prevention measures vary accordingly. In less developed countries, investments in simple traditional as well as novel technologies to combat losses at the farm, storage and distribution have a great potential to reduce losses and combat poverty. In developed countries, the main causes of food wastage are rooted in the decision-making mechanisms and the behavior of suppliers, retailers and consumers, making efficient prevention a more complex issue. On that ground, “hotspots” of food waste generation, as well as prevention options in every single stage of the food supply chain should be identified, described, and explicitly analyzed. Food supply chain stakeholders accord that the main obstacles in addressing the food wastage challenge is the lack of: a universal definition; reliable baseline data; proven and efficient management options; and public awareness. Additionally, to tackle food wastage, the boundaries of the conventional food waste management schemes should be extended, as to embrace the mechanisms of the surplus food generation and redistribution. The establishment of holistic and cross disciplinary management schemes, serving as benchmark for policy-makers, to address food surplus and waste, based on sustainable food production and consumption models is required. However, the development of these schemes prerequisites regulatory and operational reforms.

Keywords: food waste prevention, food supply chain, practices

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Methodologies for food waste quantification

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Abstract

Every year, about 4 billion tonnes of food are produced, but poor practice in harvesting, storage, and transport, along with market and consumer wastage, mean that about 40% of it (1.2-2 billion tonnes) is wasted. Feeding a projected population of 9.6 billion people by 2050 is going to be an unparallel challenge for humankind and may well require a multidimensional and integrated global strategy. Increasing food production is merely one of many ways to rise to this challenge. Researchers argue that one strategy to enhance food availability would simply be to lessen waste generation. The apparent necessity of food waste quantification, and standardization of methodologies has been repeatedly demonstrated. Scholars and decision makers have concerns on the current data deficiency and inconsistency, while they indicate that measurements of higher numbers and quality are needed (Xue et al., 2017). All involved parties - in both food supply chain and food waste management sectors - agree that the existing data on food losses and waste suffer from major gaps, such as narrow spatial coverage, outdated figures and statistics, unbalanced focus among the different stages of food supply chain, lack of primary data, and heterogeneity of definitions and boundaries, which leads to inefficient, incomparable, and in some cases unreliable data (Xue et al., 2017). Thus, the adoption of a standard methodological approach that would ensure uniform measurement, would tackle the issues related to data availability and quality. The study is designed to comprise a pool of the most adequate methodological approaches, indicating their selection criteria, their benefits, and restraints. Special effort was made to address barriers, obstacles, difficulties, and ambiguities, which usually hinders quantification and reporting process. The development of a baseline of food waste quantities generated will be achieved through the selection of the appropriate combination of methodological approaches (e.g., direct measurements and questionnaires). Overall, these approaches fall into two distinct categories: direct measurements of food waste generation along the food supply chain, and inference on food waste amounts by calculation (Corrado et al., 2019; Hanson et al., 2016; Moller et al., 2014). The study aims at presenting a thorough overview and compare food waste quantification methods. It presents an overview of the main food waste (FW) quantification methods, namely surveys, kitchen diaries, waste audits and estimates based on secondary data, considering in detail to compare the strengths and limitations of each method. The need for standardized methodologies for food waste quantification is further highlighted.

Keywords: food waste, quantification, methodologies, Greece

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Compositional Analysis of Household Avoidable Food Waste in Four European Countries

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Abstract

Food loss and waste account for a significant part of the food production, estimated to about 1/3 of the total food produced worldwide. The wide body of literature on the subject, which has been developed mainly in the last decade, highlights the significant environmental and economic impacts of food wastage. Assessing the scale of the problem is a prerequisite for successfully addressing it, as it is not possible to manage something that you have not measured. Accurate quantitative data is a powerful tool for policy makers. A review of the literature demonstrates that it is not sufficient to just record the total amount of food waste; a more detailed knowledge of their composition is required, to provide more information on aggravating factors and support the development of targeted actions and practices to prevent food waste generation. This study aims to compile and compare data from previous food waste quantity and composition analysis studies. Four studies were selected, for four European countries, Greece, Germany, Switzerland, and Hungary, which provide quantitative data for the different categories of avoidable food waste – food and drink thrown away that was, at some point prior to disposal, edible (e.g. slice of bread, apples, meat) - at the household level. The different types of food waste reported in the studies were grouped in six categories (Vegetables-potatoes, Fruits, Meat & Fish, Dry food such us pasta, rise, cereals, flour, legumes, Bakery/Bread, diary such as milk and cheese). The statistical analysis focused on comparing the percentages of each category for the four countries, in order to capture a first insight of the avoidable food waste composition, differences and potential associations with causal factors. For all countries examined fruits and vegetables accounted for more than 40% of the generated food waste. Moreover, a comparative analysis was performed for Greece In Greece, the category with the highest percentage is dry food, for Switzerland and Hungary the bakery products and for Germany fruits. In addition, a hypothesis test (t-test) was performed by collecting the results in cumulative frequency diagrams, so that the categorization is obvious and through Pareto analysis it becomes clear which category contributes the most and which the least to waste generation. The result of this analysis is that for all countries the category for meat and fish is the one with the lowest quantities. The three categories with the highest percentages are: for Greece dry foods, vegetables-potatoes, and dairy products; for Germany fruits, vegetables-potatoes and bakery products; for Switzerland bakery products, fruits, and dry foods; and for Hungary bakery products, vegetables-potatoes,

and dairy products. The above differences reflect the eating habits in the countries under study and may be influenced by the prevailing socio-economic conditions. A deeper knowledge of the quantitative and qualitative contribution of each category constitutes a significant research and policy question, so that a future study could assess both the environmental footprint and the economic cost of avoidable food waste in the abovementioned countries.

Keywords: Quantification, Comparison, Statistical analysis, Reduction

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Best Practices for Food Waste Prevention

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Abstract

In an effort to improve our knowledge in the field of food waste prevention, a systematic review and comparative assessment of related actions and best practices, which have been implemented in both European and global level has been performed. Sources from the scientific and grey literature have been examined, as well as databases for EU-funded projects, and from other funding sources. Indicatively, we searched for relevant programs such as LIFE, HORIZON, INTERREG, in the bibliographic databases Scopus and Google Scholar, the database of the special platform for the reduction of EU food waste, as well as databases of ministries, etc. and eventually more than 170 actions have been identified and relevant information collected. Following that, the identified actions were group according to the categories proposed by the EU in a corresponding report (Patinha Caldeira et al., 2019): food redistribution; food utilization; improvement of the food supply chain; change in consumer behavior; and, development of governance tools. More specifically, redistribution includes redistribution activities and practices, gleaning and use of electronic tools that help redistribute food. Utilization actions convert excess food residues into useful products for human nutrition (e.g., vegetable broths, food supplements) and if this is not possible, they make food available for animal feed. Actions to change consumer behavior include information and awareness campaigns, in addition to the development of tool applications, training programs, competitions and awards events, etc. Actions aimed at improving the supply chain can range from processing innovations and innovative packaging products, to the sale of products that do not meet the typical aesthetic customer selection criteria ("ugly" fruits and vegetables) and market requirements (which do not affect safety and nutritional value of the food products). Finally, governance tools include voluntary agreements, national guidelines, additional legislation, strategic planning, etc. Reducing food loss and waste can have multiple benefits, such as: saving money on both production and consumption; providing extra food to combat malnutrition that plagues some parts of the world but also many vulnerable social groups in the developed countries; and, saving valuable resources, such as water and soil and reducing GHGs emissions. The compilation of a good practices list and their comparative assessment can assist the adoption of the most suitable of them for each stage of the food supply chain, under given conditions, at the national and local

level, and guide the development and implementation of the National Food Waste Prevention Plan.

Keywords: food waste, prevention, best practices, LIFE IP CEI Greece

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Quantification of retail food waste through the analysis of in-store data

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Abstract

Food loss and food waste happen throughout the food supply chain. Food loss derives from the early stages of agricultural production, post-harvest treatment and processing and packaging. Food waste refers to the stages of retail and consumption. Therefore, the retail sector is a key player for the prevention of food waste. In order to tackle the problem of food waste generated by the retail sector, for the first time, in Greece, a common effort has been undertaken by AB Vassilopoulos, one of the top three food retailers in Greece, and Harokopio University. In terms of methodology, the retailer provided the data for year 2019. The data were then analysed based on the main store activity departments (e.g., grocery, fresh meat, fresh fish, bread and pastry, etc) and the main categories reported by the retailer, namely food donation, store food waste, warehouse food waste and store returns to warehouses. The results indicate that the main food waste volumes are generated by the fresh grocery store department, followed by the dairy and refrigerated product department. The key outcome is that grocery retailers can - and should - make meaningful changes to help limit food waste

Keywords: retail, food waste amounts, prevention

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Behavior of Greek Households on Food Waste Generation

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Abstract

The factors that contribute to the formulation of food waste generation behavior at the household level, have begun to be investigated in recent years, as food waste has emerged as a stream with many environmental, economic and social impacts. The aim of this study is to develop appropriate methods for the introduction of food waste prevention, as a conscious behavior integrated into the daily activities and choices of Greek citizens. To achieve this goal, the Theory of Planned Behavior was used, which is the predominant approach of environmental psychology for understanding, interpreting, predicting and modifying environmental behavior. Through this approach, the mechanisms of behavioral change were sought, in an attempt to clarify the forms of intervention to which the strategy for the prevention of waste generation should be oriented, with the ultimate expected result of their minimization. The research data were collected through the self-completion of a structured questionnaire, from 921 people aged 18-75 years, during the period April - July 2017. The statistical analysis of the results was done using STATA 12 software. The research results showed that while the attitude of Greek households towards the general environmental issues is positive, the same does not happen with their attitude towards the adequacy of the natural resources of the planet. Conflicting perceptions were identified about the degree of household involvement in the amount of food waste generated, as respondents appear to be aware of the problem in general, but do not realize their own involvement in it. 61% of the sample know that most food waste in developed countries is generated by households, but 46.4% consider that they discard little food and 32.5% little or no food. No statistically significant difference was found in food waste prevention behavior between the two sexes, while the correlation between age and food waste was found to be negative, as young people appear to waste more food than older people. The results showed that the extended TPB model applied is useful in predicting consumer waste behavior. Intention has a positive effect on food waste prevention behavior. The strongest predictive factor of food waste prevention intention is the general environmental attitude and attitude towards food waste, followed by perceived behavioral control. In conclusion, the attitude of people (especially young people) towards food waste and their environmental impact should be given priority in the design of intervention programs to reduce food waste generation.

Keywords: Food waste, Prevention, Theory of Planned Behaviour, Factor Analysis

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Food Waste Prevention as a Key Tool for Resource Management in Montenegro

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Abstract

Montenegro is a well-developed country in the Balkans and has recently signed an Association Agreement with EU. Montenegro focuses to align with the EU acquis in the waste area and has transposed the past Waste Framework Directive. However, considerable efforts are still needed on implementation, as well as enforcement both in recycling infrastructure, separate collection and monitoring. Sustainable development is recognised as highly important by the Government of Montenegro, in particular for tourism and agriculture, sectors that play a multiple role in the development of society and economy of Montenegro. Tourism exhibits one of the fastest rates of growth in the world, but it is concentrated in the coastal – central areas. In the northern and rural areas, agriculture contributes to the fight against poverty and is an important factor in preserving tradition and the overall cultural heritage of the Montenegrin villages. The Montenegrin Government is at present interested in harmonising the Circular Economy Directives. The food waste stream is an integral part of the Package. EU member states should aim to achieve an indicative Union-wide food waste reduction target of 30% by 2025 and 50% by 2030. Member States should establish specific food waste prevention measures. European initiatives combating food waste have been intensified, bringing together various key players and producing a number of reports, statistical data, best practices and guidance documents. In light of these activities, UN Development Programme has financed in 2019 a technical assistance project for assessment of food waste in Montenegro. The project aims to develop the prevention measures and introduce incentives to reduce it. The project attracted particular attention from personnel of various national authorities, as well as the Chamber of Commerce. The project had four objectives: - Analysis of legal, regulatory and institutional framework for food waste management - Assessment of quantities generated, including the SDG indicators: Food loss and food waste index - Development of national recommendations for food waste management - Preparation of guidelines for future measurements The outcomes of the above four tasks will be presented in this paper. Focus will be given to food donation that entails the highest environmental and social benefits. Being a tourism services-oriented country, Montenegro has an enlarged food service sector (catering industry) which generates significant quantities of food waste. However, limited knowledge of social organisations as well as liability of donor companies regarding food safety and hygiene, were identified as main barriers influencing food donation.

Keywords: food waste, Montenegro, methodology for monitoring, prevention measures

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State of the Art of Food Waste Measurement: a Key Challenge to Support Prevention and Reduction

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Abstract

Reducing food loss and waste (FLW) is a key challenge of current food systems and halving the amount of per capita food waste at the retail and consumer levels is listed among the Sustainable Development Goals (SDG n. 12.3) together with the reduction of food losses in the production and processing stages of global food chains. Despite the broad consensus on the importance of reducing FLW to make food systems more sustainable, considerable gaps of information still exist. Early studies on FLW provided an overview of the scale of the problem (Parfitt et al., 2010; FAO, 2011), and had a very important role in spreading the awareness about this issue. The number of studies reporting the amount of FLW in different stages of the food chain increased steeply after 2010, by providing evidence of the amount of FLW generated in different settings. However, the approach of the studies has continued to be quite fragmented for several years, by providing studies with limited representativeness, and mostly focusing on case studies. To design effective interventions against FLW, policy makers need a detailed measurement of the extent of FLW along food supply chains, as well as evidence about the context-specific drivers of FLW, is crucial to inform such interventions (Cattaneo et al., 2021). This challenge is directly addressed in the EU with legally binding targets to reduce FLW and, at the same time, the construction of a monitoring framework that requires Member States to produce regular reports of FLW by stage of the food chain. In October 2019, a common methodological framework to develop FLW measurement at all stages of the supply chains, entered into force in the EU. The first mandatory national reports of FLW, following the common methodological framework, are due in June 2022, referring to the year 2020.

Keywords: waste hierarchy, food waste prevention, food waste assessment, SDGs

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VAL: Valorization of Food Processing By-Products

The Food industry is a continuously growing sector due to the increasing population and globalization that create the need of a wide variety of food products. During food processing, many by-products are thrown away and accumulate as an environmental burden. The problem is greater in developing countries, where 40% of food waste is generally generated at post-harvest and processing levels. Valorization of food processing by-products offers sustainability by circumventing landfilling or disposal and aims to recover matter, energy, and biomass in the form of “secondary” products and energy contributing to circular economy.

The RETASTE Session on Valorization of Food Processing By-Products focuses on the significant efforts of the contributors to address these issues in all major food industries: meat, poultry, fish and seafood, fruits and vegetables, dairy, and cereal. Secondary products presented have a vast area of application, from food additives to cosmetic products.

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Utilization of the Strained Yoghurt Whey by Incorporating or Converting into Food Products

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Abstract

Strained Yoghurt Whey production has appeared as a global problem in recent years due to the rapid growth of the market demand for Greek-style yoghurt. The high BOD and low pH (4.5-5.1) limit the options for cost-effective solutions for utilization, disposal or further use of SYWhey. Nowadays, it is used as animal feed or in anaerobic digesters for energy production. Other value-added options include isolation of valuable components (proteins, lactose) and production of galactooligosaccharides. A very promising option is the utilization of SYWhey by incorporating or even converting into food products. The aim was (i) to use of SYWhey as a solvent during Osmotic Dehydration of fruits/vegetables and (ii) the incorporation of SYWhey into a fruit/vegetable based beverage. (i) Pumpkin cuts were immersed in OD solution containing pasteurized SY whey along with other solutes (glycerol, trehalose, oligofructose, ascorbic acid, sodium chloride, calcium chloride-w_{OS}:w_{fruit}=5:1) for 120min at 55 °C. OD process parameters (water loss, solid gain) and product characteristics (water activity, colour, texture, sensory properties, vitamin C, microbial growth) were measured, after processing and during storage (5 °C). The use of SYWhey as OD solvent was proven effective enhancing mass transfer phenomena (20% solid gain increase compared to Water). Osmosed samples were of high quality (increased hardness, vivid yellow to orange colour, high vitamin C, no microbial growth). The product was stable for 90 days at 5 °C supporting the applicability of SYWhey as a novel OD solvent for the production of innovative products of high nutritional value and fresh-like fruit characteristics. (ii) Avocados were blended with SYWhey, prebiotic fibers, vitamin C, salt, natural rosemary extract, and immediately cooled. The blended ingredients are packed in PET packages and High Pressure processed (600 MPa-25 °C-10 min). Physico-chemical (pH, water activity, viscosity, colour), nutritional (vitamin C), microbiological and sensorial analyses were conducted, after production and during storage (5 °C). The beverage was microbially stable and maintained its nutritional as well as quality characteristics characterized by vivid green colour, creamy and consistent texture and natural avocado taste. The shelf life was calculated based on the sensory quality as 120 days at 5 °C. The reintroduction of SYWhey into food supply chain is of utmost importance with significant effect on process sustainability.

Keywords: acid whey utilization, osmotically dehydrated pumpkin, avocado based beverage

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Supercritical CO_2 Extraction of Oil from Arctic Char Side Streams

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Abstract

The increasing global demand for fish products, leads to the need for more sustainable utilization of fish processing side-streams. Presently fish industry by-products are mainly used as animal feed or as organic fertilizers. As these by-products are rich in exploitable valuable compounds such as polyunsaturated fatty acids, proteins and minerals, novel, environmentally friendly processes should be investigated to optimize the recovery of these components. In this framework, supercritical fluid extraction (SFE), a green extraction technology without the use of conventional organic solvents, was explored. Fish by-products from filleting of arctic char (*Salvelinus alpinus*) were provided by a Swedish fish company (Umlax AB) and consisted of heads, skin, bones, frames and tails. The supercritical CO_2 extraction of the contained fish oil was carried out under different operating conditions of pressure (200-450 bar) and temperature (40-80 ^{o}C). The total extraction time was set at 2 h and the efficiency of the process was evaluated based on the yield of total extract (dry weight basis). Since the arctic char contains lipophilic antioxidants such as astaxanthin which are extracted together with the fish oil, the impact of the operating conditions on the antioxidant activity was also evaluated. Fish oils are prone to oxidation, therefore peroxide value was measured in order to estimate the oxidation level between the different samples. The recovery of fish oil ranged from 20-36% on dry basis under all the examined conditions, except for 200 bar and 80 ^{o}C where the fish oil yield was very low (0.6%). The yields at 350 bar and at 450 bar/40^{o}C were at the same level (27-28%). Peroxide value was expressed with EC_{50} value which is the efficient concentration of extract that reduce 50% the absorbance of the free radical DPPH. At 450 bar, the temperature increase led to 36% higher EC_{50} value (lower antioxidant activity). At intermediate pressure levels, the extracts had similar EC_{50} values (18.2 and 20.0 mg/mL respectively). In terms of peroxide value, increasing both temperature and pressure resulted in higher oxidation levels in oil except for 200 bar. Under this condition, the oil showed higher peroxide value (1.83 meq O_2/kg_{oil}) than the other samples at 40 ^{o}C. SFE can effectively applied for the extraction of valuable compounds such as polyunsaturated fatty acids from fish industry by-products. The

remaining defatted material after oil extraction can further be used for protein extraction for more effective valorization of fish side-streams.

Keywords: Supercritical CO_2 extraction, Salmonid by-products, fatty acids

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Utilization of Acid Whey Lactose Using Commercial and Innovative Biocatalysts for the Production of Galactooligosaccharides

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Abstract

Greek yoghurt is a dairy product with high nutritional characteristics and quality that has gained significant popularity by consumers worldwide, over the past few years. However, its production is related to certain environmental issues, since during the straining procedure large amounts of acid whey with high Biological Oxygen Demand (BOD) and low pH value are produced, turning its management by waste treatment facilities problematic. As a result, innovative processes for whey valorization have to be explored. In this context, galactooligosaccharides (GOS), i.e. oligomers of lactose with prebiotic properties, could be enzymatically synthesized using commercially available or novel β-galactosidases, utilizing the high lactose content of acid whey. In this research, the production of GOS catalyzed by two commercial (from *Aspergillus oryzae* and *Kluyveromyces lactis*) and one novel, in-house produced (from *Thermothielavioides terrestris*, heterologously expressed in *Pichia pastoris*) β-galactosidases was studied, taking into account several parameters, e.g. lactose concentration, enzyme load, pH value, temperature, and reaction time. The products were analyzed through chromatographic methods. Results showed that the production of GOS is significantly dependent on the origin of the biocatalyst used. Due to the different microbial origin, the three enzymes exhibited different optimal reaction conditions, regarding mainly the pH value and the reaction temperature. For the quantification of the results, maximal GOS yield, expressed as the percentage of total GOS concentration to the initial lactose concentration, was used. Maximum GOS yield of 25.4% was achieved after 9 h using 2.4 U/mL of β-galactosidase from *A. oryzae* at 45 °C and pH 4.5. Similarly, a maximum GOS yield of 37.0% was achieved after 2 h using 0.052 U/mL of β-galactosidase from *K. lactis* at 37 °C and pH 7.0. In both cases, acid whey with initial lactose concentration of 15% w/v was used. When the enzyme from *T. terrestris* was used, a maximum GOS yield of 14.8% was achieved after 5 h at 50 °C and pH 4.5, using acid whey with initial lactose concentration of 10% w/v. Although β-galactosidase from *K. lactis* seems to lead to the highest GOS yield, it was observed that this enzyme also lead to hydrolysis of the formed oligomers and lactose precipitation, due to the requirement for pH adjustment to the optimum value, resulting in inefficient process control. Therefore, the optimization of

lactose oligomerization is a key factor in order to maximize production yields of high nutritional value ingredients, in the framework of circular economy.

Keywords: acid whey, galacto-oligosaccharides, β-galactosidase, prebiotics

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Physicochemical Properties, Structure and Antioxidant Activity of Pectin from Persimmon (Diospyros kaki): Effect of Extraction Conditions.

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Abstract

Persimmon (*Diospyros kaki Thunb*.) had a global production of around 4.7 million tons. Spain has become the second global producer and the first exporter from Valencia region. Although great efforts have been carried out in post-harvesting techniques and storage conditions to improve the quality and shelf-life of the product, huge amounts of discarded fruit, (about 15-20% of the fruit harvested) is wasted. In the present study, conventional acid extraction was explored for the production of bioactive pectin extracts from persimmon. First, a compositional characterization of different fruit ripeness stages of the residues was done, and immature fruit was selected due to its higher pectin and polyphenol content. Then, a 3-level full factorial design was carried out to study the effect of temperature (70-95 ºC) and pH (0.5-1.5) on the yield, degree of esterification, carbohydrate constituents, phenolic content and antioxidant capacity of the extracted pectin. The determination coefficient (R^2) for the models generated was around 74-98%, advocating a good adjustment for the prediction values. The results showed that both temperature and pH significantly affected the response values. Pectin yield, phenolic compounds and antioxidant activity ranged from 1.37 to 4.5%, 53.26± 2.27 to 111.71 ±9.74 (mg GAE/g pectin) and 0.29 ±0.01 to 2.77 ±0.04 TEAC (Trolox µmol/mg pectin), respectively. degradative effect of very low pH and high temperature heavily influenced the pectin structure, phenolic content, and antioxidant activity. The outstanding antioxidant properties of the bioactive pectin was linked to the substantial quantities of bound polyphenols, resistant to acid extraction at pH≥1. These findings suggest the potential use of this bioactive pectin with non-extractable polyphenols associated to health-promoting properties with remarkable antioxidant activity. Further studies will endorse the potential use of pectin extracted from persimmon fruit as a bioactive compound for wider applications.

Keywords: Antioxidant capacity, Monosaccharide analysis, Pectin extraction, Polyphenolic compounds.

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Towards the Integral Waste Valorization of Three Relevant Mushrooms

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Abstract

Mushroom consumption has increased in recent years with a consequent industrialisation to obtain fungal biomass, fact which has derived in an increased generation of mushroom wastes. For this reason, there is an opportunity to look beyond fresh consumption to the recovery and use of fungal waste. In this work, three mushroom species relevant for their great fresh consumption volume and for their reported high bioactive value, specifically Grifola frondosa, Lentinula edodes and Pleurotus ostreatus were deeply explored to study their potential valorization. A series of sequential extractions were carried out to obtain partially purified fractions of different bioactive compounds, specifically β-glucans, which are mainly responsible for the high bioactive value of the mushrooms. Their yields and composition were studied to cost-efficiently optimize the processes for the production of extracts rich in β-glucans, protein, polyphenols, etc., with potential use as food additives and nutraceuticals. Possible simplification strategies are discussed to obtain multifunctional less purified fractions.

Keywords: mushroom, β-glucans, bioactive compounds

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Citrus Fruit Waste as a Nano-Factory for Super Paramagnetic Iron Oxide Nanoparticles: Decorator and Enhancer for Microbial Desulfurization Efficiency

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Abstract

The readily available and costless mandarin (*Citrus reticulata*) peels were applied for one-pot synthesis of crystalline, highly stable spherical shaped super paramagnetic iron oxide nanoparticles (SPION) with 11.58 nm average size and 51.12 emu/g magnetic saturation. Such green and non-toxic biofunctionalized SPION was used to decorate and magnetize the selective desulfurizing *Rhodococcus erythropolis* HN2. That recorded 24.97emu/g at the optimum SPION/biomass ratio of 0.9 g/g. The magnetized HN2 found to be characterized by higher tolerance and BDS efficiency for relatively increased oil feed concentrations relative to non-magnetized HN2. Besides; the ease of separation by applying an external magnetic field, longer life time, higher storage and operational stability, magnetized HN2 was found to be effectively reused for six successive times without losing much of its activity. In a 120 h mild operating biphasic batch BDS process (30% v/v oil/water), magnetized HN2 removed 96% of the 690 mg/L total sulfur content in a hydrodesulfurized diesel oil without affecting its fuel content.

Keywords: Phytogenesis, Super paramagnetic iron oxide nanoparticles, Waste citrus fruit debris, Bacteria magnetization, Hydrodesulfurized diesel oil biodesulfurization

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Partial Substitution of Flour by Date Seed Powder into Cookies

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Abstract

The United Arab Emirates (UAE) are one of the top date producing countries in the world, which leads to significant amounts of generated waste, in the form of date seeds. Furthermore, type-2 diabetes incidences in the UAE are among the highest in the world. As date seed are nutritionally rich (Habib et al., 2014), especially in antioxidants and fibre, efforts have been made in the past to incorporate date seed powder into baked goods (Platat et al., 2015). With the aim of reducing waste and improving cookies quality in terms of nutritional value, the effects of substituting date seed powder (DSP) into cookies were studied. Cookies with three addition levels (2.5, 5.0 and 7.5%) of fine date seed powder from four date varieties, locally named Khalas, Sukkary, Zahidi, and Fardh, were prepared. Two types of flour were used (white flour and whole wheat) at two different baking temperature 180 and 200 °C. The incorporation of date seed powder had no or slight influence on moisture, ash, fat, and protein content of the baked cookies, while it significantly affected their colour and hardness; the higher level of addition, the darker and crispier were the resulting cookies. The sensory analysis indicated that the date seed powder containing cookies were acceptable in terms of smell, taste, texture, and overall acceptability. Overall analysis indicated that cookies with acceptable physical characteristics and improved nutritional profile can be produced with partial replacement of the wheat flour.

Keywords: waste utilisation, flour substitution, cookies, date seed powder

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The Sea Urchin Supply Chain and the Reuse of Waste for New Products. An Example of Circular Economy on Applications Deriving from Marine Collagen

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Abstract

The classic linear economy model based on extraction, processing, production, and waste no longer seems to be functional in a world where natural resources are starting to run out. Therefore, the aim of this study is to analyse the transition from a linear system to the circular economy, providing an example of reuse of sea urchin waste for the creation of new eco-sustainable products. The reuse of sea urchin scraps represents a valid aid in reducing waste, considering that every year tons of inedible parts are discarded along the entire supply chain. Some experiments carried out on marine collagen have shown how this material could be used as biomedical devices and cosmetic products (Ferrario et al., 2020). For these reasons, this study considers sustainability as a strategic driver and a key to generate profits. To make their core business effective, companies should not consider only the financial perspectives but also the social and environmental aspects. Therefore, this work aims at analysing these three frameworks using the Triple-Layered which is a useful tool to support the creative exploration of sustainable and innovative business models (Joyce and Paquin, 2016). The environmental and social benefits can be several. The innovative products produced with discarded sea urchins materials can contribute to limiting the loss of biodiversity, while from a social point of view, the industrial conversion to a circular economy would guarantee new job opportunities for the local community and the possibility to train employees. In conclusion, the reuse of sea urchin waste is a clear example of how companies through this virtuous model can be projected towards a green economy based on a more eco-sustainable vision.

Keywords: circular economy, food waste, marine collagen, sustainable transition

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High-Added Value Products Obtained from Freshwater Fish Waste Processing

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Abstract

Farmed cyprinids, carp and especially introduced species novac, cteno, phytophagous are large fish usually sold after processing, with the separation of scales, main bones and head. The lateral flows of freshwater fish processing, instead of becoming waste, can be used for obtaining protein hydrolysate (for nutraceuticals), gelatin like polypeptides (as plant biostimulants) and fish flour (nutritional supplement) (Gómez-Guillén et al., 2011). The aim of this work was to obtain high value-added products with a significant market value, through an integrated extractive biotechnology, from the side streams of freshwater fish commercialization. Protein hydrolysate was obtained by an enzymatic method using papain, from waste provided by a local freshwater fish processing factory. Peptides with a low molecular weight (LMW) <15 kDa were separated by ultrafiltration and were analyzed physico-chemically and biochemically (protein content, extraction yield, SDS-PAGE electrophoresis) and regarding their in vitro biocompatibility. The residue from the filtration was dried up, resulting fish flour. Peptides with a high molecular weight (HMW) >15 kDa were tested for their antimicrobial activity, effect on fungal phytopathogens, influence on the proton pump and alpha-amylase activity in barley endosperm. Fish hydrolysate extracted with papain has 95.2% protein content and an extraction yield of 70.94%. The hydroxyproline concentration in the fish residues analyzed sample was 4.078%, respectively the collagen concentration was 33.97%. The presence of LMW peptides in protein hydrolysates was proven by electrophoresis. Test results on normal fibroblast cells (Moldovan et al., 2009) showed that all fish peptide samples were biocompatible up to a concentration of 6000 ug/ml. Separated collagen polypeptides with biostimulant effect for plants (Oancea et al., 2017), with a peptide content with an average molecular weight >15 kDa of more than 85% had demonstrated bioactive properties: antimicrobial effect, inhibition of fungal phytopathogens, stimulating the proton pump and inducing alpha-amylase activities in the barley endosperm. Getting protein hydrolysate from freshwater fish by-products allow a higher recovery of food industry waste. We separated bioactive peptides with different molecular weights that can be used in the nutritional supplements industry, cosmetics and agriculture.

Keywords: fish by-products, bioactive peptides, nutraceuticals, biostimulants

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Mixture Design Approach for Optimization of Complementary Food Formulation from Sorghum, Soybean, Karkade Seed and Premix for Better Nutritional and Sensory Qualities

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Abstract

Consumption of nutritionally poor complementary foods in developing countries is among the main contributing factors to malnutrition of infants and young children. Therefore, this study aimed to optimize the nutritional and sensory properties of complementary food made from malted sorghum, blanched soybean, boiled karkade seeds and premix. A constrained D-optimal mixture experimental design with 18 runs were generated by design expert software to evaluate and optimize the formulation. The constrained formulations used comprises: 40-60% malted sorghum, 20-30% blanched soybean, 10-20% boiled karkade seeds and 10% premix (5% figl leaf powder, 4.5% sugar and 0.5% iodized table salt). Statistical model evaluation and optimization were done using D-optimal mixture design expert software. Sensory evaluation was conducted using 53 untrained panelists on two selected formulations along with the control (local formulation). The study shows that with an increasing the ratio of blanched soybean and boiled karkade seeds flour in the blend a significant ($p < 0.05$) increase in protein, fat, energy and mineral contents with decreased tannin and phytic acid of high mineral bioavailability except oxalate:Ca ratio in the formulations were observed. The optimal blending ratio was 45.0% malted sorghum, 26.0% blanched soybean, and 19.0% boiled karkade seeds flour plus 10.0% premix. The gruel samples made from the new formula were significantly ($p < 0.05$) liked in terms of aroma, flavor, mouthfeel and overall acceptability than the control sample. The findings suggested that the optimal mix of these traditionally processed ingredients can alleviate protein-energy malnutrition and micronutrient deficiency and replace expensive commercial infant complementary foods sold in the market.

Keywords: Complementary foods, Figl leaves, Karkade seeds flour, Mineral bioavailability, Nutritional optimization

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Sustainable and Valuable Antioxidant Recovery from Winery Food Waste

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Abstract

Agro-food industries are highly water demanding and generate vast amounts of organic waste resulting in a relevant environmental problem. Winery byproducts are rich in polyphenols, natural bioactive compounds with high added-value due to their antioxidant, antimicrobial and anti-inflammatory properties that lead to high market demand. Nevertheless, commercially available polyphenols come from edible sources while they are discarded with food wastes. In the circular bio-economy frame, an innovative and integral solution is proposed to extract and recover polyphenols from winery byproducts while processing wastewater is recovered as high-quality water that might be reused. Hence, a new value-added business market and model is proposed for the primary sector. Polyphenols were effectively extracted by mechanically mixing the waste and a solvent (hydroalcoholic mixtures) for 20 min at 30 °C. The ethanol percentage increase in the solvent favoured the polyphenols extraction from 165 to 461 mg GAE (Galic acid equivalent)/$kg_{bagasse}$ when the solvent was changed from water to water/ethanol (50:50, v:v). Moreover, the effect of milling over the extraction capacity from solid wastes (scrape and bagasse) was also revealed as a key factor to maximize the bioactive compound recovery. Polyphenol recovery from milled bagasse rose up 1.9 g GAE/$kg_{bagasse}$ using water as solvent and it was further promoted to 6 g GAE/$kg_{bagasse}$ using 50 % ethanol solvent. Milled scrape has higher specific polyphenol content with 6.2 g GAE/kg_{scrape} and it increased 46 % (up to 9 g GAE/kg_{scrape}) using water/ethanol (50:50, v:v) solvent. Wine lees are a more liquid byproduct generated during wine fermentation. Their lower polyphenol content, 1.2 g GAE/L_{lees}, is compensated by their more stable production throughout the year, making them attractive for polyphenol recovery. Moreover, the distribution of the major polyphenol families obtained from each waste were different. Hydroxybenzoic acids were the most abundant for all studied wastes, while flavonoids were only present in the bagasse and scrape, 25 % and 45 % of total polyphenols, respectively. Wine lees contained hydroxycinnamic acids (up to 12 % of total polyphenols), which were almost negligible in the rest of the byproducts. Thus, a versatile biorefinery platform might be developed to convert various agro-food wastes (solid and liquid) into different polyphenol-

rich products with diverse potential applications and market demands depending on their composition. These products might be used within the food sector as antioxidants and functionalized food and drinks or in other sectors like cosmetic.

Keywords: circular bioeconomy, life cycle extension, polyphenols, valorization

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Raw Earth-based Building Materials: an Exploration on Mechanical Behavior of Floridia Soil-based Adobes

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Abstract

Raw earth, with wood and stone, has a place among the oldest building materials used in the world. Nowadays, on a circular economic context, researchers' interest in raw earth-based building materials has been growing because they are highly available and environmentally friendly. The use of this traditional material has positive environmental consequences, especially in traditional rural building reuse and in rural landscape preservation. In fact, raw earth is locally available and totally recyclable and, thanks to its perfect integration into the landscape, it improves site visual perception. Often, in order to increase mechanical performances and durability of earth materials additives and/or chemical stabilizer agents (i.e., Portland cement) are used to produce raw earth-based building components. This production process reduces the environmental sustainability of the base material and causes a relevant increase on the embodied energy. This research work aimed at investigating how to improve the mix-design of earth-based building materials in order to increase their mechanical properties without addition of chemical agents. A physical stabilization was performed on an original texture soil, through the addition of different particle sizes. Mechanical tests have been carried out on five different soil mixes by changing soil composition, aggregates, and water. Specimens realized with the mix-design 5 showed best results of flexural and compressive strength values with 1.65 MPa and 6.74 MPa, respectively. Mix 3 obtained the lower linear shrinkage rate (6.04%). Since raw earth-based materials are highly sensitive to soil composition and aggregates, the attempt of this study is to obtain a repeatable process to produce semi-industrial adobes by the optimization and control of different natural materials (i.e., soils, aggregates, and water).

Keywords: raw earth building components, physical stabilization, mechanical tests, circular economy, sustainability

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Correlations Between Antioxidant Activity and Bioactive Compounds in Ethanolic Extracts of Pomegranate Peels and Seeds and Their Physicochemical Composition

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Abstract

Pomegranate by-products have been widely studied for their bioactive and antimicrobial potential. Managing waste from pomegranate peel and seeds can lead to large reductions in environmental burdens. Its valorisation is of utmost relevance and requires preserving its biological properties. However, there is a lack of information regarding its composition and physicochemical characteristics, which correlate with its biological potential. This study aims to characterize the peels and seeds of three cultivars (Acco, Big Full and Wonderful) grown in Alentejo Region of Portugal, in terms of moisture, ash, volatile solids, protein and lignin content, pH, titratable acidity (TA), electrical conductivity and elementary composition (C, N, S). In addition, the bioactive potential of the peels and seeds extracts produced under sonication-assisted extraction was evaluated in relation to total phenolic compounds, total flavonoids and antioxidant activity. The effect of different ethanol/water solvents (water; EtOH25%; EtOH50% and EtOH75%) was also evaluated. Significant differences were observed between the composition of pomegranate by-products, as well as between cultivars. In terms of pH and titratable acidity, the peels (pH = 3.55-3.96; TA = 5.38-6.21 g citric acid/100 g (db)) were more acidic than the seeds (pH = 3.77-5.31; TA = 1.86-5.07 g citric acid/100 g (db)). However, seeds had the highest moisture content (14.06-21.15%), protein (9.25-15.83%, db), nitrogen (1.48-2.53%, db) and insoluble lignin (22.76-29.80%, db). The EtOH25% and EtOH50% mixtures proved to be the best solvents to improve the extraction yield and increase the content of bioactive compounds. Regardless of the cultivars, the peels gave the best results. Peel from Big Full had the highest extraction yield (56.41%) and antioxidant activity (0.009 mg/mL IC_{50}) with EtOH25%, but higher total phenolic content (0.499 mg GAE/mg extract) was obtained with EtOH50%. The highest content of total flavonoids was obtained for seeds of the Wonderful cultivar with EtOH25%. Negative significant correlations were found between phenolic compounds and total Kjeldahl nitrogen and the protein content of the by-products. The main conclusions were that more acidic matrices, with less nitrogen content, lead to greater antioxidant activity of

the extracts. It was also observed stronger correlations for solvents with a higher ethanol content. Among the cultivars studied, Big Full proved to be the most differentiated, either in the composition of the peel or seeds. The results obtained allow to expand the knowledge about the physicochemical composition of the pomegranate by-products of the studied cultivars, besides allowing to establish predictions regarding its bioactive potential.

Keywords: Pomegranate peel and seeds, physicochemical composition, antioxidant activity, Sonication-assisted extraction, Punica granatum L.

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Characterization of Biochar Derived from Agricultural Residues as Potential Adsorbent for Extracting Phytohormones in Waste Coconut Water

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Abstract

Coconut (*Cocos nucifera linn.*) is a key agricultural crop in the Philippines. The coconut industry produces huge volumes of waste including coconut husks, shells, and water. In this study, waste coconut water is utilized by extracting phytohormones from it using biochar as adsorbents. Phytohormones are valuable, naturally-occurring compounds that play essential roles throughout the different stages of plant growth. As such, they are widely used for plant propagation by tissue culture. For extraction, eight agricultural residues were studied as potential raw materials for biochar production: rice straw, bamboo, durian shells, calabash husk, banana peels, sugarcane bagasse, coffee husk, and cacao pods. The goal of the study is to convert the waste coconut water and agricultural residues into phytohormones that may then be reused by the agricultural sector. The residues were analyzed for moisture, volatile matter, fixed carbon, ash content, and then further characterized using Fourier-transform infrared spectroscopy (FTIR) and thermogravimetric analysis (TGA). Conversion into biochar was done by pyrolysis at 500 °C for 1 hour with a heating rate of 16.67 °C/min. Pyrolysis yields ranged from 26.14% to 49.48% with the produced biochar having pore sizes between 134.9 nm and 3415 nm. Further treatment with KOH were done to improve the surface area and phytohormone adsorption capacity. Adsorption experiments were also performed on waste coconut water samples for 2 hours at room temperature and a loading rate of 100 g/L. The phytohormone adsorption capacity was measured using UV-Vis Spectroscopy by measuring absorbance at 267 nm. The biochar produced from agricultural wastes showed promising results as adsorbents for phytohormones.

Keywords: biochar, agricultural residues, bio-circular economy, adsorption ability, phytohormones

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Recovery of Bioactive Compounds from Corn Water Stream by Grape Marc Hydrogel as Pre-treatment Before Membrane Processes

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Abstract

Corn steep water (CSW) is an agro-industrial stream obtained in the wet steeping process of corn (Vecino et al., 2014). CSW is a complex stream composed mainly by water, solids, carbohydrates, amino acids, polypeptides, fatty acids, lactic acid, antioxidants, minerals, vitamins, ashes, heavy metals, inorganic ions, fibers and fats, among other compounds (Hull et al., 1996). Additionally, CSW could be used as a source of biosurfactants, which are obtained after the spontaneous fermentation of corn during the steeping process (Vecino et al., 2014). Therefore, before membrane process application for biosurfactant recovery, it is necessary to pre-treat the CSW. In this work, CSW was treated with bio-oxidize grape marc entrapped in calcium alginate beads. The adsorption by using grape marc hydrogel was carried out as pre-treatment step for lactic acid and sugars removal. CSW was provided from FeedStimulants company (Lot No. CSL-0003-1217) diluted up to 50 g/L and then centrifugated for solids removal (5000 rpm, 30 min, 4 ºC). The ratio between beads and CSW, containing initially 4 g/L of lactic acid and 2 g/L of glucose, was 1:1 (v/v) at room temperature during 24 h in an orbital shaker at 150 rpm. Results showed that it was possible to recover 97.1 ± 0.4 and 69.0 ± 2.2 of glucose and lactic acid, respectively, under the operational conditions mentioned. For that, adsorption by means of grape marc hydrogel could be a suitable process to purify CSW.

Keywords: corn stream, pre-treatment, adsorption, resource recovery, membrane technology

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Infrared Spectroscopy as Tool for Evaluating The Effect Of pH in the Purification of Bioactive Compounds From Corn Steep Water

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Abstract

The use of agro-industrial streams as corn steep waters (CSW) is an interesting alternative to obtain cost-competitive and value-added biosurfactants, since they are produced by spontaneous fermentation of corn during the steeping process (Vecino et al., 2014). Additionally, these CSW are composed mainly by water, solids, lactic acid, sugars and lipids, among other compounds (Hull et al., 1996). On the other hand, membrane technology is proposed as an ecofriendly technology for biosurfactant recovery; however, these CSW is a complex fermented stream. For that reason, CSW should be pre-treated before applying membrane processes. Thus, in this work, the composition changes of CSW, after acidification or basification processes, were evaluated by means of Fourier-Transform Infrared spectroscopy. CSW was provided from FeedStimulants company, diluted up to 50 g/L and then centrifugated for solids removal. The initial pH of CSW was around 4. Then, one sample of CSW was acidified using 1M H_2SO_4 up to pH=2 and another one was basified up to pH=6 with 1M NaOH. The FTIR analysis were carry out before and after pH adjustment using a Nicolet 6700 Spectrometer. Comparing the 400 to 4000 cm^{-1} region, the spectra from basic CSW presented a similarity of 89.6% in comparison with raw CSW (without pH change); whereas the acidic CSW showed 44.6% of match. This means that the functional groups of the CSW are modified when the sample is acidified, providing more defined bands in the 1700-1500 cm^{-1} region. These bands indicate the presence of protein-related weak bands. In this way, the presence of these proteins, in the acidic CSW, could be an indicator of purify biosurfactants. Therefore, before membrane application for biosurfactant recovery, it would be recommended the acidification of CSW in order to obtain a stream more concentrated in biosurfactants.

Keywords: corn stream, acidification, basification, biosurfactants, membrane technology

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Effect of a Biosurfactant Extract Obtained From Corn Steep Liquor on the Wettability of Grape Surface

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Abstract

Biosurfactants are surface-active compounds produced by microorganisms. In addition, some of these biosurfactants possess an important bactericide and fungicide capacity (López-Prieto et al., 2020). Based on these antimicrobial properties biosurfactants are very interesting to be used in the food industry as preservatives, in order to increase the shelf-life of fruits, which are quickly spoiled. Therefore, the aim of this work was to evaluate the contact angle and wettability of grapes coated with biosurfactant extracted from corn steep liquor. Grapes were washed with water and submerged in an aqueous solution containing 1 g/L of biosurfactant using the methodology described in previous works (Rodríguez-López et al., 2016). Following, a drop of 3 mL of ultrapure water has been added on the grape surface and the contact angle measured using a See SYSTEM E instrument. For comparative purposes, in the study also were included non-coated grapes. The results showed that grapes coated with biosurfactant, after 1 day of storage, possess a contact angle of 89.6°, whereas grapes without treatment gave contact angles of 81.1°. Thus, the biosurfactant slightly increase the hydrophobicity of grape surface and decreased its wettability. Moreover, it was observed that grapes with more storage time, 11 days, gave higher contact angles (106.6°). This can be explained because grapes increase their roughness with the storage time, favoring the hydrophobicity of grape surface and thus decreasing the wettability.

Keywords: corn steep liquor, biosurfactant, grapes, hydrophobicity, contact angle

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Effect of a Biosurfactant Extract Obtained From Corn Steep Liquor in The Properties of a Natural Orange Juice

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Abstract

From corn steep liquor is possible to obtain a biosurfactant extract with multifunctional properties that could be interesting to be used in the food industry in order to obtain more functional. It was demonstrated that this extract is able to inhibit pathogenic microorganisms (López-Prieto et al., 2020), whereas promote the growth of probiotic bacteria (López-Prieto et al., 2019). On the other hand, generally one of the main problems of orange juices is their presence of vitamin C, which is easily degradable making quite difficult to keep it as L-ascorbic acid form over time (Rincón-Fontán et al., 2020). In this work, a biosurfactant extract, with antioxidant properties was obtained from corn steep liquor, following the procedure described in previous works (López-Prieto et al., 2019) and added to orange juice. For this purpose, several conditions were tested: biosurfactant concentration (0, 0.5 and 1 g/L); storage time (1, 4 and 7 days) and temperature (4, 20 and 36ºC), evaluating physicochemical parameters such as pH, lightness, color, as well as the microbial biomass growth, in order to detect changes promoted by the biosurfactant extract. The results obtained indicate that the presence of biosurfactant in the orange juice did not cause changes in pH and lightness, which remained constant. Otherwise, the growth of microbial biomass showed analogous values in presence and absence of the biosurfactant extract. This fact could indicate that biosurfactant extract, do not change the organoleptic properties of orange juice, and it could be included to prevent de degradation of vitamin C.

Keywords: biomass, physicochemical properties, biosurfactant, juices, corn stream

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Valorisation of Alginate Waste Streams from Industrial Extraction as Promising Source of Bioactive Compounds

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Abstract

Brown algae represent an important potential source of functional molecules while, nowadays on an industrial scale, only alginate polysaccharides with gelling properties are obtained. In fact, the extraction of alginate from algae biomass produces a large amount of waste streams and residues with great potential value. In this work, a similar industrially used alginate extraction process was applied to Saccharina latissima and Ascophyllum nodosum. The alginate fractions, waste streams, and residues were characterized as for their proximate composition and by means of Fourier Transform Infrared spectroscopy (FTIR) and High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection (HPAEC-PAD), while the functional properties of the various fractions obtained were assessed by means of total phenolic content (TPC) and antioxidant activity (ABTS free radicals scavenging activity, and β-carotene bleaching inhibition assays). Interestingly, the first fraction and the residues exhibited high antioxidant activity and high protein content. Besides, the monosaccharide composition showed a significant amount of fucoidan and glucose polysaccharides in some of the waste streams with reported bioactive functionalities. These results point out the potential for the integral valorization of these bio-residues, which could be applied in a broad range of applications, including as fertilizers, feed ingredients, biostimulant, or even food packaging additives, thus representing an interesting approach to make extraction processes more sustainable giving raise to added-value products.

Keywords: Alginate, antioxidant activity, protein, residues, seaweeds, valorization.

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Re-Use of Viticulture Waste: The Case of Unripe Grapes for the Development of New Vegetal Foods Enriched with Phenols

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Abstract

Unripe grapes (UG) discarded during thinning are an undervalued source of phenols which can be suitable ingredients for new functional foods. In developing phenol-enriched foods, temperature, pH and interactions of phenols with macronutrients of food can influence the chemical stability and antioxidant activity of phenol compounds. Moreover, astringency and sourness sensations could limit consumers' acceptability of these products. Interactions between phenols and macro-nutrients have been subjected to extensive studies. Nevertheless, chemical and sensory properties of vegetable foods enriched with UG phenols have not been investigated before. An UG phenol extract, obtained using a green solid-liquid extraction technique, was selected on the basis of its antioxidant activity. Three plant-based food models were used: carbohydrates/acidic pH/sweet - beetroot purée (BP), proteins/neutral pH/sweet - pea purée (PeP) and starch/neutral pH - potato purée (PoP). Phenols from UG were added at four concentrations (0.21, 0.44, 1.11 and 1.93 g/kg). The UG extract contained phenolic acid, flavanols, flavan-3-ols, procyanidins and trans-resveratrol and showed good stability during storage. Food models enriched with UG phenols showed differences in their chemical properties as a function of the amount of phenols added. The UG phenols recovered from the PoP and BP was averagely higher with respect to the amount recovered from PeP while the mean antioxidant activity detected in the BP (3,794 µmol TEAC/kg) was significantly higher than in the PoP (1,722 µmol TEAC/kg) and PeP (1,127 µmol TEAC/kg). The carbohydrates/acidic pH/sweet food model showed best health-promoting properties in term of both phenol recovery and antiradical scavenging. The main contribution of UG phenols to the sensory properties of the food models was sourness. Sweetness/sourness interactions were observed in the BP and PeP, resulting in a partial suppression of both the sour and sweet tastes. BP food model resulted more appropriate to counteract the impact of phenol on negative sensory properties. Liking slightly decreased with increasing concentration of phenols, even if all the samples were considered acceptable by consumers. In conclusion, it was demonstrated that it is possible to find a good balance between health-promoting and sensory properties of the proposed functional food and the development of new phenol-enriched food using phenols from UG is a promising solution for the exploitation of this waste from viticulture.

Keywords: unripe grapes, phenols, functional food, food preferences

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Application of Hydrothermal Treatment for the Optimal Extraction of Phenols from Olive Mill Wastewater in Lesvos Island

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Abstract

A major fraction of Lesvos Island economy is supported by Olive Mills that produce olive oil but at the same time produce significant amounts of Olive Mill Wastewater (OMWW). Overall, more than 50 facilities operate on the island, and their operation varies from less than 1 ton per hour up to 6 tons per hour. The vast majority of these facilities have a 3-phase production process and some of them have a 2-phase production process. OMWW can be a significant source of phenols (if retrieved), and the extraction of phenols can be a very lucrative endeavor. But, molecules in OMWW tend to biologically degrade, and the phenols that are contained in the liquid fraction decrease over time. The University of the Aegean has developed a solar distillation facility that aims to recover phenols from OMWW and has implemented a supporting survey that assessed the operating Olive Mills in Lesvos island. The recovery of phenols has been advanced by means of hydrothermal treatment in a reactor that is installed in the Laboratory of Energy Management. The OMWW underwent hydrothermal treatment for the optimal recovery of phenols (operating temperatures: 160 °C, 180 °C, and 200 °C). On the one hand, the application of hydrothermal treatment optimized the recovery of phenols from OMWW that is stored for more than 15 days due to the secondary production of phenols. Characteristically, more than 7 g/L phenols were retrieved in the final hydrothermal liquid fraction. On the other hand, the application of hydrothermal treatment allowed an increased concentration of phenols in the distillate for the case of extraction via distillation (a study in support of the solar distillation facility). The results showed that the percentage of recovered phenols was more than tripled in respect to conventional distillation, i.e., 2.9 mg/L vs 0.9 mg/L. Overall, hydrothermal carbonization can be a great enhancing application when the scope is to extract phenols from OMWW.

Keywords: Olivemill wastewater, Hydrothermal treatment, Phenols, Hydrochar

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Development of A High Added-Value Healthy Spread by Valorizing Olive Oil Production Residue

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Abstract

Olive oil production is an important Mediterranean agricultural activity, considered as one of the major driving forces of the Greek economy. Olive oil is typically produced by mechanical extraction; initial pressing process was replaced by the continuous centrifugation process, including a three-phase and later a two-phase system. Application of a patented cold oil pressing machine resulting in improved oil yields and quality characteristics could significantly offer. By using this patented machine for the extraction of olive oil, olive paste (residue) consisting mainly of pulp is also separated from olive pit and skin. The usual practices in olive oil by-products management in Greece include the production of olive pomace oil, the use as additives in animal feeding, as combustible biomass and mainly the direct disposal into environmental systems without any pretreatment. Since the residue of the patented machine contains only olive pulp and is also considered a valuable source of phenolic compounds, we propose its reuse in order to produce high added-value food products. Olive oil (using Koroneiki cv. Olives) was cold extracted using the patented cold oil pressing machine and the residue (approximately 70%, pit and skin-free) was used for the product development. The olive residue was debittered before its reuse by application of High pressure technology (200MPa-20°C-15min). The formulation of the high added-value healthy spread included grinded olive residue (50%) and honey (25%), enriched with proteins (24.5%) derived from grinded nuts (hazel, almond, pumpkin and sunflower seeds). Citric acid (0.5%) was also added to fix pH value to 3.9. In-pack thermal treatment at 80-100°C followed, to assure food safety and shelf-life extension. Quality parameters such as color, water activity, moisture, pH, ash, total fats, proteins, and dietary fibers, the antioxidant potential including total phenolic compounds content and antioxidant activity as well as the sensory evaluation of the olive spread were determined. Microbiological growth in terms of total aerobic bacteria and the molds/yeasts was also tested. The results showed that the proposed olive spread product had texture similar to peanut butter and high content of proteins, dietary fibers, essential fatty acids and phenolic compounds. Therefore, it has considerable potential to be consumed as a healthy spread. Furthermore, the valorization of olive residue significantly affects the environmental impact of olive oil production, minimizing the most important olive oil production drawback.

Keywords: olive oil residue, valorization, spread, high phenolic content

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Polyphenolic Profile and Biopharmaceutical Potential of Istrian Malvasia Grape Skin Extract

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Abstract

Grape pomace consisting of fragmented skin, pulp remaining, seeds and stalks is the main by-product in the wine industry that has attracted considerable attention as a source of bioactive compounds, especially polyphenols. The pomace from white grape is particularly attractive for further exploitation as it usually does not pass the maceration process. Accordingly, it preserves nearly all phenolic compounds originating from the grape cluster. The aim of the presented research was to determine the potential of the grape skin originating from the autochthonous Croatian white grape variety Istrian Malvasia, the leading viticultural and wine making variety in the region of Istria. Extracts from grape skin were obtained by extraction with 70% ethanol and ultrasound treatment. The polyphenolic profile of skin extracts was determined by direct infusion mass spectrometry, while contents of total phenols and flavonoids were determined spectrophotometrically. The biopharmaceutical potential was explored by antioxidant, antiproliferative and enzyme inhibitory activity assays of the extracts. Obtained results showed that the Istrian Malvasia grape skin has a specific polyphenolic profile characterized by the presence of catechin, procyanidins type -B, procyanidin trimers and quercetin and kaempferol glycosides. The extracts showed antioxidant activity as well, reaching values up to 6.85±0.48, 18.45±0.60, 32.90±0.20 and 20.43±0.13 mg TE/g for DPPH, ABTS, CUPRAC and FRAP assays, respectively. Grape skin extracts were better glucosidase inhibitors than the amylase inhibitors. In addition, extracts showed antiaging potential by inhibiting tyrosinase. At last, the extracts exerted the most potent antiproliferative activity on the growth colorectal carcinoma cell line HCT116 at the same time exerting antiproliferative activity towards HFF-1 normal fibroblasts as well. Grape skin has a prominent biological potential and can be therefore, exploited along with other parts of grape pomace as a functional ingredient in pharmaceutical, cosmetic and food industries.

Keywords: grape pomace, polyphenols, mass spectrometry, antioxidant activity, enzyme inhibition

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Usage Potential of Vegetable Residue Streams

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Abstract

Harvesting of various vegetables produces large amounts of vegetable waste, consisting of leaves (potatoes, beets, and carrots), cuttings (leeks), but also other plant residues (beans and peas). In 2017 total amount of these residues in the German Lower Rhine region and the Dutch Provinces Limburg and North Brabant was 16.000 T dry matter. The total amount of vegetable residue streams in the Netherlands in 2012 was about one million ton per year (Korthout and van der Meulen, 2012). These residue streams consisted of material that was left behind on the fields during the harvest, fruit and vegetables that did not meet the quality standards, material that is removed during the process after the harvest and residues that are unsold and disposed of at the end of their shelf life (Bondt, et al, 2010; Elbersen et al., 2011; van der Voort and Rooij, 2012; van der Voort et al., 2006). Currently, the majority of this material is either used in feed or in the generation of biobased energy. The residue streams contain valuable components as plant-based protein and sugars as well as long-chain carbohydrates. Those components can be extracted and separated into different fractions that could be processed in the food or feed industry. Within the frame of the Interreg project BIVAC, first attempts to extract valuable components of different residue streams have been analysed and have shown promising results. The use of these previously unused residue streams would lead to the local production of food ingredients in contrast to the imported soy that is currently used and by this prolong the shelf-life of the produced food due to shortened transport times. At the same time, the use of the residue streams would reduce the flushing of nutrients on the land currently caused by leaving the excess amounts of material and at the same time being able to locally apply minerals received from this material where necessary. Ultimately, this use would result in the creation of higher value chains by using the residue material as food.

Keywords: Biorefinery, Circular Bioeconomy, value chains

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Bioactive Ingredients from Custard Apple By-products for Nutraceutical Applications

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Abstract

From agricultural production until food consumer, tons of food are thrown away. It is estimated that, globally, approximately on third of the produced food is wasted at some point in the food chain (FAO, 2011). One solution to this problem could be the application of circular bioeconomy models which allow the use of these byproducts to reduce waste and promote sustainability. Many food byproducts, mainly from fruits and vegetables, are part of the initial raw material and may contain substances of interest that have made them ideal for developing of added value products due to the fact that peels and seeds from this food group contain a great variety of bioactive compounds such as polyphenols that are characterized by having biological properties (Ben-Othman et al., 2020). For this reason, the objective of this study was to use the non-edible parts of the custard apple (*Annona cherimola*) to obtain bioactive ingredients with nutraceutical applications. To do this, the levels of bioactive compounds and their activity in peel and seeds were identified and evaluated from hydroalcoholic extracts by high-performance liquid chromatography coupled to mass spectrometry and antioxidant and anti-inflammatory capacity assays. As a result, custard apple peel and seeds were found to be a natural source of procyanidins and other phenolic compounds. However, peel had a higher phenolic content than seeds. The main phenolic compounds identified in peel were catechins and procyanidins, while flavonoids and organic acids were mainly identified in seeds. For the determination of the antioxidant and anti-inflammatory capacities, it was observed that both peel and seeds showed high potential. In conclusion, custard apple byproducts, specially peels, can be interesting bioactive ingredients for the production of nutraceuticals due to their biological properties providing added value to human health.

Keywords: revalorization, byproducts, circular bioeconomy, custard apples, bioactive compounds, nutraceuticals

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Green Extraction Strategies for Sea Urchins Waste Valorization

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Abstract

*Paracentrotus lividu*s, a species of sea urchins occurring in Mediterranean Sea and eastern Atlantic Ocean, is a highly appreciated food resource, being Italy the main consumer among European countries. 30 million individuals are annually consumed only in Sardinia (Grisolia *et al.*, 2012). Since gonads are the edible part, representing only a small fraction of the entire animal, the remaining ends up as a waste. Recently, it was successfully developed an innovative methodology to obtain high-value collagen from sea urchin by-product tissues to be used for regenerative medicine applications. However, the tissues used for collagen extraction are a small portion of sea urchin waste (less than 20%) and the remaining part, mainly the carbonate-rich test and spines, would be discarded (Ferrario *et al.*, 2020). In the present project, this “secondary waste” was first grinded to powder and employed as valuable addition to feed for animals requiring high doses of carbonates, like laying hens and sea urchins themselves. Second, and most importantly, the biologically relevant products contained in the powder have been investigated. These compounds, contained in residual cell tissues, tests and spines, are polyunsaturated fatty acids, carotenoids and a class of small polyphenols, called polyhydroxynaphthoquinones (PHNQ). PHNQ have high economic significance because of their widespread application in several cosmetics and pharmaceuticals industries and, because of their polyhydroxylated quinoid nature, PHNQ show remarkable pharmacologic effects, representing also a potential valuable addition for aforementioned regenerative medicine applications (Shikov *et al.*, 2018). In this work, green extraction strategies aimed to obtain compounds of interest from sea urchins’ waste were developed and the results were compared to conventional solvent-based extraction methods. The core strategy was supercritical CO_2 technique, characterized by low environmental impacts: organic solvents are avoided and CO_2 is used as extraction fluid, ensuring safe and selective process, with the possibility to recycle the employed CO_2 in industrial plants. The extraction was performed directly on the powder without any pretreatment. Fatty acids, carotenoids and PHNQ were successfully and selectively extracted depending on the physical parameters of the extraction. Overall, a selective and green extraction method was validated for the valorization of waste from sea urchins, demonstrating the feasibility of the technique targeting added-value compounds.

Keywords: Supercritical CO2, Green extractions, Polyhydroxynaphthoquinones, antioxidants.

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Revalorization of Mango Byproducts to Obtain Bioactive Ingredients for Developing High Added-value Cosmetic Products

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Abstract

Food-related loss generation has been a worldwide problem for years. For this reason, one of the objectives pursued in this field is to design and implement new methodologies that revalue these wastes to return them to the market, thus significantly reducing this loss by stimulating the circular bioeconomy. In this sense, much of the health benefit they generate are due to bioactive compounds whose concentration in skins and seeds exceeds that presented in the pulp. This is a powerful starting point that would encourage waste reduction and even the revaluation of parts that are not normally exploited. More specifically we talk about phytochemical such as phenolic compounds, whose beneficial and therapeutic effects are mainly due to their biological properties, which are widely demonstrated (Chiocchio et al., 2021). It has been well documented that mango fruits (*Mangifera indica* L.) are an important source of micronutrients, vitamins and polyphenols, present both in its pulp and in its byproducts (Jahurul, et al., 2015). For all these reasons, the aim of this work was to obtain bioactive ingredients from mango byproducts by the extraction with GRAS solvents, the comprehensive characterization of the phenolic profile using high-performance liquid chromatography coupled to mass spectrometry and the bioactive evaluation of the potential in skin targets. From the extraction, a considerable number of phenolic compounds were obtained. On one hand, from mango peel, ethyl gallate and penta-O-galloyl-glucoside were predominant, showing a remarkable antioxidant and metal-chelating activity. On the other hand, mango seed and kernel harbor important phenolics as mangiferin, related to effects against Alzheimer's disease for its strong antioxidant activity, or ellagic acid, whose scavenging radical activity grants it cardioprotective effects (Torres-Leon, et al., 2016). Likewise, mango fruit byproducts can be appointed as suitable sources of natural food ingredients for its use in food, cosmetic, nutraceutical and pharmaceutical applications. Its utilization has become an important aspect in waste management to contribute to sustainable and less polluting production in food and pharmaceutical industries.

Keywords: Bioactive compounds, revalorization, circular bioeconomy, fruit byproducts, cosmetics

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Valorization of Sea Urchins Waste: Antioxidant Pigments Extraction Strategies

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Abstract

Around 75,000 tons of sea urchins are sold annually worldwide for the gonad consumption and in recent decades the demand for sea urchins has increased. Most of the marketed sea urchins come from natural stocks, hence resulting in a large environmental impact and a reduction in sea urchin population in many parts of the world. A valid alternative to the removal of natural stocks could be sea urchin aquaculture, which however is still underdeveloped worldwide and in Europe in particular (Stefánsson et al., 2017). In this framework, CIRCULAr and BRITEs projects aim to fully reuse waste from the sea urchin food industry to convert them, according to the logic of the circular economy, into products with high added value, including animal feed supplements. For this purpose, sea urchins wastes from some Milan's restaurants were finely grinded to produce a powder that could be a valuable addition to the feed for animals requiring high doses of carbonates, like laying hens and sea urchins themselves. The powder was characterized in its mineral and pigments content. In fact, the pigments contained in Paracentrotus lividus, the sea urchin species under investigation, are of high interest. They belong to the family of polyhydroxynaphthoquinones, a class of small polyphenols, and are natural antioxidant products with potential health benefits. Pigments were obtained from sea urchin powder by solvent-based extraction procedures, performing initially a treatment with an aqueous acidic solution to decompose the carbonates matrix, and then counter extracting pigments with selective organic solvents (Powell et al., 2014). A high content of polyphenols in the extracted pigments was confirmed by a Folin-Ciocalteau assay. An ABTS assay confirmed a potent antioxidant activity, comparable to the one of Trolox®, an effective antioxidant used as a reference in the literature. No evidence of cytotoxicity was observed, through a MTT assay in vitro using human dermal fibroblasts. The extract was then characterized by UPLC-MS and the presence of Spinochrome A and Spinochrome B was confirmed. The developed extraction strategy allows to obtain a product of high added value useful to be employed as feed additive or even in other biochemical applications.

Keywords: Sea urchins, polyhydroxynaphthoquinones, circular economy

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Valorization of Sea Urchin Wastes: Characterization of Marine Collagen Peptides

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Abstract

The purpose of the recently launched CIRCULAr and BRITEs projects is the recycling of wastes from the sea urchin food industry and its valorization in diversified products, including innovative collagen-based biomaterials for applications in regenerative medicine. In previous works, we have developed and characterized prototypes of biodegradable medical devices (skin substitute) made of this eco-friendly marine collagen, analyzing their microstructure, mechanical performances and *in vitro* cytocompatibility. In the current work, we want to further characterize them in terms of the amino acid (aa) composition of the starting material (collagen) and the *in vitro* degradation rates in both physiological (PBS) and enzymatic (collagenase) conditions. We also evaluated the antioxidant activity and *in vitro* cytotoxicity of the biomaterial degradation products. Indeed, the in vivo physiological degradation of collagen-based biomaterials leads to the formation of collagenous peptides, which can have anti-inflammatory and antioxidant effects and could in turn become "bioactive molecules" useful in the regenerating tissue microenvironment. Analysis of the amino acid profile of sea urchin-derived collagen confirmed that it is composed of glycine, hydroxyproline and proline and its overall aa composition is similar to that of human collagen, with some small exceptions for alanine, arginine, methionine and glutamic acid. The degradation test showed that, in enzymatic condition, the biomaterial is degraded by 66% after 48 hours and completely degraded after 10 days. In PBS, as expected, the degradation rate was slower than in collagenase, with a reduction of 54% after 10 days. A commercially available bovine collagen membrane (Integra) was used as control. In collagenase, Integra is degraded by less than 10% after 48 hours and not yet completely degraded after 3 weeks, while in PBS it remains intact even after 10 days. The faster degradation rate of the sea urchin biomaterial, due to a lack of cross-linking procedures, may promote a better incorporation in vivo conditions. Preliminary analysis of the antioxidant activity of collagen peptides suggests that these may have a potential role as a radical scavenger and thus anti-inflammatory biomolecules. Finally, the *in vitro* tests on human fibroblasts showed that at short time (24h) high concentrations (100 µg/mL) of collagen peptides increase vitality (and, indirectly, proliferation) of human dermal fibroblasts. Overall, this

work has strengthened the potential usefulness of our innovative and environmentally friendly biomaterial in tissue regeneration. Further *in vivo* studies will provide information on the actual regeneration efficacy of this new biomaterial.

Keywords: collagen peptides, sea urchin, waste valorization, circular economy

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Extraction of Chlorophylls from Bioresidues of Daucus Carota L. (Carrots) Aerial Parts for Food Colorants Development

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Abstract

The use of bio-residues from fruits and vegetables such as seeds, peels, aerial parts, etc., in the food industry has been of great interest due to the possibility of developing new secondary added-value materials such as natural colorants, which not only provide a colour to the food or product, but also provide health benefits to the consumer (Tiwari et al. 2019). In the present study, the extraction of chlorophylls from the aerial parts of carrots was carried out in order to develop natural food colourants. For that purpose, two types of extraction (maceration and ultrasound-assisted extraction) were performed to maximise the yield of chlorophyll recovery. Three types of solvents were used, prioritising green solvents (water, 90% ethanol, and hexane). At the same time, different parameters were varied in each of the techniques: i) in maceration: extraction time and solvent; ii) in ultrasound-assisted extraction: power and solvent. The extractions were carried out protecting the samples from light and the results were obtained using a newly developed chromatographic method through high performance liquid chromatography (HPLC) coupled to a diode array detector (DAD) and mass spectrometry (MS). In general, the aerial parts of carrot revealed as main compounds chlorophylls a and b, as well as derivatives in significant concentrations. The ultrasound technique proved to be more efficient than maceration extraction, with higher extraction yields when higher ultrasonic power was used. Compared to water and hexane, ethanol allowed the extraction of greater amounts of chlorophylls. These compounds can find application in food industry, but also in other industrial fields, given their high coloring properties, making these bioresidues valuable sources to exploit for colorants development.

Keywords: Chlorophylls, bioresidues, maceration, ultrasound-assisted extraction, green solvents.

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Nutritional Evaluation and Development of Anthocyanin-Rich Colouring Formulations From Bioresidues of Lonicera Caerulea L. Fruits

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Abstract

The production of waste in different industries such as food or agro-industry can lead to environmental pollution and economic losses. Therefore, the transformation of these biowaste into other raw materials has become an important part of industrial processes, as they can be used for human or animal consumption, which would lead to environmental and economic benefits in the industries (Kowalska et al. 2017). In this perspective, this study aimed to evaluate the nutritional properties and to characterize in terms of anthocyanin and non-anthocyanin compounds the bio-residues of *Lonicera caerulea* L. fruits (haskap) (fallen, maggoty and/or bird-bitten fruits, not appropriated for consumption). Moreover, four anthocyanin-based colouring formulations (two liquid and two solid) were developed by means of thermal gelation (with adragant gum and pectin) and spray-drying (with Arabic gum and maltodextrin) methodologies. Preliminary pasteurization studies were carried out to determine the best preservation conditions. The extracts were pasteurized prior to the preparation of the colorants, thus guaranteeing their microbiological safety. The colorants stability was evaluated over three months (stored at 3 °C and room temperature) by monitoring colour variation, anthocyanin concentration, and cytotoxicity. The fruit biowaste presented a balanced nutritional value, showing carbohydrates as the main macronutrients, as well as proving to be excellent sources of anthocyanins, mainly cyanidin derivatives. On the other hand, the solid formulations revealed a higher stability, with lower variations in colour and anthocyanin concentration, especially the formulations containing stabilising agents. None of the colorant formulations (solid or liquid solutions) revealed cytotoxic properties for a non-tumour primary culture of porcine liver cells, thus validating their feasibility for application in the food industry without associated toxicity issues. Thus, the present study allowed obtaining stable anthocyanin-based colouring formulations using *Lonicera caerulea* L. biowaste, with high potential to be used in several sectors such as food, pharmaceutical, and cosmetics.

Keywords: Haskap, bioresidues, nutritional value, anthocyanins, colouring formulations.

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Blueberry Bagasse, a Bioactive Residue to Be Included in New Food Products

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Abstract

Blueberry (*Vaccinium myrtillus* L.) is a very popular fruit, native to the northern hemisphere and consumed worldwide. It has been widely studied for being a rich source of bioactive compounds with recognized beneficial properties for human health. For this reason, several industrialized products, such as juices and derivatives, have been developed from blueberries. However, its manufacture produces about 20-30% of solid waste, which is usually discarded without recovery. In juice processing, for example, there is a large amount of residue generated (bagasse), which represents an environmental issue and a high cost of waste treatment for the industry. Because of light stimulation and other environmental reasons, the phytochemical content of a fruit is usually greater in the epicarp, which is the most representative part of the production of blueberry juice residues (Paes et al., 2014). In this sense, the present work aimed to analyse the phenolic composition of blueberry bagasse hydroethanolic extract, by HPLC-DAD/ESI-MS, and to evaluate its bioactivity, namely the antioxidant capacity, through TBARS and OxHLIA assays, and the antimicrobial activity against a set of eight bacterial strains of interest in the health field, by the microplate microdilution method using a colorimetric assay (INT), as well as its cytotoxicity through the *in vitro* sulforodamine B (SRB) assay, tested in a primary culture of cells prepared from porcine liver. Eight anthocyanin compounds were identified in significant amounts, with cyanidin-3-*O*-glucoside and malvidin-3-*O*-glucoside as the most abundant compounds, and four non-anthocyanin compounds, with *cis* 5-*O*-caffeoylquinic acid and *trans* 5-*O*-caffeoylquinic acids as the most representative ones. Regarding bioactive properties, as expected considering its chemical composition, the extract also revealed a strong antioxidant capacity, being able to inhibit lipid peroxidation and oxidative hemolysis. In terms of antimicrobial activity, the studied extract did not show bactericidal action at the tested concentrations; however, it inhibited the growth of four of the five gram-negative bacteria and two of the three gram-positive bacteria. The best results were achieved against *Morganella morganii* and methicillin resistant *Staphylococcus aureus* (MRSA). Regarding cytotoxicity, the effect of inhibiting non-tumour cell growth was not observed, which is of great importance for considering its inclusion if foodstuff. The results

obtained in the present study validate the bioactive quality of the extract obtained from blueberry bagasse, justifying its application in the development of novel and functionalized foods.

Keywords: Blueberry bagasse, bioresidue, phenolic compounds, bioactive properties, food ingredient.

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Prunus Spinosa L. Fruit Epicarp: Extraction of Compounds With Colouring Capacity for Food Application

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Abstract

Prunus spinosa L. is a wild shrub with bitter and astringent fruits, also known as blackthorn. These fruits are commercially underexplored, despite presenting high amounts of anthocyanins, and the epicarp if often discarded in the production of blackthorn jams and jellies. The present study aimed to characterize the fruit epicarp and develop an anthocyanin-based food colorant, predominantly rich in cyanidin 3-rutinoside and peonidin 3-rutinoside. The extract was obtained by ultrasound-assisted extraction, a rapid and low-cost extraction procedure (Leichtweis, 2019), and it was incorporated in a typical Brazilian pastry product named “beijinhos”. The coloured products were monitored and compared to control samples (uncoloured products) in terms of nutritional, chemical, and physical properties, immediately after manufacture and after 24h, according to the typical shelf-life of this product. For that purpose, the colour parameters were evaluated using a portable colorimeter, through the CIELab spherical coordinates (L*, a*, and b*), the nutritional value was assessed following AOAC procedures, the texture was evaluated using a texture analyser, the pH using a portable pH-meter, the phenolic profile was assessed by HPLC-DAD/ESI-MS, the fatty acids composition was assessed by GC-FID, and the free sugars by HPLC-RI. The extract presented a reddish-purple hue and conferred a purple colour to the pastry product. The addition of the colorant extract did not cause changes in pH, fatty acid profile, and nutritional parameters of “beijinhos”, except in the content of free sugars, where the levels of glucose and fructose were higher when compared to the control, reflecting the profile of free sugars of this fruit epicarp. Regarding the rheological parameters, the addition of the colorant extract significantly changed the hardness, cohesiveness, springiness, gumminess, and chewiness of the coloured products, compared to the control ones. The colour analysis was performed with a portable colorimeter and the CIELab spherical coordinates (L*, a*, and b*) were obtained and calculated. The purple colour conferred by the extract has lost some intensity after 24 h, but this observation was also made for the control sample, over the 24-hour period. In general, the obtained colorant revealed a good colouring ability, without causing significant alterations in the nutritional, chemical, and physical characteristics of the food product, corroborating the applicability of this bioresidue for the development of natural additives.

Keywords: Blackthorn bioresidue, anthocyanins, food colorant, pastry product application.

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Valorization of Sea Urchins Waste for Innovative Products and Diversified Supply Chains. A Multidisciplinary Research Project

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Abstract

Waste recycling and valorization are main societal challenges and two of the pillars of the Circular Economy approach. In this framework, the recently launched CIRCULAr and BRITEs projects aim at completely recycling a food by-product, namely sea urchin wastes originating from food industry (restaurants and seafood enterprises) and transforming them into innovative products, addressed to specific application fields: - innovative collagen-made biomaterial for skin regeneration; - alternative calcium and antioxidant rich supplement feed for animals. In this contribute we will present an overview of the main aspects of these on-going multidisciplinary projects, which will be detailed in other more specific talks/posters. Around 75,000 tons of wild sea urchins are sold annually worldwide; however, their consumption is limited to their gonads, so that most part of the animal ends up in waste. The CIRCULAr and BRITEs projects aim to use part of the sea urchin wastes to extract highly valuable marine collagen and produce tailored medical devices (skin substitute) for skin wound healing and regeneration. These bilayered membranes will be assessed for their regeneration efficiency in animal models that mimic human conditions. The remaining part of the waste will be dedicated to the production of a bioactive calcium-rich flour (containing antioxidants) to be used as supplement feed for layer hen or sea urchins. The former need high amount of Ca to produce high quality eggs, the latter to rapidly grow and reach the market size. Normally the major source of Ca in animal feeding is limestone which, however, has the considerable disadvantage of

variability of Ca content; furthermore, as inorganic material, it cannot provide other bioactive molecules which can be useful to further support animal welfare and productivity. The development of an optimal feed for sea urchins will allow to completely close the “waste circle” while promoting sea urchin aquaculture and reducing the impacts on natural stocks. In this context, the juridical analysis is fundamental, because the “end of waste” regulation is unclear and based on case-by-case authorizations. Assessing the juridical requirements for the CIRCULAr and BRITEs projects to be replied in the market, along with their economic sustainability and environmental impacts (Life Cycle Assessment), the interdisciplinary research team will try to set up new and reliable supply chains connecting sea urchin processing SMEs to the final end users (biopharmaceutical enterprises, feed mill companies, poultry farmers and aquaculture enterprises), allowing a true by-product valorisation.

Keywords: sea urchin, circular economy, marine collagen biomaterial, animal feed

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Summer is Coming: How Heat and Sugar Affect Saccharomycopsis Fibuligera Biomass and Cell-Wall Fractions Production in Mussel Process Wastewaters as Culture Media?

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Abstract

β-glucans and oligosaccharides have been reported for their beneficial effects on human health due to certain target properties such as antitumor and immunomodulatory activity. Although these compounds can be found along the vegetal kingdom, microbial cell-walls have been reported as an excellent source of these compounds. On the other hand, wastewater is produced as a result of the mussel production industry causing harmful effects for the marine ecosystems. These effluents contain high amounts of organic matter and thus, they have been studied as culture media for microorganisms. So, different yeasts have been utilized for this purpose. Also, despite biomass production of yeasts has been object of study very frequently, less efforts have been made in the assessment of the kinetic process behind cell growth and the parameters that can affect it (*i.e.*, temperature, pH, sugar concentration). In this study, *Saccharomycopsis fibuligera* yeast strain was selected as case study for the optimization of cell-wall/biomass yield. The experiments were designed following a *response surface methodology (RSM)* to reveal the possible interactions between temperature and initial sugar concentration and predict the optimal values for the production of *S. fibuligera* biomass, cell-walls and cell-wall fractions. Once the conditions were optimized, a cell-wall/biomass yield of 63.5% was obtained and statistical analysis confirmed the validity of the optimization model proposed. Therefore, this approach could offer an eco-friendly solution for valorizing wastewater derived from mussel industry, trying to find both a sustainable solution from the economic and the environmental point of view, integrating the perspective of circular economy model.

Keywords: Saccharomycopsis fibuligera, cell-wall production, glucan-based cell-wall compounds, bioactive compounds, process optimization, response surface methodology

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The Sea Urchin Collagen, Recycled from the Food Industry Waste, is a Novel and Valuable Biomedical Resource

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Abstract

The marine environment could be a huge source of undiscovered “blue” materials that might be exploited for different applications. The sea urchin (*Paracentrosus lividus*) is a greatly appreciated food in Italy and other Mediterranean countries; however, its edible part is restricted to a small portion and the majority of the product becomes waste. Consequently, we proposed to recycle the sea urchin by-products, originated from the food industry (e.g., restaurants), and reconvert them into a valuable and innovative source of collagen to develop an innovative biomaterial for skin wound healing. In this work, we describe the application of a collagen-based skin-like scaffold (CBSS), a skin substitute previously developed by Ferrario et al. (2020), to treat experimental skin wounds in a large animal model. The wound healing process was assessed with clinical, histopathological, and molecular analysis at 7, 14, 21, and 42 days post-wounding. CBSS-treated wounds showed a reduction of inflammation in comparison to untreated ones. Moreover, the CBSS application improved cell proliferation and wound re-epithelialization, thus favouring wound healing. Concomitantly, the biomaterial induced the expression of VEGF-A, supporting neoangiogenesis and the maturation of the granulation tissue into a mature dermis. These results were further corroborated by the observed gene expression of collagen type I and III: the CBSS properly regulated the expression of these two genes leading to an appropriate deposition of collagen in the wound bed. On the contrary, untreated wounds showed an altered gene expression of collagen type I and III, leading to the appearance of dermal fibrosis at 42 days. Moreover, histologically, treated wounds presented a correct development of skin adnexa since day 14; this observation was supported by the upregulated gene expression of hKER in treated wounds. Overall, the application of a biomaterial made with recycled collagen,

obtained from the sea urchin by-products, led to a better quality of the healed skin, resembling its appearance before injury (i.e., presence of skin appendages, proper development and organization of the dermis). The positive results obtained in this study, make the sea urchin-derived CBSS a promising biomaterial for skin wound healing application demonstrating how “blue biotechnologies” might handle seafood waste in a sustainable and circular economy context.

Keywords: sea urchin, food waste, regenerative medicine, circular economy, marine collagen

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Removal of Organic Compounds Using Chemically Modified Mixtures of Olive Cake and Wheat Straw Under Batch Processing

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Abstract

Olive cake and wheat straw, two different by-products of agro-food industries, are the most abundant lignocellulosic biomasses among agricultural residues in the world. Olive cake is a by-product of olive oil production and is a solid material consisting of seed particles and the fleshy parts of olive. Wheat straw is a by-product obtained after harvesting of wheat grains. Adsorbents, which derived from olive-cake (OL.C.) and wheat straw (W.S.) in pellet form, have been produced by the chemical activation of the corresponding raw materials and their adsorptive properties were studied with methylene blue dye solutions (MB). The materials (100% W.S., 100% OL.C., 50-50% and 30-70% w./w. OL.C./W.S.) were activated using HCL acid solutions of 5M. The adsorptive properties of raw materials were also examined after their activation at 8M HCL acid. The increase in the adsorption capacity of each sample (% dye adsorption), that have been activated in 5M HCL solution for the first 12h, follows: 100% W.S. (93.21%) > 30-70% w./w. OL.P./W.S. (90,31%)>50-50% w./w. OL.P./W.S. (84.69%)>100% OL.P., (69.45%). The activation of raw materials to higher HCL acid concentration, i.e. 8M than 5M, shows a decrease in MB dye adsorption percentages equal to 92.50% for 100% w./w. W.S. and 63.75% for 100% w./w. OL.S during the first 12h. The implementation of different kinetic models, i.e. pseudo-first order, pseudo-second order, Elovich and intraparticle diffusion shows that the pseudo-second order kinetic model describes better the experimental adsorption data. In conclusion, chemically activated wheat straw alone or in combination with olive cake can be used as filters for the purification of water from organic compounds such as dyes reducing the by-product amounts released to the environment.

Keywords: olive cake, wheat straw, methylene blue dye, kinetic analysis

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Adsorption of Methylene Blue Dye from Aqueous Solutions onto Chemically Modified Apple Seeds (Malus Domestica)

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Abstract

Apple juice production belongs to the branches of industry that produce large quantities of by-products in relation to the initial amount of processed fruits. Apple seeds were collected from by-products generated during the preparation of fruit salads and in juice pressing and can be used not only as sources of bioactive compounds but also as high-cost adsorbents for purification purposes. In the present study, samples of apple seeds (A.S.) and zeolite (Z) are prepared in proportions of 100% A.S., 80%-20% A.S.-Z and 50%-50% w./w. A.S.-Z. The samples are chemically activated with HCL acid at two different concentrations of 6 and 8M. The adsorption of methylene blue dye (MB) in the above samples are studied and compared with the zeolite one (100% w./w. Z). Four different kinetic models are applied to the experimental adsorption data: pseudo-first order, pseudo-second order, Elovich and Intraparticle diffusion model. The results show that the increase in MB adsorption follows the order: zeolite > 50-50 % w./w. A.S.-Z. > 80-20 % w./w. A.S.-Z. > 100% w./w. A.S. for the adsorbents activated with HCL acid, 8M. Adsorbents activated with HCL acid of 6M present lower MB adsorption percentages ranging from 90 to 97.5% compared to the adsorbents activated with HCL of 8M. Materials, such as 50-50% w./w. A.S.-Z. activated with HCL acid of 8M have similar adsorption properties (99.4% of MB adsorption) to zeolite (99.8% of MB adsorption) but lower cost than minerals. The implementation of different kinetic models has shown that the pseudo-second order kinetic model describes better the experimental adsorption data. In conclusion, chemically activated apple seeds alone or in combination with minerals such as zeolites can be used as filters for the purification of water from organic compounds such as dyes reducing the by-product amounts released to the environment.

Keywords: apple seeds, zeolite, kinetic models, adsorption

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Innovative Approach for Bioactive Compounds Extraction from Beetroot Crown (Beta Vulgaris L.)

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Abstract

Bioactive compounds are non-nutrient molecules existing in a wide variety of foods but in small quantity with extraordinary health benefits and so mostly consumed as nutraceuticals. Volarisation of them from food wastes drew the attention of entrepreneurs and environmentalists due to their accessibility to sustainable developments. Regarding the processing waste of agro-industries, the crown part of beetroot (Beta vulgaris L.) was utilized as a raw material in this study. To innovate the conventional way of extraction, the following techniques were accomplished: microwave-assisted extraction, leaching, infusion and maceration. The leaching process was performed by the central composite design of response surface methodology using R software with two variables of processing time (20 min, 40 min and 60 min) and temperature (30 °C, 45 °C and 60 °C). To accommodate the novelty of extractions, fresh crown samples were pretreated with microwave for 3 min at 800 W prior to infusion with hot water for 5 min; and maceration with distilled water, 15% aqueous ethanol and acidified water (0.5% citric acid) for 40 min. Meanwhile, the control samples were prepared without microwave pretreatments. Characterization of the extracts' profile was realized for betalain colour compounds analysis by Nilson's method; total phenolic compounds analysis by Folin Ciocalteu method; and antioxidant activities by FRAP, DPPH and ABTS methods, respectively. From our study, short-time pretreatments of microwave boosted the recovery amounts of the examined bioactive compounds compared to conventional extractions. In conclusion, time and energy consumption efficiency for the volarisation of bioactive compounds from beetroot processing waste was achieved through microwave irradiation.

Keywords: betalains, phenolic, antioxidant, microwave, beetroot crown

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UTL: Food Waste Utilization

In the session Valorization of Food Processing By-Products we saw how we can get the most out of raw materials to reduce losses before they reach our plate. But once it leaves our plate, waste becomes more difficult to manage. In industrialized countries this fraction contributes to over 40% of food waste. The utilization of food waste in bioplastic production or other biorefinery processes is for many an ideal option. With one stroke we reduce petroleum-based plastics, we reduce the cost of biodegradable plastics that today require overpriced pure substrates and we also reduce the volume of waste.

The RETASTE Session on Food Waste Utilization is part of the A2UFood group of sessions. The A2UFood project proposes a holistic approach to food waste management, including food waste utilization. Among other activities, A2UFood constructs a bioplastic production unit to utilize the food waste of the local hospitality sector

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Valorization of Coffee Brew By-products Via Recovery of High Nutritional Value Bioactive Ingredients and Their Incorporation into Bakery Products

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Abstract

Coffee is one of the world's most popular daily consumed beverages. Spent Coffee Ground-SCG is the main byproduct generated in coffee beverage preparation and instant coffee manufacturing (45%). About 2 kg of wet SCG are obtained from 1 kg of instant coffee produced, with an annual generation of around 6 million tons worldwide. The most common applications of SCG include animal feed, biofuels, composts, biosorbents and enzymes. More recently, there is a growing interest in food and health applications as SCG contains large amounts of organic compounds, polyphenols and fibers that can be exploited as a source of value-added food ingredients. The aim was (i) the recovery of high nutritional value bioactive ingredients (antioxidant and dietary fibers) from SCG and (ii) the enrichment of bakery products with these ingredients obtained from SCG. The ultimate goal was to evaluate the potential use of SCG as a food ingredient (application in bakery products). Freeze-dried SCG was subjected to oil and flavor removal with successive solvent extraction (water, methanol:water, acetone:water, acetone). The remaining solvent was removed from the solid residue by vacuum evaporation and further nitrogen purge to obtain a defatted, odorless powder with high antioxidant and dietary fiber content. Then, SCG was incorporated into cookie formulation: 0%(control), 4% and 7% SCG/g. Packed cookies were stored at (T:)25, 35, 45 °C, and their quality was monitored during storage. Total Phenolic Content (TPC:Folin-Ciocalteu), Peroxide Value (PV:oxidation-reduction titration), Total Dietary Fibers (TDF:Megazyme Assay Kit) and Chlorogenic Acids (CGA:HPLC) were determined. Sensorial characteristics (individual and overall: 1-9, coffee aroma intensity: 1-9), instrumental texture (hardness:texture analyzer) and color (CIELab:chromatometer) were evaluated. SCG presented high TPC and TDF: 21,566±627 ppm (dry) and 66.69±4.54% w/w (dry), respectively. 4% and 7% SCG enriched cookies also presented high TPC: 588±24 and 1,017±5 ppm per cookie, respectively, and TDF. 7% SCG cookies could be classified as source of dietary fiber (EU Regulation No:1924/2006). SCG cookies were characterized by light-to-dark brown color, crispy texture and pleasant coffee flavor/aroma. Based on total sensory quality, the shelf life of 0%, 4% and 7% SCG cookies (25 °C) was calculated: 359, 541 and 409 days, respectively. TPC slightly decreased during storage; PV increased but it was in acceptable levels. The significance of the study is to propose an innovative use of SCG in food industry producing high nutritional value products and reducing coffee brewing

byproducts.

Keywords: spent coffee ground, fibers, antioxidants, cookies

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Optimized Process of Lactic Acid Production from Food Waste

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Abstract

The society is facing tremendous challenges due to the extensive use of petrol based plastics. At the same time, a huge amount of environmentally harmful waste is produced (Jambeck et al., 2015) and, special treatment is required to eliminate their negative effect. Food waste in particular, adds to 1.4 billion tons per year. Apart from prevention and reduction through education and policy, advanced technology plays a crucial role in facilitating food waste management and recycling. In the past decades, many research groups have described the conversion of different kinds of food waste -including molasses, bakery waste and sugar cane- into value-added products, such as lactic acid. Lactic acid (2-hydroxypropanoic acid), is an organic compound widely used in food, pharmaceutical and chemical industry, which can be polymerized to form the biodegradable and compostable polymer polylactic acid (PLA), a potential substitute for petroleum-derived plastics. The present study focuses on the optimization of lactic acid production from food-waste collected from the Municipality of Heraklion according to the method proposed by Sakai and collaborators (Sakai et al., 2003) and, on the development of a scalable synthetic process. More specifically, a sequence of fermentations was initially performed to produce optically pure L-lactic acid from food waste, followed by purification of the produced L-lactic acid via esterification to the corresponding ammonium lactate and a final hydrolysis of the isolated ester. The process was optimised on terms of energy consumption and enrichment, for lactic acid production in a bench unit. The yields and limitations of this process will be discussed.

Keywords: waste management, L-lactic acid, fermentation, bioplastic

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Production of Biodegradable Polymers from Food Waste

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Abstract

Around 15 million tons of disposal plastic trash and 88 million tons of food ends up as solid wastes every year in Europe. Renewable and biodegradable polymers have been considered as one long-term solution for the environmental damaging impact of petropolymers and plastic pollution. Aiming to contribute to the reduction of food and plastic waste, we designed a pilot bio-refinery for the production of compostable bioplastic as a total material recycling process for municipal food waste following the system proposed by Sakai et al. (2003) This contribution focuses on the optimization of the polymerization step for the synthesis of poly-lactic acid (PLA) from the waste produced lactic acid. PLA was synthesized via a tin (II) 2-ethylhexanoate catalyzed direct polycondensation of lactic acid or via ring opening polymerization of the cyclic intermediate lactide. Both resulted in the production of low or medium molecular weight PLA and optimized to afford the targeted molecular weights. Main goal of the laboratory studies was to develop an efficient experimental process based on lactic acid produced from food waste collected in the municipality of Heraklion to achieve PLA synthesis in high yields.

Keywords: biodegradable polymers, bioplastic, PLA

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Prediction of Properties of Poly(L-lactic acid) with the Aid of Atomistic Molecular Dynamics Simulations

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Abstract

We present results of Molecular Dynamics simulations of L-poly(lactic acid) in the context of modelling and optimising its synthesis from recyclable food waste material. Predicted properties will serve both as input for the optimisation of the synthesis process and as benchmark for the pilot plant. A fully atomistic force field from the relevant literature (McAliley & Bruce, 2011) has been utilised to simulate amorphous and crystalline structures of isotactic L-PLA of various molecular weights from decamer to 100-mer. The structures have been relaxed and subsequently simulated at the isothermal-isobaric ensemble at atmospheric pressure and temperatures from 200 degrees Celsius down to ambient conditions, covering a range between conditions of PLA synthesis and those of end-product usage, respectively. Predictions include structural (static structure factor, radius of gyration), dynamic (decorrelation time scales), transport (self-diffusion, viscosity) and thermodynamic (density, isothermal compressibility) properties as functions of PLA molecular weight. The glass transition temperature has also been verified by gradually lowering the temperature below the above mentioned range and looking at the change in slope of specific volume with temperature. Finally, the Young modulus has been predicted by looking at the change in energy with elongation of the simulated cells. Where experimental data are available, predicted properties are in very good agreement.

Keywords: polylactic acid, molecular simulation, molecular dynamics, bioplastic

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Production of Compostable Bio-Plastics from Food Waste: Design of Bench-scale Unit

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Abstract

Biodegradable plastic materials are an interesting alternative to petrol based ones for some applications because of the environmental benefits such as reduced greenhouse gas emissions and lower energy consumption. Furthermore, there is an added economic impact related to the petroleum shortage exists, the dependence on third countries (petroleum-producing countries) and the fluctuation of raw materials cost. However, biopolymers are mostly synthesized from different vegetables used in human feeding (sugar cane, soya, corn, potatoes, etc.), and their production can entail a series of environmental and social problems. In this scenario, it is very important to analyze and demonstrate the potential of other natural sources for plastic production as alternatives to the food itself. Biowaste to Bioplastic (B2B) project will identify all the parameters of the production process of PLLA monomers and (poly) lactic acid in relation to the quality characteristics of the raw material (bio-waste) collected from Hospitality Units. The production of bio-polymers and bio-plastics from food waste has been proven on a laboratory scale, with the main limitation being the variation in the quality and composition of the waste. All the above are tested on a bench-scale unit that allow their further study and their substantial improvement, as well as the extraction of realistic results. In this study is presented the designed and constructed bench scale unit within B2B project. In the Bench scale unit, the collected quantity of pre-selected organic fraction from Hospitality Units is conducted to processing. Initially, the preselected fraction is led into the pre-screening area, where a special belt is manually sorted. Depending on the raw material, a rotating sieve is used to optimize the raw material. Then the pure organic fraction is shredded. This shredded material is fed with a special pump to the PLLA (Poly-L-Lactic Acid) Bioplastic Production Unit. The production process for the production of poly-L-lactic acid (PLLA) from food waste involves the following steps: (a) Fermentation of propionic and lactic acid (1st Reactor & Centrifuge-Filtration system), (b) Purification of L-lactic acid (2nd Reactor), (c) Polymerization of L-lactic acid. The final PLLA product is used for the production of compostable bags.

Keywords: bio-plastics, food waste, bench scale unit, PLLA

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Effect of Substrate Concentration and Retention Time on the Anaerobic Digestion of Food Waste for the Production of Valuable Chemicals

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Abstract

Food waste (FW) is, thanks to its composition and high organic and moisture content, a suitable substrate for anaerobic digestion (AD), an established process currently exploited for the production of biomethane. In AD, ethanol, lactic acid and volatile fatty acids (VFAs), such as acetate, propionate and butyrate, are produced as intermediates during acidogenesis and acetogenesis. Because of their various applications, the economic value of these liquid products is higher than methane. They are currently produced from petrochemical sources and food crops and their industrial production from AD is not yet economically feasible, due to high recovery costs and product inhibition. Hence, a concentrated substrate, which is rarely investigated, would facilitate their recovery and lead to a higher volumetric productivity. To maximise yield, concentration and productivity of the desired liquid phase products, batch and semi-continuous reactors were run, investigating different substrate concentrations of a model FW, hydraulic and sludge retention times (HRT and SRT). In order to have a process with low operating costs and low energy consumption, room temperatu.re was maintained and pH was uncontrolled, reaching acidic values that would inhibit methanogens. Initial substrate concentrations between 429 and 27 gCOD l^{-1} were assessed in batch runs. Lactate was the main product, being 80% in most experiments, due to the low pH (around 4). Results achieved with a more concentrated substrate have so far been promising, reaching a maximum product concentration of 61.5 g l^{-1} with the highest substrate concentration. Similar yields were obtained at all substrate levels (22-16% COD COD^{-1}). Different HRT and SRT were then investigated in semi-continuous runs, in combination with different substrate concentrations. Maximum product concentration of 101 g l^{-1} and yield of 29 % COD COD^{-1} were obtained at HRT of 30 days and fed with a substrate concentration of 429 gCOD l^{-1}. However, the highest productivity of 9.7 g l^{-1}•d^{-1} was achieved in a CSTR with same feed concentration but shorter HRT (7.5 d).

Keywords: food waste, anaerobic digestion, volatile fatty acids (VFAs), acidogenic fermentation

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Studies on The Catalytic Activity of Materials Obtained from Waste in the Form of Coffee Grounds in Oxidation and Isomerization Reactions

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Abstract

The aim of the study was to use waste in the form of coffee grounds to obtain heterogeneous catalysts and their use in the oxidation of alpha-pinene, 1,5,9-cyclododecatriene (CDT) and cyclohexene, and in isomerization of alpha-pinene. On the basis of the obtained results, the catalytic activity of the materials obtained from coffee grounds was found in all tested reactions. During the tests, approximate, most favorable conditions for carrying out these reactions were determined. The main products of alpha-pinene oxidation were: alpha-pinene oxide, verbenol, verbenone, campfoleic aldehyde, pinocarveol, myrtenol, myrtenal and carveol. During the oxidation of CDT as main product was 1,2-epoxy-5,9-cyclododecadiene, and during isomerization of alpha-pinene the main products were camphene and limonene. The catalysts that were used in the tests were prepared using coffee grounds that were initially washed with acetone to remove solvent-soluble impurities. They differed only in the additional grinding of the grounds used for the synthesis of one of them. The catalyst synthesis method consisted in dissolving Pluronic P123 (Aldrich, MW = 5800) in a mixture of water and HCl (37 wt% aqueous solution) at the temperature of 35 °C, and then adding to the mixture thus obtained: tetraethyl o-silicate (TEOS, 98 % Aldrich), tetraisopropyl o-titanate (TiPOT, 97%, Aldrich) and coffee grounds (the mass ratio the mixture obtained above to coffee amounted to 15:1). The resulting mixture was stirred at the temperature of 35 °C for 24 h. After the agitation was turned off, the contents of the reactor were further heated at the temperature of 35 °C for 24 h. The resulting precipitate was filtered off, washed with deionized water, and then dried at the temperature of 100°C for 24 h and next calcined for 6 h at the temperature of 550 °C. The described reactions allow for the management of waste in the form of coffee grounds, as well as for obtaining valuable compounds for the cosmetics and polymer industries and for medicine.

Keywords: coffee waste, oxidation, isomerization

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Conversion of Food Waste to Levulinic Acid Utilising a Catalytic Membrane Reactor

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Abstract

Food waste is a growing environmental and societal concern, especially as population growth and urbanisation continues to increase. However, food waste represents an abundant material that can be used as biomass feedstock for the synthesis of valuable bio-based chemical intermediates. One such chemical is levulinic acid (LA). LA is a C5 chemical intermediate that holds tremendous potential as a building block chemical for the synthesis of a wide number of compounds including plastics, polymers, agrochemicals, and biofuels. Here, food waste from vegetables and other starch-based food groups have been investigated for its conversion to LA using a unique solid acid catalyst immobilised on a membrane substrate. This one-pot conversion process using a novel enzyme-mimic catalyst offers many benefits over other technologies that rely on corrosive homogenous acids or toxic metal-based catalysts. Additionally, the porous membrane enables the immediate separation of the LA product from the feed stream, driving the reaction to completion and improving the yield. Lastly, hot water extraction as a pre-processing step was found to be effective in removing some of the proteins that can adversely affect the conversion reaction. For starch-based food waste such as rice and noodles, over 90% levulinic acid yield was obtained. For more recalcitrant cellulosic vegetables, 50% levulinic acid yield was achieved, indicating the promising potential of the technology for food waste utilisation.

Keywords: catalytic membrane reactor, biomass conversion, food waste, levulinic acid

TFM: Technology in Food Waste Management

It’s a brave new world out there and it’s also a brave new world for our food waste. From smart farming to smart kitchens, technology promises to solve problems that were previously though unsurmountable, all the way from farm-to-fork. Innovative ways to manage, connect, sense, and distribute are emerging, and with them an entire new field of research and entrepreneurship. An entirely new way to reduce wasted food and create new jobs in the process.

The RETASTE Session on Technology in Food Waste Management is part of the A2UFood group of sessions. The A2UFood project proposes a holistic approach to food waste management and technological innovations are at its core. Among other activities, A2UFood equips the citizens of Heraklion in Crete, Greece, with mobile apps to better manage their shopping and monitor their compost, and hotel kitchens with a smart scale that monitors their kitchen waste.

European Regional Development Fund

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Rethinking Food Waste in the Industry 4.0 era: A Review of Blockchain Research in the Food Supply Chain

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Abstract

The challenge of reducing Food Waste (FW) is a complex social problem leading to environmental degradation and devastating economic inefficiencies. At the same time, FW is raising significant ethical challenges, since according to the Food and Agriculture Organization of the United Nations, one third of the food produced in the world for human consumption every year gets lost or wasted, whereas 870 million people globally, or one in eight, are suffering from chronic malnourishment. The realization of FWs immense negative effect on society has prompted -in the last decade- a positive shift of focus towards the establishment of a common understanding of the phenomenon and its root causes and the initiation of coordinated actions to promote citizen awareness and alleviate negative ramifications of FW at all levels of the Food Supply Chain (FSC), i.e. agricultural production and stock-farming, post-production handling, upstream distribution and storage, processing including packaging, downstream distribution and storage and finally food preparation, consumption and disposal. The complex and dynamic nature of the FSC along with the non-negotiable need for food freshness, quality and safety from harvest, slaughter or catch to the consumer's plate delimit a very demanding environment, which subsequently creates numerous information technology requirements and challenges. Fortunately, the wave of Industry 4.0, although not still mature enough, provides a set of innovative technologies, which seem capable of transforming the way the FSC operates enabling sustainable food production, distribution and consumption. This paper focuses on probably the most controversial of Industry 4.0 technologies, i.e., Blockchain and provides a detailed review of the research efforts attempting to implement blockchains for reducing food waste across the food supply complex network. In doing so, the paper will study synergies between Industry 4.0 technologies complementing blockchain potential implementations, such as IoT sensor networks widely used in upstream FSC processes, IoT sensors and telecommunication services for food transportation and condition monitoring during storage, machine learning and artificial intelligence for forecasting and better inventory management at both the supply and demand levels and finally end-consumer facing applications using blockchain for supporting efficient and responsible food consumption.

Keywords: Blockchain, Food Supply Chain, Food Waste, Industry 4.0, Internet of Things

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Acronym: TRACKPLAST).

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GIS-based Model for Assessing New Suitable By-products for Renewable Energy Production Within the Context of Circular Bio-economy

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Abstract

Biogas production from biomass by anaerobic digestion has developed significantly in the last years. In this field the use of agro-industrial wastes and by-products has been put forward to produce biomethane in a more sustainable way. In this context the processed fruit and vegetable and the related waste production represent a suitable resource for producing biofuel as a new frontier within the context of circular economy. Given the uncertainty of data related to biomass quantities, this research aims at filling the gap in the knowledge of the production and yield of these by-products useful as biomasses for energy uses in those territorial areas where biomethane sector is still developing. This aim is relevant to plan the sustainable development of biomethane sector regarding environmental protection in terms of reduction of both soil degradation for dedicated energy crops and greenhouse gas emissions derived from biomasses logistic supply, as well as the re-use and valorisation of the agro-industrial by-products that become resources. On this basis, a GIS-based model was developed and applied to Sicily region, by investigating the specific regulatory framework as well as analysing descriptive statistics. QGis software, was used since it is a valuable decision support tool suitable to collect, organise, analyse, and localise geographical data. The results of the GIS analyses allowed to carry out the localisation of the highest productive territorial areas and highlighted where fruit and vegetable wastes are highly located. In this regard, about 7 million of Nm^3/ton of biogas could be produced by reusing only the fruit and vegetables residues coming from the three considered most representative Sicilian wholesale markets. Finally, the regulatory framework was analysed since could play a key role for supporting or inhibiting the utilisation of the considered biomass.

Keywords: Renewable energy, Agricultural-waste, recycling, valorisation, biomethane, GIS, green economy, circular economy, bioresource policy

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Effective Tools to Reduce Domestic Food Waste: Bio-Based Dual Sensors Devices for Naked-Eye Freshness Monitoring of High-Protein Foods

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Abstract

One-third of food produced for human consumption every year is lost or wasted and, in Europe, 53% of food waste occurs in households. For this reason, food waste represents an increasing issue nowadays that could no longer be neglected and any efficient policy to face this problem must involve the entire food supply chain, from the producers to the households. Domestic food waste is in part attributed to date labels since they are calculated according to the worst storage scenario and their meaning is often misunderstood by consumers. As a result, date labels may lead consumers to waste foods still safe for human consumption, thus provoking an unjustified loss of food and money. This issue can be solved by the introduction of smart labels, able to detect the real freshness of foods, rather than calculating it, basing on the average perishability or storage conditions. Countless devices have been recently proposed for this application but most of them usually fail the test of real samples freshness monitoring or large-scale applicability. With a specific focus on solid protein foods, like fish or meats, our research group developed several sensors array suitable for the application as naked-eye smart labels, when placed over foods: the receptors used are pH indicators that turn their colour in a wide pH range, able to detect volatile spoilage by-products with different acid-base behaviour, while several solid supports and linkage mechanism have been tested, ranging from ion exchanger to covalently modified polymers (Magnaghi et al., 2020). To further increase the biocompatibility and sustainability of these devices, a new series of bio-based sensors, whose main components are cellulose, starch, glycerol and carboxymethylcellulose, properly functionalised with the reactive dyes of interest, have been developed and optimised using a multivariate approach. The result is a portfolio of dual sensors arrays, suitable to identify the different spoilage steps of protein foods during storage at home conditions. The shift from plastic-based to bio-based films allowed us to widen the range of devices without losing the key points of reliability, resistivity, naked-eye evaluation and large-scale applicability.

Keywords: domestic food waste, bio-based materials, colourimetric sensors, smart labels, chemometrics

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How to Control Milk Freshness at Home: Multi-Purpose Colorimetric Sensor to Face Milk Waste and Health Issue

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Abstract

Milk is an important food for the world's population but, Unfortunately, due to its high nutritional value, it is also an excellent growth medium for microorganisms and it is thus an extremely highly perishable product that possesses a short shelf life (Ziyaina et al., 2020). Furthermore, the standard for "spoiled" milk is strongly subjective and the term "spoilage" is difficult to normalize and to measure with accuracy. Nowadays, the shelf life is determined by the time duration to which the milk remains in its original state and expressed through "sell by" or "best if used by" dates. These dates are intrinsically inaccurate and can result either in the consumption of no longer eatable milk or in the waste of still safe product. This second option is even more likely nowadays since many dairy producers are introducing innovative active packaging that ensures significant elongation in milk shelf life, not taken into account by the date labels. As usually happens in food freshness monitoring, conventional qualitative and quantitative methods are currently used to detect milk level of freshness in dairy industry but, once in the supermarket or in the household, milk freshness could no longer be controlled due to the lack of rapid, low-cost and reliable methods. In this scenario, we developed a multi-purpose miniaturized sensor, based on a pH indicator covalently bound to polymeric material, following the already proposed synthetic pathway (Magnaghi et al., 2020), able to change colour according to milk freshness, following pH modifications provoked by microbial activity. Despite the apparent simplicity of the system, this sensor can give information at different levels. Firstly, when milk is no longer eatable, a glaring colour shift from green to yellow is observed. Secondly, the sensor colour evolution during milk freshness monitoring, expressed as average RGB triplets, were used to develop classification models using Linear Discriminant Analysis that allows predicting the freshness of milk samples at any time. Eventually, sensor colour can be used to calculate milk acidity, expressed as °SH/100 mL, using Partial Least Square regression. This last application represents a huge innovation since it allows to replace the reference Soxhlet-Henkel methodology, destructive and time-consuming, with a much simpler method with similar performances, both in terms of precision and accuracy.

Keywords: domestic food waste, health issue, colourimetric sensors, naked-eye evaluation, chemometrics

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E-Tongue Based on Metallo-Porphyrins for Histamine Evaluation

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Abstract

The aim of this work is the development of an e-tongue like sensor. It is based on modified screen printed electrode (SPE) structures with a receptor part made of porphyrins/metalloporphyrins that are chemically bound to graphene (the sensitive assembly) to act as antennas and “capture” the histamine molecules. Histamine is a compound strongly connected to the level of freshness in foods: the caution level of histamine is 50 ppm, whereas the maximum accepted levels range from 200 ppm to 500 ppm. Using a single, ultra-sensitive electrochemical sensor, we measured the concentration of histamine. In our approach, the chemical immobilization of the porphyrins onto the graphene surface was via substitution reaction using $SOCl_2$. The sensitive assembly revealed a quasi-reversible reaction towards histamine with an oxidation potential at approximatively 600 mV. The results indicate a linear dependence of concentration of histamine as a function of intensity and good chemical stability in acidic environments.

Keywords: histamine, cyclic voltammetry, food freshness, metallo-porphyrin

Acknowledgments: 87PD/2020, 393PED/2020, 18/N/2019

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ICC Initiative: Transformation of The City of Corfu Into a Smart, Green and Sustainable City

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Abstract

The waste management issue is the biggest problem that the island of Corfu has ever faced. The Municipality of Central Corfu and the Diapontian Islands (MCCDI) is a new municipal authority which is formed in 2019. In order to solve this major problem, the MCCDI tried and succeeded in becoming part of the 100 Intelligent Cities Challenge (ICC) which is a European Commission initiative that supports 136 cities in using cutting-edge technologies to lead the intelligent, green and socially responsible recovery. The ICC initiative is trying to provide: a) Strategic advice from international experts tailored to each city that is participating, b) Mentoring from the most innovative mentor cities in the EU, c) Community conventions – for action over talk, d) Support by transversal services on access to data, access to finance and through a marketplace full of innovative solutions. Corfu's ICC team and the new Mayor are committed to provide sustainable and permanent solutions to the waste management problem and adopt all the necessary circular economy principles that will allow the citizens to be proud to live in Corfu. In the following paper, all the efforts that have already taken or will take place in order to achieve our vision to transform the MCCDI into one of the most smart, green and sustainable islands in Europe, will be presented.

Keywords: 100 Intelligent Cities Challenge, ICC, Corfu, circular economy, waste management, digital transformation, green and smart mobility, green and smart energy, European Green Deal, Covenant of Mayors.

Acknowledgments: I would like to thank the Mayor of the Municipality of Central Corfu and the Diapontian Islands, Mrs. Meropi – Spyridoula Ydraiou but also the Deputy Mayor and Project Manager of Corfu's ICC team, Mrs. Panagiota Tzanne, whose their trust, support and cooperation were really valuable for me so I can fulfill my duties. The Intelligent Cities Challenge (ICC) is a European Commission initiative which is funded by COSME, the EU programme for the Competitiveness of Enterprises and SMEs.

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Managing Household Food Waste with the FoodSaveShare Mobile App

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Abstract

In Europe, it is estimated that households are responsible for the largest portion of food waste generation, which contributes up to 16% of the CO_2 emissions of the food supply chain. Major reasons for household food waste generation are food spoilage, date label confusion, overbuying, and poor shopping planning (Gunders, 2017). Thus, food-waste prevention at the household level is largely an issue of optimizing food resources monitoring. Here we address this issue by designing and launching a decision support tool implemented in a smart phone application, the FoodSaveShare App. FoodSaveShare combines data from user input and supermarket loyalty schemes to take advantage of their combined shopping tracking features. The App features a shopping list functionality that allows either selection from a list of over 14,000 products as well as product barcode scanning and manual entry, and subsequent crossing-out during shopping. Shopping lists are linked with the loyalty account, thus allowing household members to create and share common lists. After purchase, tips are provided about optimal storage of purchased food items. Food products are assigned approximate expiration dates based on food and packaging type, drawing from a list of 597 possible types. Notifications offer reminders about eminent expiration dates and provide suggestions about the utilization of food items that are about to expire or are on the shelf, drawing from a list of over 7,000 recipes. Additional functionality allows users to identify products that have been consumed in time or had to be discarded. Statistics such as purchase history and resources spent versus resources saved allow for a better overview and provide incentives for better shopping and consumption habits. The FoodSaveShare App was launched during the A2UFood Project (Chroni et al., 2019) that includes food waste prevention actions at the household level. The App has been tested under real customer data and conditions and is scheduled to be adopted by the largest supermarket franchise of the Island of Crete, Greece.

Keywords: mobile app, household food waste management

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Remote Monitoring and Management of In-vessel Composting

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Abstract

Home and community composting, which are essential components of every bio-waste management strategy, are gradually succeeded by in-vessel composting which allows a more efficient and hustle-free process, especially in the urban environment. Following this development, several Information Communication Technology (ICT) applications came to fill the gap of remote monitoring and management of in-vessel composters to further automate the process and render composting units truly autonomous (Autonomous Composting Units – ACUs). Previous work (Nikoloudakis et al., 2016; Nikoloudakis et al., 2018) emphasized on the cloud-side of such Internet of Things (IoT) applications, presenting the organization and data management strategy for the remote control of the composting process. Here we focus on ACU-side, proposing a framework that can allow faster deployment of multiple ACUs into a cloud IoT application with little effort. Our approach recognizes that heavy industrial automation units as ACUs are mostly controlled using typical industrial grade PLCs and private communication protocols instead of using popular IoT microcontrollers and open-source technologies. Hence, with our work we attempt to integrate such close-source technologies into the world of Industrial IoT, warping them into an open-source envelope. To this end, bridging of the two worlds is accomplished using an ad-hoc Machine-to-Machine (M2M) protocol. The flow of the control data is based on the bidirectional communication of the industrial PLCs with the open-source environment using the SNAP7 Protocol (SNAP7). This M2M communication is developed over Ethernet networks following the Client-Server paradigm, thus also isolating and securing the industrial system from the Internet world. Open-source technologies like Node.js, MQTT, Grafana, and Influx DB are also used in our development to accomplish a fully monitored environment and a seamless integration of the industrial world with IoT. Taking into consideration the potential of non-accessible ACUs, message transmission takes place via mobile links. To this end, a 4G router using an IoT Sim Card is installed in the ACU’s electronics enclosure as well. The system was implemented in the ACUs developed during the Project “ACU - Autonomous Composting Units” on a composter with capacity 3 m3. Preliminary results show the efficiency of our approach. The great advantage of this configuration is the bidirectional communication with ACUs that allows the end user to monitor and control all the Inputs/Outputs of PLCs

from a friendly UI. All sensors and actuators connected to the ACU can be monitored and controlled via the developed responsive web application, while historical data are stored in the data base and are visualized through analytical reports.

Keywords: IoT, Autonomous Composting Units, SNAP7, PLC, Machine-to-Machine, Node.js

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AWP: Awareness and Prevention

Today’s food systems are broken. Our diets are the leading cause of disease. 33 million people in the EU cannot afford a quality meal every second day. At the same time, 50% of adults are obese and we dispose 200 to 400 gr of food waste per day. Unfortunately, Greece is typically at the top of these lists. Beyond an urgent environmental issue, food waste is primarily a social issue; a societal inefficiency. To change this paradigm, we need to make bold changes, starting from our schools, all the way to our consumer habits, and the way we address food residues as waste rather than as a resource.

The RETASTE Awareness and Prevention session is part of the A2UFood group of sessions. This session is part of the A2UFood group of sessions. The UIA A2UFood project proposes a holistic approach to food waste management, and social aspects are at its core. Among other activities, A2UFood is building a second opportunity restaurant in Heraklion in Crete, Greece where food otherwise wasted will be transformed in nutritious meals for those in need.

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Investigating the Ethical Dilemma of Food Waste in Long-Term Care Facilities

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Abstract

Food waste is an increasingly important consideration for all food-service providers. This research investigates the volume of food waste generated at two long-term care (LTC) facilities located in southern Ontario. Food waste was measured across all aspects of the food delivery system including preparation, production, and service. Results of the study show significant food waste of over 50% at both facilities. Investigation into the generation of this waste isolated the major cause being government policy ensuring patients at these facilities are offered various choices throughout the meal selection process. In addition, significant plate waste was generated because of additional policies guaranteeing pre-determined nutritional and caloric intakes for each patient. These findings put into question the operating practices involved with adhering to such policies. Ethical questions are also raised pitting a patient's "quality of life" improved by food choice versus the environmental impact of the waste generated because of this policy.

Keywords: Food waste, Long-term care, Quality of Life, Food-Service

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Comparing the Effect of Price, Regional and Environmental References on the Willingness to Purchase Sub-optimal, Regional Dairy Products in Germany

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Abstract

As part of the European Union, also Germany has committed itself to the United Nations goal of halving its annual 12 tons of food waste by 2030. Consumers are not only increasingly concerned about reducing food waste, but also about buying regional products to shorten transport routes for food. Giving preference to local, regional foods is a general trend in Germany that is still growing. Consumers often recognize regional foods by means of regional labels. At the same time, grocery stores are also trying to reduce food waste with the help of product marking - in the form of product stickers. While the effect of cost-saving and food waste reduction labels on the purchase of sub-optimal food has already been investigated, there is no study that examines the effect of a regional label on the willingness to buy a sub-optimal, regional product. This study aims to close this research gap. For this purpose, a laboratory experiment was conducted with 375 participants in a between-groups design (control group, price saving sticker, generic regional sticker, specific regional sticker, sticker to fight to food waste) on the willingness to buy suboptimal dairy products (two days before expiry of the best-before date). Overall, results show a very high willingness to buy sub-optimal dairy products among study participants. While no significant differences were found between the different sticker manipulations, besides the price saving sticker, study participants' origin is influencing the willingness to buy as well as the participants' attitude towards food waste and to which degree they consider the expiry date as an orientation guide for consumption.

Keywords: regional food, food waste, label, Germany

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Children's Food Waste Behaviour Between Concept-Based Education, Peers, and Family Influence. Insights from Primary School Canteens in Northern Italy

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Abstract

Information campaigns play an important role in the strategy to tackle consumer food waste. However, food waste results from deep-seated routines that are difficult to change by means of suasive policy interventions. This suggests that the provision of concept-based education in early years, when an individual's habits have not formed yet, could be a more effective approach for tackling this challenge than focusing on adults. To test this hypothesis, we carried out research on students in the last two years of primary school in the Province of Modena, Northern Italy. We developed a novel protocol to assess the effects on students' food waste behaviours at school and at home of a lessons on the environmental impact of food waste. Our protocol consists of three waves of questionnaires administered to students in different times of the year; two questionnaires administered to their parents; a half-day interactive lesson implemented in half of the classes (randomly extracted) in correspondence of the second wave; and behavioural economic experiments implemented during the first wave. The questionnaires included also questions to detect different types of social networks within each class. This approach allowed us to test the impact of the lesson while controlling for the influence on students' food waste behaviours of their classmates, and of their parents' approach to wasting food. We estimated multilevel proportional odds models to identify the variables affecting the frequency of food waste in school canteens and at home, and students' perception of their own food waste in the same settings. We find that concept-based education has only a short-term (reduction) impact on self-declared food waste at school, and that parents' approach makes no significative difference, although children perceive their own waste level as lower if parents link food waste to environmental concerns. Instead, imitation seems to play an important role, as students' frequency of food waste tends to align to the frequency of students sitting nearby in school canteens. Finally, behavioural factors such as care for the public good are not related with one's food waste. These results call policymakers to take account of network effects, and to favour

the observation and replication of virtuous behaviours in social settings, rather than focus purely on concept-based education. School canteens, and by extension workplace canteens, represent an ideal setting to promote a more responsible approach to food use.

Keywords: children behaviour, food waste, school canteens, education, networks

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sObres Mestres - Pop-up Food Waste Restaurant

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Abstract

sObres Mestres is a food waste pop-up restaurant based in Barcelona, Spain. Since July 2017 we have rescued 1.717 kg of surplus fresh veggies and fruits from local farmers, wholesalers, supermarket and artisan bread from local bakers. sObres Mestres's glocal character is based in global recipes, inspired by world´s precious gastronomy heritage, made by local products. We organize itinerant culinary events (memorable dining and workshop experiences) as well as we participate in artisan local markets. We recover veggies and fruits both from the fields (as they do not meet industry's standards) in collaboration with Espigoladors (Barcelona's gleaning initiative) and from bakeries, groceries, supermarkets and wholesalers (surplus at the end of the day). sObres Mestres is an initiative which aims to raise awareness on food loss and waste in a direct and amusing way. Our objective is introducing more people to fight food waste and reveal the quality and quality of nutritious meals can be done by surplus food. In addition, following the principles of zero waste, we avoid disposable products and use food as edible tableware.

Keywords: food waste, surplus, zero waste, reusable

Acknowledgments: To all collaborators: Espai Ambiental, Espigoladors, chef Eva Davó, Cuina de la Diversitat (Fira solidaria Cornellà), Zero Waste BCN, Plataforma Aprofitem els Aliments, La Cuina del Món, Foodism, chef Sergi de Meià, Nevera Solidaria, Gourmand Gohan, Volantes, Slow Food Barcelona, chef Ada Parellada, Semproniana, BonAprofit, Comer Feliz, Aromas de Siria, Cultural, Fundació Comtal, Fàbrica del Sol, Mescladis, Banc dels aliments, Cuchara-Eines de enmancipación alimentaria, Open Art, Associa\'t, Energies Comunitàries, Food Coop BCN, La Cuina del MACBA, Menjador Ca la Rosa, Eixarcolant, Naturalwalks, Tasty Hour, Mercat de Pagès de La Sagrera, Som la Clau, (des)vestint aliments, Dona Forta-Guerreras de Baró, Associació Cultural Popular Xinesa.

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“Save Our Food”: A Pilot Food Waste Project in Cyprus

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Abstract

“Save Our Food” project (in Cyprus) had two core objectives: 1) To minimise food waste of edible food in Cyprus, and 2) To minimise the group of people who face food insecurity. The main aims of the project are to a) minimise the amount of wasted food in various levels of economic activity, b) offer food to people who cannot satisfy their basic needs by offering them food that otherwise would be wasted, c) organize awareness raising workshops on food waste and circular economy for young people. A consortium of five stakeholders was established, in order to run and complete the project, involving a research center, a local authority, the country’s youth board, volunteers and a consulting company from Greece. The expected outcomes would be to inform both youngsters and the Cypriot society on food waste and how everyone could act responsibly. The main characteristics, barriers and challenges of the project will be presented at the conference.

Keywords: food waste, circular economy, local authorities, Cyprus

Acknowledgments: Frederick Research Center (Cyprus) was the leading organisation of the project for a period of two years (April 2019-April 2021). The project was funded by the Research and Innovation Foundation (Cyprus).

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A 4D Approach to Food Waste Prevention - The "Healthy Little Eaters" Case Study

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Abstract

Educators play a crucial role in paving the way for future generations' rational approach to food waste prevention and management. This is clearly stated in the 17 *Sustainable Development Goals Agenda set by the United Nations (Goals 2 + 12). Healthy Little Eaters* (*www.healthylittleeaters.gr*) is an educational project consisting of 82 language school owners/members, in Greece and Cyprus. It was set in motion in 2014. Members apply multisensory and multidimensional experiential learning and teach students the benefits of healthy eating on both the human body and the environment.*1st dimensional approach*: *Nutritional*: It has been proven scientifically that apart from being beneficial to humans, healthy eating is a lot more filling than junk food. Therefore, *Healthy Little Eaters* are taught that they do not have to buy large quantities of food that they might have to dispose of later, but rather buy good quality food in smaller quantities. They are rewarded for their healthy choices and every school needs only 2 weeks before 80% of all students replace unhealthy snacks with healthy ones. *2nd dimensional approach: Educational.* Fruit and vegetables are not sold in packages and homemade food is more carefully prepared and cooked than food sold in restaurants and canteens, consequently it can be preserved longer. The longer a food is preserved, the less need there is to buy or make more. The less food we buy or make, the less food waste we produce. HLEs visit local farms, plant nurseries, food industries, they set up their own greenhouses and seed banks, they go *zero package shopping* (i.e., shop products with no packaging) so as to learn all about the cultivation, the making of and shopping of healthy food as part of their experiential activities. The impact is life changing to all participating students. *3rd dimensional approach: Practical.* Healthy food's basic ingredients are fruit and vegetables whose peels are used by the HLEs to make their own compost. A single school of 180 students can produce about 400 litres of compost/year. *4th dimensional approach: Academic*. HLEs write their own healthy food recipes in a book that travels all around Greece, they organise and take part in writing and photo contests about healthy eating, they organise events to celebrate *World Food Day* and have created two worksheets collections about fruit and vegetables. Most importantly, they are the greatest Healthy Food and Food Waste Prevention Ambassadors to the world. The impact of the HLE's project in numbers: 6500 students took part from 82 schools. 80% of these students changed their eating habits for at least 9 months (during the academic year). Around 5200 students produced less food waste including packaging, but only around 6 schools

altogether have moved on to producing their own compost minimising food waste. The next step would have be to run a survey on whether these students have managed to change their families' eating habits too which is unfortunately pending due to the closing down of schools because of the COVID- 19 pandemic.

Keywords: healthy food, education, experiential learning, SDGs

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Intelligent and Sustainable Food Packaging in a Circular Economy and Consumers Changing Needs

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Abstract

For a long time, packaging expresses the values of the product, it ensures the transportation of the product maintaining the quality and offering protection. Design and material play a crucial role to the attractiveness and sustainability of the product. Packaging is considered as an environmental and economic cost instead of a considered value for the waste decrease. Alternative packaging material and the current packaging technology could easily protect food waste. The possibilities of intelligent packaging in the circular economy are expanded through intelligent communication systems. With the term intelligent packaging we refer to the situation that conceptually surrounds packaging in relation to its use, technology and its interaction with humans and the environment. Through this interaction, innovative communication fields of action and applications are formed in the viability of the packaging. Contributing to the circular economy it is required to redefine conventional packaging through the possibilities of intelligent packaging. The variety of consumer as people with kinetic or visual disabilities, aging population highlight the need for easy-to-read and openable product packaging adapted to their needs. The global consumer market with the increasing of singe person living, the increasing of ageing population, requires products designed friendly to the environment and to the peculiarities of customers need. With the provided applications of industry we can have safer packed faster with improved quality products. With smart technology, augmented reality, internet of things, the interconnection between machines and people through wireless sensors, RFID labels can ensure the relationship of the product with the environment, industry and the user. Mobile Augmented Reality in combination with location-based applications supporting by GPS and built-in sensors can easily monitoring the packaged object and sending all the necessary information to a server and display all stages from the production to the use. This report aims to provide an overview to the food packaging sector in our ‘modern’ way of living the impact to the environmental and the customer’s need. With the evolution of technology we attempt to create smart applications and an environment that is considered intelligent.

Keywords: Intelligent food packaging, circular economy, food waste, consumer needs

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The "A2UFood Training Kit": A Path to Food Wastage Reduction

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Abstract

Food loss and waste is a global issue because of its environmental impacts and intense resources use, its financial losses and its social consequences. The A2UFood project aspires to design and implement a holistic management scheme in which all aspects of reduction, reuse, and recycling of food waste are included. An integral part for an efficient strategy to combat food wastage is the awareness and information of the public. Among the designed off line activities of the A2UFood project developed in the localized detailed informative and dissemination campaign, were the following: promotion materials (e.g., leaflets, communication spots) and events and/or activities for public awareness, publicity, visibility and training to citizens and related enterprises. In this context, the “A2Food training kit”, in the form of an e-book, had a key role, in order to involve a large percentage of the population, in a participatory way. It includes a short theoretical background and nine sets of participatory activities. All the above activities are linked to Education for Sustainable Development and are related to the respective Sustainable Development Goals with content related/adjusted to the topic. The dissemination model employed draws on adult education theory under the form of participatory workshops and follows also the “train the trainers” principle. All the workshops are based on the principles of active learning related to real life experience and cooperative learning. Along line with these theories, learning is best conceived as a continuous holistic process of adaptation to the world through the transformation of experience. Following these principles, the activities designed for the workshops aimed to bring participants’ preexisting experience, values and beliefs into confrontation with the new context. Therefore, participants were engaged in reflective learning experiences rather than just been exposed to information. Since the main aim of the workshops was the transformation of long-time established practices regarding food waste management, the implemented activities shifted from the superficial transmission of information, tips (i.e. shopping) and data to the ability of solving problems applying the principles and ideas of sustainable food waste hierarchy. To date, the present material has been used in six workshops. Moreover, this period our team responding to COVID19 pandemic made

the necessary adjustments so that all activities can be implemented in a new form, adapted to the distance training (learning) environment. In this last form has been used in two more workshops.

Keywords: Food waste, Education for sustainable development, Participatory workshops, Food prevention, Awareness raising

Acknowledgments: The A2UFood Project (UIA02-115) is co-funded by the European Regional and Development Fund through the Urban Innovative Actions (UIA) Initiative.

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The Profile of People Claiming Food and Material Support Benefits Due to Extreme Poverty: Data from the Region of Crete

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Abstract

The financial crisis of the last decade has increased the number of people living in extreme poverty in Greece and those excluded from social benefits. The development of material support agencies was a new phenomenon necessitated by the increase in the number of vulnerable groups and families living on the edge and below the poverty line. The current study reports on the socioeconomic circumstances and psychosocial profile of 798 people confronted with severe poverty in the region of Crete in Greece. The study was funded by the Fund for European Aid to the Most Deprived (FAED), which is specialized in Greece through the “Food and/or Basic Material Assistance” Operational Program (Crete Regional Unit). All the people that were registered at their regional or local social service agencies in Crete as beneficiaries for material support benefits, were eligible to be included in the study. A structured questionnaire was employed to investigate the profile, living conditions, health, and mental health status of the participants. A combination of socio-economic and psychosocial problems was recorded. A huge health and mental health burden was evident among the participants (50.0% mild to severe depression; 40.0% with symptoms of anxiety; 5.0% with severe alcohol/drug related problems; 25.0% with certified disability, 50.0%. with chronic disease). People experienced long periods of unemployment (mean time 4.2 years), bad housing and living conditions (e.g., 18% lacking heating) and absence of a supportive social/family network (e.g., 12.0% lacking trusted others). Family-focused care seems necessary to meet the complex bio-psychosocial needs of people living in extreme poverty. The need to strengthen mental health counseling services in the community emerged as a priority.

Keywords: poverty, psychosocial needs, mental health, living circumstances, housing conditions, social issues

Acknowledgments: We would like to express our gratitude to all the participants for taking part in the study and sharing personal information and experiences.

F4F: Food for Feed

Today, 33% of croplands are used for livestock feed production. Food waste has been a traditional source of animal feed for household animals but had to be banned from the livestock breading industry due to sanitary concerns. The wide disparity in government policies among countries regarding recycling of food waste into animal feed has severely limited the ability to reuse the valuable nutrients and reduce the negative environmental impacts of food waste. This session deals with solving these issues with state of the art approaches.

The RETASTE Food for Feed session is part of the “Food for Feed: An Innovative Process for Transforming Hotels’ Food Waste into Animal Feed”, LIFE+ Project Workshop. The LIFE-F4F project evaluates an innovative low-emission solar drying technology that allows the safe transformation of source-separated food waste into animal feed at pilot plant scale. The project is taking place in Crete, Greece, in the tourist areas of Heraklion. The session describes experience from within the Food4Feed Project but also success stories from Italy and Ethiopia.

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Effects of Dietary Dried Food Waste Addition to Broiler Diets on Growth Performance and Haematological Parameters

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Abstract

The increasing world population in combination with the improvement of living standards has caused a raising demand for poultry products. In recent years, high cost for poultry feeding has led to demand for an alternative source of energy for poultry feeds. Food waste can be an alternative feed ingredient. Heating process and dehydration set food waste a valuable feed for monogastric animals. The aim of the present study, was to investigate the effect of adding dried food waste collected from hotels to diets of meat type chickens (broilers). Two hundred (200), male, day-old, broilers were used in total. The duration of the experiment was 42 days. There were ten (10) replicate pens of two dietary treatments. Namely control (C), which was consisted of a basal diet based on corn and soybean and treatment (T) with an inclusion of 15% dried food waste. There were ten 10 broilers per pen and 100 per treatment. Both diets were isocaloric and isonitrogenous. Broilers were weighted at the end of each growing phase, in order to calculate body weight gain, feed intake and feed conversion ratio (FCR). The carcass and breast yield were determined. At the age of 38-41 days, a digestibility trial was conducted to determine energy and nutrient digestibility. Both groups performed well, despite that those fed the treatment diet had lower body weight and feed intake. FCR did not differ between two groups. Haematological and biochemical parameters were similar for the two treatments. Carcass yield did not differ between groups. Minor differences on colour traits and shear force were observed as far as meat quality. No differences in the digestibility of nutrients were observed for two treatments. The results of the present study indicate that dried hotel food waste may be an alternative ingredient to be incorporated to poultry diets and that future studies will determine the optimum inclusion level.

Keywords: food waste, broilers, growth performance, meat quality, digestibility

Acknowledgments: The research is funded by (LIFE 15 ENV/GR/0002057): “Food for Feed: An Innovative Process for Transforming Hotels’ Food Wastes into Animal Feed”.

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Performance and Meat Quality as Affected by the Dietary Inclusion of Food Waste in Fattening Pigs

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Abstract

Nowadays, the use of food waste as an alternative source of energy in animal diets has gained considerable attention, because of the increasing needs of human population and the high prices of conventional arable based animal feeds. The aim of the present study was to investigate the effect of adding dried food waste (DFW) collected from hotels to the diet of fattening pigs. Twenty (20) castrated male pigs were allotted into two (2) dietary treatments (n=10 pigs per treatment), namely control (C) and DFW, balanced for body weight (BW; 50.3± 2.54 kg). In treatment C, pigs were fed a corn-soybean meal based diet without DFW, whereas in treatment DFW, a diet containing 100 g DFW/kg. Both diets were isocaloric and isonitrogenous and were formulated with similar digestible lysine, methionine+cystine and threonine contents. Feed intake and body weight were recorded to calculate BW gain and feed conversion ratio (FCR). At the age of 144-147 days, a digestibility trial was conducted to determine energy and nutrient digestibility. At the end of the trial (156 days of age), pigs were sacrificed to investigate treatment effects on carcass dressing percentage, as well as on meat quality indices (pH, colour, cooking loss and shear force). Overall, pigs performed well with a final body weight of 98.57 and 94.23 kg for treatments C and DFW, respectively. Average daily feed intake tended (P= 0.058) to be lower and average daily gain was lower (P= 0.027) in DFR compared to C pigs; however, FCR was not affected by the treatment. No differences in the digestibility of energy and nutrients were observed between treatments. Cold carcass dressing percentage did not differ between treatments and reached the optimum commercial values (77.0 and 77.7 % in treatment C and DFW, respectively). Meat color traits were also not affected by the dietary treatment. In conclusion, the results indicate that the dietary addition of DFW did not affect the feed utilization and the quality of the produced meat; hence, the use of DFR in pig feeding can be supported.

Keywords: food waste, pigs, growth performance, meat quality, digestibility

Acknowledgments: The research is funded by (LIFE 15 ENV/GR/0002057): “Food for Feed: An Innovative Process for Transforming Hotels’ Food Wastes into Animal Feed”.

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Reintroduction of Fruit and Vegetable Waste in the Food Supply Chain: From Their Bioconversion to Earthworm Meal as Protein Source

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Abstract

Food waste affects the sustainability of the food supply chain leading to the squandering of economic, social, and environmental resources. Furthermore, food wasted ends its "life" with high nutritive elements. Among the food categories, a high portion of waste and loss is represented by fruit and vegetable. Earthworms have the ability to bio-convert fruit and vegetable waste (FVW) into products of high value: the vermicompost, a high-quality fertilizer, and the earthworms themselves. Indeed, earthworms grown up on a safe substrate may represent a valuable food or feed source, reintroducing in the food chain all the nutritional components wasted in the FVW. If earthworms will be reared for food purpose, they have to be considered as "farmed animals" and FVW is admitted in EU legislation for feeding livestock. If they are reared as feed sources, earthworms could be used as feed in poultry and fish diet as a source of protein, reducing the use of soybean and fish meal and the livestock production impact. In this study, the bioconversion process of FVW to produce the earthworm meal (EM) as food or feed source, has been evaluated considering: the nutritional value of the EM as food or feed source; the safety of EM as food or feed; the propensity and willingness towards earthworms as future food and the environmental sustainability of the EM production process. The results showed that earthworms reared on FVW are a valuable source of protein 62.3% DM (Dry Matter) and essential amino acids 22.45% DM (particularly in lysine, threonine, methionine+cysteine), vitamin B12 and niacin, iron and iodine; toxicological and microbiological evaluation showed the safety of EM; as food, EM will be more accepted if included in salty snacks; compared to other food or feed protein sources the environmental impact of EM was lower. Therefore, reintroducing FVW into the food supply chain to produce earthworms is an eco-sustainable and ethical solution, which offers a valid resource of animal proteins and can reduce the downsides of meat production, addressing the future need for food in a fast-growing population scenario.

Keywords: Fruit and vegetable waste, bioconversion, earthworm meal, food source, feed source

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The Potential of Some Underutilized Plants for Food and Nutrition Security in Benishangul-Gumuz Regional State of Ethiopia

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Abstract

In Ethiopia, particularly in the Benishangul-Gumuz region, there are numerous underutilized plants like figl (*Raphanus sativus*), girgir (*Eruca sativa*) and karkade (*Hibiscus sabdariffa*) which are cultivated and consumed only by the local communities. However, information on production practices, postharvest handling, and utilization trends of these plants is limited. Given this, production, handling and utilization trends of figl, girgir and karkade in Benshangul-Gumuz region of Ethiopia were assessed. A cross-sectional household survey was used to collect primary data from 274 producers and 30 users using a semi-structured questionnaire. The data were analyzed using SPSS (Version 20.0) software package. The results showed that, about 46% of farmers produce figl and girgir for food, medicine, and income generation. More than half (55%) of the farmers produce karkade for beverage and medicine. About 93% of the respondents showed that, edible parts of figl and girgir could attain commercial maturity within 15–35 days whereas, calyces of karkade takes 121–150 days (from 59% respondents). All the farmers (100%) consumed leaves and roots of figl and leaves of girgir as salads while 84.31% of them used dried calyces of karkade for beverage. About 94% of the farmers allocated less than 0.25 hectares of land for production of figl and girgir while 81% of them allocated this amount of land for production of karkade. The majority (80%) of the farmers are not getting extension service for production and 53% of them lament that there is no market linkage for the crops. Figl and girgir play significant roles in mitigating food insecurity because they mature in a short time, could be harvested soon; have high yield potential, and they have ability to grow in marginal soils. Karkade calyx extract has potential for use as a natural colorant for food industries. However, land allocation, extension support and market linkages are poor. Therefore, stakeholders at different levels should take part in increasing production, handling, utilization and commercialization opportunities of these plants.

Keywords: Figl (Raphanus sativus L), Girgir (Eruca sativa L), Karkade (Hibiscus sabdariffaL.), Karkade calyx, Postharvest handling

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The Effects of The Dietary Inclusion of Dried Food Residues on The Fecal Microbiota of Cats

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Abstract

Dried food residues (DFR) might be an interesting ingredient for petfood in the future, although their use is currently subject of legal restrictions. As a part of the project "Food for Feed", the current study aimed to investigate the effects of DFR on the fecal microbiota of cats. Seven adult cats were fed a complete diet with or without DFR (0, 5, 10 and 15 %). At the end of each three-week feeding period, fecal samples were collected. The fecal microbiota was analysed by 16S rDNA sequencing. A GLM repeated measures and calculation of polynomial contrasts was used for statistical data analysis (SPSS 22), with $\alpha < 0.05$ as the level of significance. Increasing amounts of DFR in the diets increased the alpha diversity of the fecal microbiota of the cats ($P < 0.05$). Additionally, an increase of the relative abundance of *Coriobacteriales*, *Collinsella*, *Lachnoclostridium*, *Libanicoccus* and *Romboutsia*, as well as of propionate and n-valerate concentrations in the feces of the cats was detected with increasing dietary inclusion levels of DFR ($P < 0.05$). The observed effects on the composition and metabolic activity of the fecal microbiota of the cats might be especially attributed to a microbial fermentation of undigestible carbohydrates as a part of the DFR. In order to prevent major effects on a balanced intestinal microbiota, which could negatively affect gut health, lower dietary inclusion levels of DFR (e.g., 5 %) can be recommended for diets for cats.

Keywords: dried food residues, microbiota, cats

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The Effects of Dried Food Residues in a Diet on the Apparent Nutrient Digestibility and Fecal Microbiota of Dogs

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Abstract

The project "Food for Feed" aims to evaluate dried food residues (DFR), derived from hotel catering, as a potential component for animal nutrition. As dogs often receive table scraps by their owners, this animal species might be an interesting recipient, although legal restrictions have to be taken into account. Ten adult dogs received a complete diet with or without DFR (0, 5, 10 and 15%). For the determination of the apparent nutrient digestibility, titanium dioxide was included in the diet. Each diet was fed for 3 weeks. At the end of the feeding periods, fecal samples were collected. The apparent crude fat and crude protein digestibility decreased, and the fecal acetate, propionate, butyrate and total short-chain fatty acid (SCFA) concentrations increased with increasing amounts of DFR in the diets ($P < 0.05$). In addition, an increase of the relative abundance of *Actinobacteria* and *Bacteroidetes*, and a decrease of the relative abundance of *Fusobacteria* in the feces of the dogs was observed with increasing dietary inclusion levels of DFR ($P < 0.05$). The DFR seemed to be intensively fermented by the intestinal microbiota of the dogs. Lower dietary inclusion levels of DFR (e.g., 5 %) might be recommended in order to prevent negative effects on the nutrient digestibility.

Keywords: dried food residues, digestibility, microbiota, dogs

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In Vitro Fermentation of Dried Food Residues Using Canine Fecal Inoculum

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Abstract

The project "Food for Feed" aims to investigate the potential use of dried food residues (DFR) for animal nutrition. Depending on the composition, DFR might provide varying amounts of fermentable substrates, which could be relevant for the metabolic activity of the intestinal microbiota. In the present study, an *in vitro* model (Vierbaum et al., 2019; slightly modified) was used for the microbial fermentation of DFR. Two different batches of DFR (batch 1: sterilized and non-sterilized DFR including meat (DFR_{ms}, DFR_{m}); batch 2: sterilized DFR without meat (DFR_{wms})) as well as different non-digestible carbohydrate sources (beet pulp, wheat bran, inulin, carrot pomace, brewer´s spent grains, cellulose and lignocellulose) were incubated with fresh dog feces for 24 hours, and the concentrations of microbial metabolites were measured afterwards. Except for inulin, cellulose and lignocellulose, all substrates were incubated as raw and enzymatically pre-treated substrates. Compared to the other substrates, the DFR were fermented to a similar or partly higher extent, as indicated by high concentrations of bacterial metabolites in the inoculum. In particular, the raw DFR were highly fermentable, although the effects were less pronounced for DFR_{wms}. When the pre-treated DFR were microbially fermented, effects were more clear for the DFR_{ms} and DFR_{wms}. Based on the results when incubating raw and enzymatically pre-treated food residues, DFR might contain both digestible and microbially fermentable substrates. For the potential future use as a component for petfood, collection and processing of food residues should be standardized in order to reduce variability in nutrient composition and effects on the intestinal microbiota.

Keywords: dried food residues, fermentation, dogs

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Acknowledgments: The study is funded by the project “Food for Feed” (LIFE15ENV/GR/000257) and the Hellenic Green Fund. We would like to thank Claudia Kipar for her support in laboratory

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Fruit and Vegetable Waste: Strategies for a Possible Reintroduction as Feed Ingredient

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Abstract

A large amount of lost and wasted food ends its “life” still containing many nutritional components, leading to the squandering of economic, social and environmental resources. Compared to the other food waste categories, fruit and vegetable waste (FVW) have a high wastage rate given by their highly perishable nature. The proposal to reallocate FVW into animal feed contribute to the sustainability of livestock production reducing the impact of feed production. Earthworms can bio-convert FVW into products of high value: the vermicompost, a high-quality fertilizer, and the earthworms themselves that as a high-protein nutrient can, in turn, be valued for animal and human nutrition. Indeed, earthworms grown up on a safe substrate may represent a valuable feed or food source, reintroducing in the food chain all the nutritional components wasted in the FVW. On the other hand, FVW is a good source of nutrients to become an efficient feed given directly to livestock. In this context, the aim of our studies was 1) to evaluate the possible use of the vegetable waste to earthworm rearing and 2) to evaluate the nutritional components of FVW during one year of sampling to reintroduced them directly in the food chain as a feed ingredient. The results showed that earthworms reared on FVW are a valuable source of essential amino acids, vitamin B12 and niacin, iron and iodine; the toxicological and microbiological evaluation showed the safety of earthworm meal and the low environmental impact to produce earthworm meal. The FVW if used directly as a feed ingredient for livestock showed on average across the year a DM (Dry Matter) content of 10.82 ± 1.21%. The neutral detergent fibre was on average 22.43 ± 4.52% DM. The results highlighted the presence of soluble sugars which were on average 30.51 ± 7.61% DM. Moreover, this waste did not show safety issues. Therefore, reintroducing FVW into the food supply chain to produce earthworms is an eco-sustainable solution, which offers a valid resource of animal proteins and can reduce the downsides of meat production. On the other hand, FVW is rich in nutrients that may be processed directly into animal feed ingredients. Since the waste of fruit and vegetable is constantly increasing, reallocating this waste to livestock feed also contributes to sustainable livestock production.

Keywords: Fruit Vegetable Waste, bioconversion, Earthworm, feed ingredient for livestock

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Characterisation and Quantification of Food Waste in the Greek Hospitality Sector

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Abstract

The management of food waste is a significant environmental problem. In Greece, approximately 2 million tonnes of food waste are generated each year, from which about 80% is generated by households, and the hospitality and food service sector, with 97% being disposed of in landfills. Food waste generation from commercial activities and services amounts to over 400 thousand tonnes annually. Hospitality and Food Service Sector food waste is just under 300 thousand tonnes and Wholesale and Retail food waste is just above 100 thousand tonnes. The intensified requirement for food waste diversion from landfill disposal and the current policy which requires its separate collection and treatment, necessitate an extensive accounting of food waste in order to acquire the relevant information regarding food waste management improvements. This study aims at presenting a methodology developed for conducting food waste compositional analysis with the use of a state-of-the-art Waste Analysis Campaign (WAC) methodology. Furthermore, the results of the compositional analysis of the hospitality sector's food waste in the intervention area of Heraklion and Hersonissos in the Region of Crete, Greece, are presented. The compositional analysis was executed using WACs. The waste collection and analysis campaigns (compositional analysis and microbiological investigation) took place between November 2017 and September 2018. During this period, food residues from four hotels in the area of Heraklion and Hersonissos in Crete were collected and the seasonal composition of the food residues was determined.

Keywords: food waste, foodservice, hospitality sector, compositional analysis, Greece

Acknowledgments: This work is partly co-funded by the European Commission through the LIFE+ project "Food for Feed: An Innovative Process for Transforming Hotels' Food Waste into Animal Feed – LIFE-F4F", (LIFE15 ENV/GR/000257), which was co-financed by the LIFE+ Programme of the European Commission.

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Microbiological Characterisation of Food Residuals Amended Animal Feed Using a Solar Drying Process

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Abstract

The study was implemented in the framework of the EU LIFE+ project “Food for Feed: An Innovative Process for Transforming Hotels’ Food Waste into Animal Feed – LIFE-F4F”. The project aims to evaluate, through the construction and operation of a pilot plant, a simple, innovative, and low-emission technology based on the solar drying process, that allows the safe transformation of source separated food residues, mainly from hotels (and generally from the hospitality and food service sectors), into animal feed. The study investigates the microbiological profile of food waste amended animal feed using the novel solar drying process, with significant potential benefits of diverting food waste for animal feed in Greece. The results of the microbiological analyses from the routine sampling of hotels’ food waste are presented. The food waste used in this study are the waste or residues generated by hotels in the general area of Heraklion and Hersonissos (Crete, Greece). This waste contained some impurities, such as paper and plastic, and manual separation was used for pre-treatment of the food waste. The food waste was mainly composed of post-consumer plate scrapings containing uneaten food, pre-consumer unserved food and kitchen trimmings. The raw waste was separated from the coarse contaminants, its particle size was reduced and the mixture was homogenized, before being thermally dried using a pilot solar drying system. Overall, the microbiological load of the collected raw food waste appears to be very low and the results are compared with similar findings to other studies. The absence of the pathogenic bacteria *Listeria monocytogenes* and *Salmonella spp.* should be emphasized, probably as a result of HACCP application in the participating hotels’ kitchen.

Keywords: food waste, animal feed, bacteria, concentration reduction, solar drying

Acknowledgments: This work is partly co-funded by the European Commission through the LIFE+ project “Food for Feed: An Innovative Process for Transforming Hotels’ Food Waste into Animal Feed – LIFE-F4F”, (LIFE15 ENV/GR/000257), which was co-financed by the LIFE+ Programme of the European Commission.

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The Environmental Impacts of Transforming Food Waste to Animal Feed via Solar Drying

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Abstract

It is estimated that 90 million tonnes of food waste is produced every year in the EU from all sectors of the food provision chain (180 kg /person). In order to address the management of food waste generated by the catering businesses, an EU-based partnership has been formed in order to implement the Life+ F4F (Food for Feed) project. The project mainly aims to evaluate, through a pilot-scale demonstration, an innovative and simple technology, and a low-emission process that enables the safe transformation of food waste, mainly from hotels into animal feed. The manuscript presents the environmental impacts of the entire process required to transform the separated food wastes into animal feed utilizing solar drying. The scope of the study includes the infrastructure and the operation of the pilot drying unit. More specifically: 1. Excavation works and construction of the presorting unit and the drying greenhouse; construction of an underground tank for wastewater collection in addition to the hydraulic and electrical infrastructure of the presorting and solar drying units. 2. Infrastructure of the drying greenhouse: metallic structure, polycarbonate greenhouse covers, a transfer belt, a pump for the transfer of the mashed material, a submerged pump for wastewater. Moreover, the solar collectors, the floor heating pipes needed for drying and two refrigerating units. 3. Operation of the presorting unit and the drying greenhouse: the electricity and water use required for the operation will be assessed. The results of the impact assessment indicate that the major environmental burdens of the solar drying unit are generated by the electricity required for the operation of the solar drying unit.

Keywords: Life cycle assessment, food waste, solar drying, animal feed, hospitality.

Acknowledgments: This study was financially supported by the EU-funded LIFE + F4F project.

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Microbiological and Chemical Composition of Animal Feed Produced from Cheese Whey and Vegetable Residues Following Thermal Drying Rate

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Abstract

The BEATLE project investigates the possibility of utilization of whey and green waste from supermarkets, in order to produce high added value products, such as feed and high quality compost. Within this survey, vegetable wastes were mixed with whey [30% (v/v)] and then were thermal dried in three different temperatures (35 °C, 45 °C and 55 °C). The product raised from this procedure was evaluated for specific microbiological parameters. For the microbiological analysis, the collected products were homogenized using suitable pre-enrichment substrates. The samples were tested for *E. coli*, *E. coli* O157:H7, *E. coli* STEC, *L. monocytogenes*, *Salmonella spp.*, *S. aureus*, total coliforms and Total mesophilic Count (TMC) following the corresponding ISO methodologies. The presence of metals (Fe, Cd, Pb, etc.) was tested by flame atomic absorption spectrometry; the amount of total aflatoxins and ochratoxins was determined by competitive ELISA; the concentrations of F- and of Hg were determined by UV-VIS spectrometer. A total of 39 samples were tested. As regards the effect of heat drying of the initial samples, it seems that for *L. monocytogenes*, *S. aureus* and *Salmonella spp*. the process results in the removal of these two pathogens from the final product. Increased counts of total coliforms were observed either in fresh products (before the drying process) or in vegetable residues mixed with whey which were dried at the lowest possible temperature (35 °C). The concentration values of heavy metals Pb and Cd were low (0.8-10.4 mg/kg and 0.01-0.03 mg/kg respectively) however, high values of mercury (3.8- 16.0 mg/kg) were observed. The amount of total ochratoxin and total aflatoxin were well below the permissible limits of the European legislation except for one sample. Drying temperature of the fresh products seems to play a crucial role since TMC was preserved at tolerable levels at 55 °C while drying at 45 °C increased TMC by 1-2 logarithms and drying at 35 °C resulted in a 4-5 logarithmic increase. No *L. monocytogenes* or *Salmonella spp.* were recorded at the final products. The concentration of heavy metals, ochratoxin and aflatoxin was not affected by any of the conditions of preservation and/or drying. The varied values are probably linked to the heterogeneity of the vegetable residues used for

the feed produce that depends at the time of collection.

Keywords: vegetable residues, thermal drying, animal feed, cheese whey

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Solar Drying of Food Waste as a Feed Production Process: Experience from the Three Operational Periods of the F4F Pilot Unit

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Abstract

International attention on the issue of food loss and waste is firmly reflected in the 2030 Agenda for Sustainable Development (FAO, 2019). It is often assumed that reducing food losses and waste will automatically help reduce world hunger and improve food security. The evidence today indicates that globally about one-third of the food produced is lost or wasted, along the food chain, from production to consumption (HLPE, 2014). Many countries are already taking actions to reduce food loss and waste, but the challenges ahead remain significant and we need to step up efforts. Within the LIFE-F4F project a pilot scale modified solar drying process provides an innovative, low-tech and low emissions method for safe transformation of source separated food waste into animal feed. The F4F project targets food waste sourced from the luxury hospitality industry units, applying strict quality assurance standards. The process involves an efficient food waste collection system and a processing unit consisting of a hand sorting conveyor belt, a shredding and pulverizing system and a solar drying greenhouse with two rotary turners, yielding a total nominal processing capacity of 1.5 t/day. An innovative solar drying procedure, supported with a heat pump and a subfloor heating system is used to dry food waste in a steady temperature of 55 ^{o}C. The initial moisture of the collected food waste is about 75 – 80% and the final moisture of the dried product is up to 12%. Three operational period have been concluded, from May till October, for the years 2018, 2019 and 2020. More than 500 tn of food waste have been collected, treated and solar dried, producing more than 100tn of a material used as a component in animal feed. About 4 days are needed for the drying of the food waste for months July and August and less than 10 days for months May and October. The produced material has been used in pets, pigs and broilers with promising preliminary results. Within the F4F project an ambitious prospect of utilization of food waste is initiated in the field of animal feed, always taking into account the limiting factors of the legislation. Is it time to incorporate source separation of food waste and utilization as part of an integrated MSW management scheme? Could any legal restriction be reconsidered?

Keywords: hotel food waste, solar drying, novel feeds, Crete

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Innovative and Operational Infrastructure for the Implementation of Research and Development Actions in Waste Management within the Circular Economy Framework

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Abstract

The development of a multidisciplinary infrastructure useful to research and development projects related with the management and utilization of solid waste and wastewater, is under development within the facilities of the Hellenic Mediterranean University's (HMU) Farm, named All4Waste. The All4Waste facility will be operated by the Hellenic Mediterranean University Property and Management Company and the main aim is to allow mainly (but not exclusively) private entities to implement their research and innovative activities related to municipal solid waste, agro-industrial waste and wastewater management, utilization and treatment in the framework of the Circular Economy. Within the development of this research and innovation park, any interested party will be able to have access for a respective fee, allowing it to utilise for example the All4Waste license to accept quantities of different residues and waste (see above), for the needs of the respective projects, since it will be able to provide the appropriate final management handling. The users will also have access to various treatment units of different dimensions and capacities such as experimental, bench size, pilot and demonstration, for all main processing technologies, such as composting, anaerobic digestion, solar drying, bio-transformation (in bio-reactors of different operating conditions) and gasification. The users will also have access to analytical equipment of high precision (with appropriate technical supervision) in order to contact their own analysis, or they will be able to assign them to specialized and experienced staff, as an alternative service. Finally, any action that will take place within this framework, will be implemented in the context of strong legal commitments on copyright and intellectual property rights and, of course, confidentiality of all supportive personnel. The common use of these facilities will reduce the expected cost of a research project between 25 to 35%, an important motivation for using All4Waste but also for investing in research and development by mainly SME. Another key feature of the All4Waste park, concerns the direct and continuous interaction between the users who wish to carry out research activities, as well as the staff and the students of HMU, which will host all these activities in its facilities. This interaction and coexistence under the same roof, is the only real way to develop synergies (including B2B services) and of course accelerate transition from research to innovation and to the market.

Keywords: waste management, circular economy, innovative technologies park

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LIFE Food-4-Feed: Context, Experience and Future Prospects

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Abstract

The F4F project was funded in the context of the European Union funding instrument LIFE, under the Environment sub-programme, and was implemented in a challenging period. This presentation will present a quick overview of the project's EU funding context, and from an external/observer's perspective - its implementation strengths and challenges, useful points for the relevant policy framework, and the project's future prospects.

Keywords: LIFE Food-4-Feed project

POL: Policy Perspective

Food waste is now mentioned in all major international policy frameworks: it is part of the Sustainable Development Goals and the new Farm to Fork Strategy within the European Green Deal. As food waste policies become more widely accepted, there is increased interest in policy tools to further the growth of waste diversion. Not all regions adopting such policies have the same characteristics and therefore, the degree of success differs. Our speakers today are among the innovators and early adopters of food waste policy. But innovators and early adopters often make mistakes, so identifying the strategies used to expand early adoption and avoid pitfalls is crucial.

The RETASTE Policy Perspective session is part of the A2UFood group of sessions. The A2UFood Project proposes a holistic approach to food waste management, ranging from social to technological aspects. Among other activities, A2UFood aims to upscale the innovations tested at Heraklion in Crete, Greece, to other Municipalities that face similar problems.

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Food Waste in Insular Communities in the Framework of Green Deal Strategy

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Abstract

The issue of food waste is of high importance in the efforts to fight hunger and raise income in the world's poorest countries. According to Food and Agriculture Organization of the United Nations, over 1/3 of all produced globally goes to waste (88 million tones in European Union). The annual value of food wasted globally is 1 trillion dollars and it weight 1.3 billion tones. Food waste is not only an ethical and economic issue but it also depletes the environment of limited natural resources. Food losses have an impact on food security for poor people, on food quality and safety, on economic development and on the environment. The 2030 Agenda for Sustainable Development highlight the increased global awareness of the problem. Furthermore, the Sustainable Development Goals set a target for halving per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains. Also, the new Green Deal European Strategy with the Farm to Fork Strategy will also contribute to achieving a circular economy. The main objective of this study is the qualitative and quantitative compositional analysis of the municipal solid waste, produced in the Sotira and Paralimni Municipalities located in the Eastern Region of Cyprus, the analysis of existing methods (door to door collection for recyclable materials, etc.), and to propose a new, more efficient and effective waste management plan. Through composition analysis, it is estimated that over 30% of the household’s food production ends up in the landfill; specifically 30.6% of food waste from Sotira Municipality and 34% from Paralimni Municipality. These amounts could have been avoided if proper food management had been implemented in every household. Also, the analysis highlighted the need to develop actions to divert food waste, as well as the development of awareness activities. Starting with prevention actions in households, household composting, implementation of the "pay as you throw" system and public awareness actions, are the main pillars of the proposed management plan.

Keywords: circular economy, municipal solid waste, green deal, sustainable development, solid waste management

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Introducing Pay as You Throw System and Autonomous Composting Units for Biowaste Management in Municipality of Probistip

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Abstract

Municipal Solid Waste management is still one of the major environmental challenges at national level, and although with national and regional waste plans in place. Republic of North Macedonia with its eight regions has only one regional landfill active, and at least 54 non-standard municipal landfills and hundreds dump sites and old landfills. And in the light of soon expected regional establishment of an integrated and self-sustainable waste management system in the eastern and north-eastern regions, in order to increase awareness by the local population and hospitality enterprises for source separation schemes of organic waste, as largest producers of organic waste, Goce Delcev & Hellenic Mediterranean Universities together with Municipality of Katerini, Municipality of Yermasoyia and Municipality of Probishtip, launched joint Project co-founded by EU, "Utilizing Pay as You Throw Systems and Autonomous Composting Units for Boiwastes Management in Touristic Areas". Annually, about 3300 t of MSW is generated in Municipality of Probishtip, with estimated 45.3% organic waste, all together disposed at a non-standard landfill just out of the city borders, and as soon as regional waste management system kick-in this should be changed, affecting current practice and costs. The Project includes transfer and application of innovative technologies Pay As You Throw - PAYT system and Autonomous Composting Units - ACUs for biowaste management in Municipalities of Katerini, Yermasoyia and Probishtip. PAYT system and ACUs as inovative technologies for biowaste management involves source separation schemes of organic waste in different bins (biowaste in 10 L bins and residual mixed waste in 80 L coded bins). Two ACUs with 60 t/year capacity have been installed and

commissioned, one for hospitality enterprises installed nearby City market and San Niko Hotel and the other one in Kalnishte urban area aimed to serves 80 households included in Project, for composting organic waste. For introducing "Pay As You Throw" system specially designed weighing equipment built into the one waste collection truck owned by PUC Nikola Karev and coded waste bins for hospitality enterprises and households have been supplied. Participants training, data collection and analytical procedure are currently ongoing and expected direct benefits including: reduction of waste quantities that are landfilled, reduction of transportation cost for PUC, reduction of charges for hospitality enterprises and households participating in separation scheme and reduction of environmental pollution caused by landfill gas emissions and leachate, as much as reaching the ambitious target of Waste Framework Directive (98/2008).

Keywords: PAYT, ACU, biowaste, source separation, environmental protection

Acknowledgments: Thanks to the Project "Utilizing Pay as You Throw Systems and Autonomous Composting Units for Biowastes Management in Touristic Areas"

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Autonomous Home Composting Units for Urban Areas in Greece: the case study of Municipality of Rhodes

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Abstract

The minimization of landfill deposition of waste containing biological components represents a big problem, especially in built-up residential areas. The need for source separation originates from the legal requirements of the European environmental legislation and specifically the Wastes Framework Directive (98/2008). Especially regarding organic waste, the target that the directive sets for 2030 is that of separate collection of 10 % of the organic wastes produced in each municipality. For Greece this target was further increased at 40 % of organic waste, through the new National Plan for Solid Wastes Management. This article presents the pilot experience of an integrated biowaste management system developed in Rhodes Island, Greece, which promotes source separation and urban composting in an autonomous composting unit (ACU). ACUs are small closed integrated composting units, with zeroing of effluent and expanding liquids. In Municipality of Rhodes five ACUs where installed in different areas. The types of wastes are used food and yard waste. The aim of this innovation is the development within the urban area of a system for the collection of produced biowaste and their treatment at the source, without, the creation of any nuisance. This system was introduced as a new-to-the-area of implementation and innovation, since landfilling of mixed municipal solid waste has been the common practice in Rhodes island, as in many other areas of insular and mainland Greece. The system was monitored on an input-output basis of critical parameters used to assess the purity of separately collected biowaste, the treatment efficiency of ACU, the quality of composts produced, and the public's awareness and participation. Results showed that biowaste source separation was practiced effectively by citizens, giving high-purity feed. The compost quality that produced by all ACUs has met the standard quality. Based quality of compost produced from all composters is suitable for use. This study demonstrated that ACUs are a sustainable system to adopt a closed unit approach to the biowaste management problem in urban areas, in line with the circular economy principles.

Keywords: Autonomous Composting, Units, Bio-waste, urban

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A Legal Approach to Food Waste: Critical Analysis of The European Union's Regulation on Food Waste

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Abstract

The European Union (EU) has been for years implementing strategies in relation to food losses and waste but only recently has adopted a legal act regulating this matter. As part of the First Circular Economy Action Plan, the Waste Framework Directive (WFD) was amended in 2018 to include, amongst others, a few but very significant regulations on food waste. The main novelties of the WFD in relation to food waste can be classified in two categories. On the one hand, the Directive foresees a new legal concept of "food waste," which is based on two preexisting concepts in EU law: "food," foreseen in the General Food Law Regulation, and "waste," foreseen in the same WFD. The construction of the concept of "food waste" may pose a number of challenges to the Member States and private operators. On the other hand, the Directive imposes a number of obligations on the Member States. Three types of obligations might be identified: (a) Member States are obliged to measure and account for the reduction of food waste; (b) Member States are also obliged to prevent food waste, following different strategies suggested by the legal text, such as donation, and by adopting prevention programs specifically addressed to tackle food waste; and (c) Member States are obliged to separately collect and recycle bio-waste, a concept that also includes certain types of food waste. The deadline to transpose the new provisions ran out on July 5, 2020, and some on December 31, 2023. My contribution to the RETASTE congress is aimed at presenting the European Union's new food waste regulations from a critical perspective, considering that currently Member States find themselves in the process of transposing the aforementioned food waste provisions from the WFD into their national legal systems. Furthermore, a new Circular Economy Action Plan is already on the table, along with the Farm to Fork Strategy, in which new horizons are set in relation to food waste within the brand new European Green Deal.

Keywords: Food Waste, Circular Economy, From Farm to Fork Strategy, European Green Deal

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CIRCULAR (Chain for Innovative ReCycling): a case study on the juridical complexity of circular economy in the food sector

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Abstract

Directive n. 2018/851/UE carried out a historic reform of the European discipline on waste management, "*with a view to protecting, preserving and improving the quality of the environment [and] protecting human health*". The key concept of the mentioned reform can be found is circular economy, intended as a re-conceptualization of our model of production and consumption based on waste reduction, innovative applications for disposable materials and the stimulation of cycles of bio-economy. Despite the clarity of the intents of the European strategy, its implementation in the Member States is being seriously hindered by an often vague or unclear normative, which overcomplicates the procedures and poses numerous issues of interpretation. In order to accompany an effective promotion of circular economy, it is therefore necessary to address and solve the systemic issues that characterize the implementation of the European policies, starting by concrete experimentations. In this light, an interdisciplinary team of research of the University of Milan has recently launched a project entitled CIRCULAR aiming at recycling sea urchin wastes originating from food industry and transform them into a feed supplement for animal farming. Since its beginning, the juridical research team focused on the aspects related to the regulations on (i) end of waste procedures; (ii) animal feed's standards and requirements. This contribution aims at discussing the first results of said research in the wider context of circular economy policies in the food sector. The study is of particular scientific interest as it constitutes one of the first academic experimentation on circular economy after the implementation of the Directive n. 851/2018. Therefore, its outcomes may be used to outline the main juridical issues facing procedures of waste valorisation and transformation in added-value products.

Keywords: circular economy, end of waste, food law, health, environment

W2E: Waste to Energy

Industrial development and increased energy demand have led to high consumption of fossil fuels with the consequences we all know today: environmental pollution and climate change. Circular bioeconomy is a promising approach to offset CO2 emissions. A large amount of agro-industrial and municipal residues are treated as waste today, but they can serve used as a renewable, and eco-friendly source of thermal and electrical energy, through biological or thermochemical conversion processes.

The RETASTE Waste to Energy session contributions discuss successful examples of food waste to energy conversion from Greece, Spain, Sweden but also Ethiopia and Malaysia and Guinea. We will be able to listen to most of them here; the rest you can always find in the poster session.

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Biochemical Methane Potential (BMP) of Quince Waste

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Abstract

Anaerobic digestion is a well-established technology combing the treatment of several wastes with the production of biogas. However, the finding of the most suitable co-substrates is still a major challenge in anaerobic digesters. Quince is a fruit which has a long history of cultivation in Mediterranean region and Western Asia. According to FAO, world production was almost 700,000 tones in 2017. In addition, quince market is expected to grow on a higher scale in the period 2020-2025. Due to astringent taste, it is used mainly cooked for the production of jams, marmalade or jellies. During this process, peel, seed and stem are separated and discarded as waste. From this point of view, the industrially produced quince wastes could be a very interest substrate for biogas production. In this work, we estimate for the first time the biochemical methane potential (BMP) of quince wastes. In addition, the BMP of banana peels was determined and compared with quince waste. The experiment was conducted at mesophilic conditions (37 ^{o}C) in 120-ml serum bottle reactors using an inoculum to substrate ratio of 1:2. Maximum biogas production, biogas production rate and lag phase were estimated using a modified Gompertz equation. Results shown that quince waste could produce almost double biogas volume (per volatile solids) in comparison with banana peels. Specifically, maximum biogas production was found 930±4 ml/g VS and 1584 ± 8 ml/g VS for banana peels and quince wastes, respectively. In addition, biogas production rate was found to be 105.6±2.6 mL/gVS/d for banana peels and 132.1±2.7 mL/gVS/d for quince waste. These preliminary findings indicate that exploitation of quince wastes in anaerobic digesters could be a very attractive option.

Keywords: methane, biogas, fruit waste, anaerobic digestion

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Hydrothermal Liquefaction of Mixed Food and Plastic Waste From Supermarkets

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Abstract

Every year in Sweden, more than 70 000 tonnes of expired food with the packaging from the supermarkets are discarded without passing through proper sorting (Food waste volumes in Sweden Reports). Separating plastic packaging and food waste from retailers requires a lot of effort, is time consuming and thus costly. Therefore, in most of the cases the waste is not separated and plastic packaging together with the expired food ends up on the same waste fraction. The hydrothermal liquefaction (HTL) is a promising technology that can be applied into such heterogeneous waste fractions. This mild temperature thermal treatment process can be used for treating food waste together with the plastic packaging without sorting. The proposed recycling route of HTL is aiming to introduce a new alternative recycling towards the concept of circular economy. Thermochemical processes are the foundation for recirculation of secondary raw materials, decomposes organic matter into lower molecular weight compounds. The products of HTL are hydrocarbon rich bio-oil that can be used for production of secondary raw materials and combustible gas that can supply the process with the energy needs. The Hydrothermal Liquification (HTL) has been tested for several applications in the past with positive results. The main advantage of this process is that it can tolerate high moisture content of the feedstock, so no time and energy consuming drying of the feedstock prior to the process is needed (Dimitriadis and Bezergianni, 2017). In the case of mixed food waste with plastic packaging, the moisture content of the waste fraction is expected to be high, which makes HTL an attractive option. Another advantage is rather low temperature of the process, which results in lower energy consumption compared to other thermochemical processes. Using these processes, the part of waste that goes to energy recovery can be minimised, leading to lower CO_2 emissions. The plastics PS, PP, PC and PET were experimentally investigated, since they constitute the most common plastics in waste from the supermarkets. Results indicate that the PC plastic can be recovered with high efficiency as its monomer, bisphenol (93% yield), while the experiments conducted on the mixture of plastics generates compounds that are difficult to purify. The food materials introduced on the simulated waste fraction were according to the data acquired from the nutrient label for every product was thrown away during this researcher was conducted. The compounds generated from food could be used mostly for energy recovery since their applications even if purified are limited.

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Keywords: Hydrothermal liquification, HTL, supermarkets waste, food waste, feedstock recycling

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Anaerobic Co-digestion of Coffee Wastes with Other Organic Substrates: A Mixture Experimental Design

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Abstract

This study investigated the viability of the anaerobic co-digestion of coffee wastes (CFW) with other organic wastes (cow manure-CM, food wastes - FW, anaerobic sludge - AS), to determine the biogas production, derived from coffee residues. Four different mixtures were tested anaerobically at 37 °C using 1 L reaction vessels that were filled with each co-substrate and 150mL of a liquid mixture of nutrients. Anaerobic sludge was used in some mixtures as an inoculum. The biogas was collected using a syringe of 60mL volume and carbon dioxide was absorbed by an alkaline solution. The co-digestion of coffee wastes with anaerobic sludge appeared to have a positive effect on biogas production. On the other hand, the co-digestion of coffee wastes with cow manure and coffee wastes with food wastes, had a negative effect. The results were analyzed using two statistical models for experiments with mixtures. Model [1] calculated the effects of co-digestion among coffee wastes, anaerobic sludge and cow manure. Model [2] evaluated the effect of co-digestion of coffee wastes with food wastes. The results were represented using the equations listed below: Biogas = 179 AS - 99 CFW + 144 CM + 482 AS CFW (1) Biogas = 7.0 FW (2) Biogas: mL/g VS of mixture The positive coefficients reveal the positive interactions between the substrates in the mixture. The negative coefficient of the term coffee wastes in Eq. 1 indicates that coffee waste inhibits biogas production when present in a mixture, due to the presence of toxic substances. By co-digesting coffee wastes with anaerobic sludge a substantial amount of biogas is produced by the CFW. On the contrary, the co-digestion of coffee wastes with food wastes revealed that coffee waste does not contribute to the total biogas generation and only food waste actually generated biogas.

Keywords: Anaerobic co-digestion, coffee wastes, organic wastes, biogas production

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Assessing the Effects of Spent Coffee Grounds on Dry Anaerobic Digestion of Kitchen Waste

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Abstract

The consumption of coffee around the world is increasing and it poses a problem about the proper management of the spent coffee grounds. At the moment, this solid residue is disposed of at landfills or incinerators. Because of its large amounts of organic matter it can be processed by biological procedures. Anaerobic digestion can convert organic matter into biogas, rich in methane, which can be used to produce renewable energy. However, mono-digestion of spent coffee grounds has been proved to be unstable in long term conditions. At the current study, mesophilic (35 °C) dry anaerobic co-digestion of kitchen waste and spent coffee grounds was performed in flasks. The inoculum to substrate (I:S) ratios which were used were 1:1 and 3:1 in respect to VS. Feedstocks were mixed at different percentages such as 100:0 (T10), 90:10 (T9), 80:20 (T8) and 70:30 (T7) kitchen waste to spent coffee grounds according VS. Tests were made in batch mode in order to determine specific methane potential, mass and VS reduction and acclimatization of the inoculum to these specific substrates. The I:S ratio 1:1 inhibited the procedure by decreasing pH at 6 to all flasks. The new run with I:S ratio 3:1 was evolved normally. The pH at the end was between 8.1 – 8.2. Specific methane production rate for T10, T9, T8 and T7 was 47.2; 42.8; 47.6 and 41.8 ml CH_4/g VS/d respectively. Mass and VS reduction was 28.2; 29.4; 31.3; 32.7% and 38.2; 35.8; 37.3; 40.9% for T10, T9, T8 and T7 respectively.

Keywords: dry anaerobic digestion, spent coffee grounds, kitchen waste

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Conversion of Used Cooking Oil Into Biofuel as Alternative and Renewable Energy

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Abstract

Food supply services such as restaurants, hotels, households use a large amount of oil for frying. After use, the cooking oil constitutes a waste whose management become an environmental issue. Huge quantities of used cooking oil are poured into the environment and contaminate water resources with severe consequences. There is a growing interest in its use in producing renewable energy to achieve potential benefits. Used cooking oil can be processed into biodiesel, an alternative to fossil oil. In fact the continuous depletion of fossil fuel and petroleum products, their limited resources and environment concerns are a matter of concern (Kumar and Sharma, 2008). This tendency in energy sector represents a challenge as well as an opportunity to look for alternatives of fossil fuels for sustainable development and environmental benefits (Bozbas, 2008). Used cooking peanuts oil was collected from hotels, restaurants and several food sellers in Conakry, the capital City of Guinea. Used cooking oil samples were settled during a week at ambient temperature and filtered by sieves of hole size 100 nm to remove suspended solid particles and other inorganic residues. Beside free fatty acids, used cooking oil contains water which leads to the formation of soaps. Pre-treatment of waste cooking oil is necessary in order to prevent soap formation. In order to remove the water content and prevent saponification, the oil, samples were heated at a temperature of 110 °C during 3 hours. After cooling the oil was subjected to transesterification process in methanol using NaOH pellets as catalyst. Gas Chromatography and Mass Spectroscopy were used to determine the physicochemical properties and the fatty acid composition of the resulting product. The values are in the limits of AST and EN standard.

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Keywords: waste oil, energy, biofuel

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Assessment of Tomato Peels Suitable for Producing Biomethane Within the Context of Circular Economy: A GIS-Based Model Analysis

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Abstract

There is a general consensus that global warming is due to the anthropogenic emission of greenhouse gases. Renewable resources will play a crucial role in the current CO_2-mitigation policy. The biomass is seen as one of the most dominant future renewable energy sources. In detail, agro-industrial by-products represent a cheap, renewable, and abundant feedstock useful for several new products, including biochemical, biomaterials, and above all biogas that in Italy is taking on an ever-increasing role. In this context, the tomato chain was analysed, by detailing the transformation process with the aim to estimate the amount of processed tomato and the related waste production (tomato peels) as new suitable resource for producing biofuel (biomethane) as new frontier within the context of circular economy. Due both the importance of tomato industry in Sicily and given the uncertainty of data relating to waste quantities, this research aims at filling the gap in the knowledge of the production and yield of these by-products useful as biomasses for energy uses. This aim is relevant to plan the sustainable development of biomethane sector by reducing both soil consumption for dedicated energy crops and GHG emissions derived from biomasses logistic supply. Furthermore, if considered as waste, tomato peels produce a negative impact on the sustainability of all the food-chain industry, since their disposal represents one main issue in terms of environmental and economic impact. A GIS-based model was developed through QGIS software. Firstly, all the Sicilian tomato processing industries (eight) were localised in a GIS map then, detailed interviews were recorded, in order to quantify the amount of tomato processed and the related waste produced. Detailed GIS analyses were performed by showing three Sicilian areas highly characterised by this kind of biomass. Yearly about 1 million of Nm^3 of biomethane could be produced if all tomato peels were used for anaerobic digestion. This strategy implies a shift from "cradle to grave" to "cradle to cradle" waste management with an increasing decrease in waste generation through the use of new business models. Therefore, it would be desirable that future policies of development of biomethane sector will take into account both the availability and distribution of these suitable biomasses within the territory.

Keywords: tomato peels, biomethane, GIS, circular economy, bioresource policy.

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Quantifying the Future Energy and Nutrient Recovery Potential of the Organic Fraction of Municipal Solid Waste

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Abstract

Anaerobic digestion (AD) arises as the most promising strategy to enhance the recovery of resources from the organic fraction of municipal solid waste (OFMSW). Understanding the future availability and characteristics of the OFMSW is therefore paramount to establish the role of AD in waste management plants. In this study we applied Material Flow Analysis to systematically quantify the mass availability and energy recovery potential of the OFMSW by 2030. The assessment focussed on Madrid, Spain, and the main assumption was that the rate of separate collection of the OFMSW can reach 70% by 2030. Based on this premise, we developed a range of scenarios for the year 2030, including alternative evolutions of food waste generation. The energy recovery potential was quantified by the biochemical methane potential (BMP), while the nutrient recovery potential was quantified by the mass of nitrogen, phosphorus, and potassium contained in the OFMSW. In 2017 (reference year), only 2,122 t/year of OFMSW was collected separately in Madrid and about 458,000 t/year was separated from the residual waste at centralised facilities (the so-called residual organic waste). Under the scenarios 2030 defined in this study, the mass of organic waste collected separately increases up to 154,000 - 343,000 t/year, while the mass of residual organic waste drops to 213,000 - 319,000 t/year. The BMP reached $53 \cdot 10^6$ m^3 methane/year in 2017, while by 2030 the BMP ranges from $30 \cdot 10^6$ to $68 \cdot 10^6$ m^3 methane/year. This large variation is mainly caused by the evolution of food waste generation. The lowest BMP is achieved under a scenario that assumes halving per capita food waste generation by 2030 as fixed by the United Nations. The highest BMP is achieved under a scenario that assumes an increase in food waste generation proportional to the GDP. On the other hand, the nutrient recovery potential generally increases accross all the 2030 scenarios compared to 2017. For example, the phosphorus recovery potential ranges from 0.92 to 1.16 kt/year under the scenarios 2030, which is substantially higher than the 0.68 kt/year achieved in 2017. Overall, the results show that the future energy and nutrient recovery potential of the OFMS strongly depends on the evolution of food waste generation. However, while the energy recovery potential may decrease in the future, the nutrient recovery potential is likely to increase driven by the improvement of separation collection rates.

Keywords: energy recovery, nutrient circularity, material flow analysis, future scenarios

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Waste-To-Fuel: Life Cycle Assessment of Hydrothermal Liquefaction of Household Food Waste

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Abstract

The goal of this study is to evaluate the life cycle environmental impacts associated with the hydrothermal liquefaction (HTL) of households' food waste to produce diesel and gasoline. The functional unit was defined as *the treatment of 1,000 kg (wet basis) food waste provided by households (including impurities)*. The system boundary encompasses the following stages: (I) pre-treatment and sorting of the input waste, (II) HTL treatment, (III) bio-oil upgrading and refining to diesel and gasoline, (IV) landfilling of the solid fraction, and (V) incineration of the pre-treatment rejects. In order to evaluate the potential benefits of the Waste-to-Fuel solution, the HTL system was credited for the avoided environmental burdens due to the substitution of fossil diesel and gasoline. The main source of data to develop the life cycle inventory was the simulation of the process in Aspen Plus. The life cycle environmental impact assessment was performed with the ReCiPe hierarchical method. The results reveal a positive impact (i.e. produced burdens higher than avoided burdens) for all categories but fossil resources. This means that the credits assigned to the HTL due to the production of diesel and gasoline counterbalance the fossil resources consumed by the system. Direct emissions from HTL are the main contributor to the impact on terrestrial acidification (94%), particulate matter formation (85%), and photochemical ozone formation (41%). The incineration of the rejects has the highest contribution to the impact on climate change (53%), freshwater eutrophication (66%), and human toxicity (90%). We found that as high as 36% of the input waste is rejected due to the contamination of the food waste with non-biodegradable materials. The life cycle climate change impact of HTL was compared against anaerobic digestion (AD) with biomethane upgrading. If excluding the incineration of rejects (same for both systems), the results show that HTL (1.77 kg CO_2 eq/t food waste) offers climate benefits compared to AD (57.14 kg CO_2 eq/t food waste). The higher climate change impact of AD is mainly due to the leakage of methane, which does not occur when using HTL. Furthermore, the environmental credits due to the substitution of fossil diesel and gasoline are considerably larger than the credits due to the substitution of natural gas with biomethane.

Keywords: food waste, hydrothermal liquefaction, life cycle assessment, food waste management

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Developing Dry Anaerobic Bioreactors Aiming in Optimum Utilization of Mediterranean Agro-waste for Energy Production

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Abstract

Research regarding the use of lignocellulosic materials as substrates for anaerobic digestion (AD) has been increasing in the last years with agricultural and agroindustrial waste representing a viable and low cost option, due to their high production rates and availability. Utilization of this waste biomass as a renewable feedstock to produce energy and valuable products will not only improve the sustainability of agricultural and forestry systems, but also reduce dependency on fossil fuels and minimize greenhouse gas emissions. Dry digestion is a suitable technology for treating organic wastes with high total solids content and compared with conventional wet AD will enhance digestion and reduce liquid digestate generation. Dry anaerobic digestion was not so popular due to lack of adequate knowledge and operational complexity. The first aim of DRYGAS Project is to determine the optimum inoculum to substrate ratio and operational conditions (temperature, moisture, Hydraulic Retention Time) in batch dry anaerobic digestion that will allow the maximization of the efficiency of the system, and therefore lead to the development / optimization of dry anaerobic digestion as a technology of energy utilization of the Mediterranean Agro-waste. A second step of DRYGAS Project will be to identify all the parameters in order to develop a dry anaerobic bioreactor (Solid State Anaerobic Bioreactor), which will be able to manage in an automated and optimal way, all the Mediterranean Agro-waste and produce the maximum possible volume and optimal biogas composition. The final outcome of DRYGAS will be the development of two basic types of dry anaerobic reactors (batch mode), with the maximum possible degree of automated operation through the design, synthesis, testing and improvement of different electromechanical structures. Key technical questions that will be answered through the project are how to safely remove biogas, how to heat bioreactors, the material and design of structures inside them, and the operation of sensors and data transfer. The expected results from the DRYGAS implementation is an optimum management especially for the residues produced in the Mediterranean basin, and a technological step, which will allow the transfer of knowledge from the laboratory to the field, allowing the commercial development of dry anaerobic digestion.

Keywords: Solid anaerobic digestion, biogas, Mediterranean Agro-wastes

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Biofuels from Hydrothermal Liquefaction of Food Waste: The Impact of Feedstock Composition on Process Economics

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Abstract

Energy recovery from wet wastes via Hydrothermal Treatments (HTs) is an emerging alternative to traditional conversion and nutrient recycling by Anaerobic Digestion (AD). In particular, Hydrothermal Liquefaction (HTL) seeks the production of a bio-oil that can be further upgraded to transportation biofuels. Together with bio-oil, an aqueous phase, rich in soluble organics, a solid (hydrochar) and gas (mostly CO_2) are generated. Experimental results show the relative yields of these products are sensitive to the operating conditions of the HTL reaction (Tzanetis et al., 2017) and the composition of the input feedstock (Li et al., 2021). Consequently, such variations are expected to have a non-negligible impact on the economics of the overall waste-to-fuel process. In this work, we intend to show the impact of Food Waste (FW) composition on the estimated Minimum Fuel Selling Price (MFSP) of renewable gasoline and diesel produced via HTL. The assessment is based on a process simulation model built on Aspen Plus® V10, which further integrates an AD stage of the aqueous phase. The production of biogas is conceptualised to diminish the external purchase of natural gas, utilised in the plant to produce hydrogen (required in bio-oil upgrading) and to fulfil the internal energy demand, which is reported to be the most significant contribution to variable costs in this kind of facilities. We are assessing different combinations of FWs described in the literature, with different contents in lipids (13-35 w%, daf) and proteins (13-25 w%, daf), the most influential parameters on the bio-oil/aqueous yield ratio, so we can elucidate the optimal ratio in economic terms. Our preliminary results indicate the bio-oil yield varies 45-52%, while the aqueous phase is between 22-26%. Our initial estimations for a high-protein, low-lipid feedstock have shown a calculated MFSP of 0.036 € MJ^{-1} produced fuel.

Keywords: food waste, hydrothermal liquefaction, process simulation, techno-economic assessment

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Utilization of Olive Mill Wastewater with Domestic Wastewater for the Production of Biogas and Microalgal Biomass

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Abstract

Despite the large number of technologies proposed for the treatment and utilization of olive mill wastewater (OMW), its management is still a major problem in olive oil producing regions. This works examines the application of two different processes for OMW treatment and utilization: a) anaerobic co-digestion of OMW with domestic wastewater and use of anaerobic digestate for microalgae cultivation and b) microalgae cultivation of OMW diluted with domestic wastewater and use of microalgal biomass for biogas production. For the first scenario, a 1L-anaerobic reactor was operated continuously in a draw-and-fill mode for a period of almost 100 days using as a feedstock a mixture of OMW with domestic wastewater at a ratio of 1:1. The effluent of the anaerobic digester was used for the cultivation of microalgae *Clorella sorokinana* in an automated flat-plate gas-lift photobioreactor (Labfors 5, Infors HT) with a working volume of 1.8 L. The anaerobic digestate was diluted with domestic wastewater at a ratio of 1:10 prior to use. For the second scenario, a mixture of raw OMW diluted with domestic wastewater at the same ratio (1:10) was used for the cultivation of *Clorella sorokinana.* The produced microalgal biomass was used for the determination of its biochemical methane potential (BMP). Results shown that COD reduction in the anaerobic digester was about 75% while the biogas production was about 250 ml/L reactor/d. In addition, total phenols reduced at about 60% during anaerobic digestion. The optical density and the suspended solids in the photobioreactor after 5 days of cultivation was increased from 0.25 and 0.1 g/L to 0.75 and 0.7 g/L, respectively. For the second scenario, the COD as well as total phenols reduction in the photobioreactor was about 60%. However, reduced optical density and suspended solids was observed at the end of experiment. In addition, BMP test shown that the biogas produced from microalgal biomass was not significant in comparison with raw OMW. In conclusion, the use of anaerobic digestion as a first step and the subsequent use of anaerobic digestate for microalgae cultivation seems more efficient for biogas and microalgal biomass production.

Keywords: anaerobic digestion, biogas, photobioreactor, microalgae, wastewater treatment

Acknowledgments: This work was conducted during the implementation of the project “Aegean AgroWaste Lab – Research Infrastructure for treatment and valorization of by-products and residues of agrowaste sector to produce alternative products and energy» (MIS 5021552) co-funded by the European Regional Development Fund (ERDF) and the Operational Program “North

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Solar Drying Method as a Pre-Treatment: Investigation of Biogas Production with Solar Dried Mixtures of Agricultural and Organic Residues

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Abstract

Biogas production through anaerobic digestion is a well-established practice combing waste treatment with energy production. Among European countries, Germany is the largest producer of biogas, while on the other hand, Greece is near the end of the list. Although in 2010, the Greek state pledged to produce 350 MW of energy from biogas and biomass until 2020, by 2018 only 18.7% of this target had been achieved. The reason for this slow development in Greece compared to other European countries is the lack of an efficient and reliable supply chain of agricultural and organic residues. More specifically, Greek agro-industrial units that produce waste with added energy value are spatially scattered, which increases the cost of collection, transportation, and storage, thus rendering the viability of waste to energy conversion difficult. To overcome the high cost of logistics, some studies recommend biomass densification (Wang, et al., 2016). In this context, solar drying can be an attractive technology for volume reduction. To assess the potential of solar drying as pretreatment for waste towards anaerobic digestion, a pilot greenhouse was constructed by the SOLARGAS project in Peza Union, Crete, Greece, and tests with various substrates are conducted. Here we investigate four different mixtures of food waste (FW), olive mill wastewater (OMW), cheese whey (CW), vegetables residues (VR), liquid pig manure (LPM), and cow manure (CM). Different combinations of this waste were created at a mixing ratio of 1:1 (v/v). For each mixture, solar drying was used to reach a final moisture of 10%.. The biochemical methane potential of these substrates was measured before and after pretreatment by solar drying.

Keywords: Anaerobic digestion, solar drying, biogas, agro-industrial waste, organic residues

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A Holistic Approach for the Treatment of Agro-Industrial Wastewater and Food Waste by Combining Anaerobic-Aerobic Sequential System and Photocatalysis

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Abstract

Co-treatment of agroindustrial wastewater via anaerobic digestion is an effective process for the exploitation of high organic content materials. On the other hand, there is a potential risk of emerging pollutants and pathogenic bacteria that may be present in the digestate. Heterogeneous photocatalysis has been noted as a very efficient technology for removing organic pollutants and much research has been applied to the use of the semiconductor TiO_2 due to its high efficiency and low cost. The main purpose of this work was to study the treatment of agroindustrial wastewater presenting a holistic approach. In order to achieve this, a three-stage process was applied, consisting of anaerobic digestion, aerobic treatment and photocatalysis. For anaerobic digestion a CSTR was used, which was followed by a SBR that was operated under aerobic and anoxic conditions on a 24hr cycle with 5 days HRT. The effluent of SBR was treated with TiO_2 P25 photocatalyst in the final stage in which the effect of several parameters that affect the photocatalytic rates were evaluated, such as UV irradiation, addition of H_2O_2 and concentration of TiO_2. The feed mixture that was used in the process, was consisted of liquid pig manure (LPM), cheese whey (CW) and dried kitchen waste (DKW). Three different scenarios were examined depending on the operational conditions (HRT, temperature) of the anaerobic digester and the concentration of the DKW. The digester was continuously fed with an influent composed (v/v) of 75% LPM and 25% of CW in which two different concentrations of DKW were added (10g/L and 30g/L) for each case study. Several parameters were monitored through each process. The average removal in the AD process for the 1st scenario (30 days HRT, 35 ^{0}C, 10 g/L DKW) of total COD was 60.7%, 72.5% for the 2nd (40 days HRT, 40 ^{0}C, 10 g/L DKW) and 85.6% for the 3rd (40 days HRT, 40 ^{0}C, 30 g/L DKW). In order to evaluate the SBR performance, total COD and nitrogen removal were monitored for the 3 case studies, which resulted to 57.3 %, 28.8%, 19.4% (COD) and 38.0%, 29.2%, 22,1% (TN) respectively. The photocatalytic treatment of the SBR effluent was monitored by UV-Vis analysis before and after 3 hr irradiation, at two wavelengths, 270 nm corresponding to the aromatic groups and 465 nm for the visible-light absorbing chromophore groups. When TiO_2 P25 was employed, high reduction rates were observed for the three effluents after 3 hr of irradiation, i.e. 18.3%, 23.9%, 17.0% for the aromatic and 31.2%, 37.9%, 17.5% for the chromophore groups respectively. Moreover, the addition of 25mM H_2O_2 as an oxidizing agent in the reaction

medium had a beneficial effect on the removal of both aromatic and chromophore groups (37.9%, 46.0%, 37.6% aromatic and 73.3%, 75.5%, 39.9% chromophore).

Keywords: Agroindustrial wastewaters, catalysis, anaerobic digestion, TiO2, treatment, toxicity

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FWS: Food Waste as Soil Amendment

Though no longer appealing to humans, food waste is a rich nutrient source for microbial growth. The transformation of food waste to soil amendment goes hand in hand with organic farming practices and leads to higher biomass and diversity, below and above ground. Such practices are crucial to the establishment of a diverse and sustainable farming system that can safely feed our world.

The RETASTE Food Waste as Soil Amendment session discusses significant efforts towards this direction from around the world, includign Europe, the United States and Japan.

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Closing the loop: Industrial Food and Agriculture Waste Valorization, the Case of Biosolarization

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Abstract

Global society faces a challenging task -- feeding a population of nine billion without irreversibly harming the environment. In order to overcome this hurdle, more sustainable agricultural practices are needed. To achieve sustainable agriculture, one needs to have measures that are both environmentally friendly and efficient. In our study, we developed a bioreactor system that can simulate the sustainable soil disinfestation process of biosolarization. Biosolarization uses the solar heat in conjunction with soil microbial community to treat the soil against weeds and pathogens. We were able to use the system to distinguish between major Californian agriculture and food industry waste streams including tomato paste and wine processing waste. Our findings suggest that tomato pomace (the residues of tomato processing food industry), grape pomace (residues of wine making industry) and fish meet waste (from canteens) can be used as a soil amendment for biosolarization. With the tomato pomace and grape pomace we observed soil temperature changes due to the microbial activity of over 2 ºC across 4 days in a well aerated system. We also observed in tomato pomace acidification that changed the pH from 6.5 to 4.68 under anaerobic conditions. Such heat and acidification are sufficient to inactivate undesirable weeds and other pest when incorporating the tomato waste into the soil. White wine grape pomace amendment showed similar trends but to a lesser extent. Red wine grape pomace was generally less suitable for biosolarization due to significantly lower soil temperature elevations, reduced acidification relative to the other pomaces and induction of methanogenesis in the soil. The fish waste residues also shown to have a promising weeds inactivation results in a greenhouse studies. This novel system can help reduce high-cost field trials and can be use to examine a variety of potential soil amendments, such as straw and green waste and more. This can help create a beneficial cycle that utilizes food processing and agricultural waste biomass back into agricultural production of food and can play a fundamental role in the future of food security.

Keywords: Biosolarization, food waste, next generation sequencing, sustainable agriculture,

volatile fatty acids

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Suppressive Effect of Plant Diseases Using Coffee Grounds

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Abstract

Strawberry fusarium wilt is a disease caused by *Fusarium oxysporum* f.sp. *fragariae* (*F*) and is mentioned as one of the most difficult diseases to control. In soil diseases, chemical control is the most trustable method of disease control in general. Biological agent impacts little on the environment and almost no occurrence of resistant bacteria. Fenton reaction generated hydroxyl radicals, which have high oxidation effect. Therefore, it can use for disinfection and degradation. The purpose of this study is to develop an environmentally friendly biological control technology for soil-borne disease caused by *F*, using coffee grounds as a composting material for the Fenton reaction. Approximately ten million tons of coffee are produced annually in more than fifty countries. Although part of coffee grounds is recycled as compost and animal feed, most of coffee grounds are burned as wastes. In addition, caffeine, tannins, and polyphenols present in coffee materials inhibit plant growth. Regarding the use of coffee grounds as a soil amendment, unlike other food waste, which have a uniform shape and excellent permeability, and are hygienic because they are extracted with hot water. Recently, C. K. Morikawa (2018) showed an Fe-coffee polyphenol catalyst (CGFe) played an important role as in the generation of hydroxyl radicals. And it could control the soil-borne disease caused by *Ralstonia solanacearum*.. In this paper, as verification methods, decomposition test of methylene blue, as an index of harmful substances, confrontation culture test using coffee grounds materials, and *F* microconidia germination test in first fermented coffee grounds (FC) and Fe-composted coffee polyphenol catalyst (FCFe) soil and germination inhibitor were investigated. Decomposition test of methylene blue revealed that the Fenton reaction occurred regardless of the component change due to CGFe and FCFe. Confrontation culture test showed that various coffee grounds materials (Coffee grounds, FC, CGFe, FCFe) had a pathogen-suppressing effect on *F*. The *F* microconidia germination test was suggested that FC and FCFe had germination inhibitory ability and bacteriostatic action on *F*, and it was speculated that the germination inhibitor was derived from a water-soluble component or a microorganism.

Keywords: coffee grounds, biological agent, confrontation culture, Fusarium

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Application of Fermented Spent Coffee Ground (SCG) With Inorganic Fertilizers in the Tea Fields and its Effects on the Nitrate Loading, Free Amino Acids and Cation Exchange Capacity

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Abstract

Nitrogen(N) fertilizers are accounted for the tea leave quality. Intensive N fertilizer application rates are being carried out in major tea cultivating areas to increase the tea quality. As a result, N leaching and contamination are developing as critical environmental issues. On the other hand, spent coffee grounds (SCG) is the waste/byproduct gathered after coffee consumption from factories that manufacture ready-to-drink coffee and disposed of after the brewing process. This study focuses on finding the combined effect of SCG with conventional fertilization on NO_3-N loading, cation exchange capacity, tea yield, tea quality, and other standard water quality parameters. The incorporation of fermented SCG into the tea cultivation field undoubtedly impacted the NO_3-N leaching. Two-fold SCG application showed a significant reduction in NO_3-N leaching. Two-fold SCG application to the tea field showed inhibitory/ slower nitrification rates. At the same time, one-fold application rates showed stimulatory nitrification rates. Secondly, SCG also seems to impact the water holding capacity (WHC) of soil. Two-fold application revealed significantly increased WHC, electrical conductivity (EC), and cation exchange capacity (CEC) compared to other treatments. When considering the amount of free amino acid, one indicator for tea quality, conventional fertilization, showed the least quality tea. Moreover, all the treatments with SCG incorporation showed higher amounts of free amino acids. Similarly, all the treatments incorporated with SCG showed increased tea yield except conventional only fertilization. These results suggest that the incorporation of SCG into conventional fertilization will benefit the environmental and economic terms.

Keywords: spent coffee grounds, tea, nitrate loading, tea quality

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Phosphorus Forms Distribution in Various Composts

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Abstract

Unidirectional flow of phosphorus (P) from limited phosphate rock is unsustainable in the long term. Recovery of alternative P-rich resources for agricultural use is highly demanded. Composting is a widely used method for treatment of large variety of organic wastes. One of less utilised organic feedstocks for composting is fish waste – by-catch fish, low quality fish and fish residues from the fishing sites and fishing processing industries. Since fish waste has high nutrient content, including P, it has great potential to be processed into nutrient-rich fertiliser and/or soil improver to promote plant growth. Nutrient concentration in compost depends on the original organic material, different composts contain different amount of P and different relative distribution of P compounds. This affects how readily plants can absorb P from the compost-amended soil. The aim of this study was to investigate P content and P forms in the fish waste compost and compare the results to different composts, which were made from sewage sludge, green waste and horse manure. Six forms of P (labile; bound to reducible metals (iron, manganese); bound to non-reducible metals (aluminium); bound to easily degradable organic material; and bound to calcium) were determined using sequential method of Rydin (2000). Results indicated that fish waste compost had relatively high proportion of labile P, suggesting good biological availability of fish compost P. Considering that labile P has a potential to be leached into the water stream, it is important to monitor that fish waste compost is not overdosed and plants are able to absorb the nutrients added to the soil. For comparison, sewage sludge compost contained the highest concentration of total P per dry weight unit, but it was predominantly in iron- or aluminium-bound forms, that is not as bioavailable as labile P. Our study suggests that evaluation of composts as alternative P sources in agriculture should rely not only on total P concentration but, additionally, on relative distribution of P forms in the compost.

Keywords: Sequential fractionation, fish waste, sewage sludge, manure, green waste

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Coffee Grounds Potential Use for Small Scale Vegetable Production

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Abstract

Coffee, one of the most valuable commodities in the world, produces large amounts of residues presenting serious environmental problems. The application of espresso coffee grounds (CG) has the potential to be a viable alternative to inorganic fertilizers in small-scale vegetable production. Two experiments were carried out to evaluate the effect of fresh CG amendment in the germination and growth of lettuce (*Lactuca sativa* L.), spinach (*Spinacia oleracea* L.), basil (*Ocimum basilicum*, L.), stevia (*Stevia rebaudiana* (Bert. Bertoni) and vervain (*Verbena sp*. L). Different rates of fresh CG were tested in both experiments, including a treatment where CG were mixed with a mineral NPK fertilizer. Soil application of fresh CG affected germination of all species. Seed emergence was inhibited at the highest rate applied. High CG rates increased organic matter and the substrate nitrogen content but decreased phosphorus and potassium availability. Fresh CG alone significantly reduced dry matter yield and total Kjeldahl nitrogen content in all the species. The mix of CG+NPK promoted plant growth for some species, a higher total Kjeldahl nitrogen content in soil and plants and the highest mineral nitrogen in soil. Application of CG with NPK fertilizer positively impacted crop growth, making this combination an alternative for domestic agriculture rather than using only inorganic fertilizers. The effectiveness of fresh CG as a crop fertilizer was species-specific.

Keywords: coffee-grounds, germination, growth, nitrogen, vegetables

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Innovative Agricultural Practices to Increase Farm Sustainability - Tomato Production of Low Nitrogen Footprint

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Abstract

Nitrogen (N) is a key indispensable nutrient for all living organisms including humans. For over one century, synthetic fertilizers and agriculture intensification allowed to feed the world population, but this came with high environmental costs. N is the element with the most altered cycle and constitutes the most pressing environmental issue faced today, making it the most important emerging environmental concern. Nitrogen use efficiency is the solution to improve soil, water and air quality while avoiding increased costs to the farmers. Tomato is one of the most consumed crops worldwide and requires high amounts of N inputs to achieve high yields. The need for new agricultural practices to reduce N inputs and promote N losses mitigation urges. One field experiment were set up to increase N use efficiency and decrease tomato production N footprint. Two different treatments were applied, with and without *Mycorrizae*. Conventional fertilization practice in the farm served as control and three other doses of N inputs were tested in both treatments, on the same tomato variety. *Mycorrhizae* are symbiotic associations between plan roots and soil fungi, able to increase crop growth through the improvement of plant's nutritional status. A mycorrhization protocol was designed and validated for tomato plants. Several samples of soil, plants and fruits were collected for chemical analysis and N monitoring along the growing cycle. At harvest, tomatoes from each treatment were collected, quantified and weighted to determine productivity. Fruit samples were analysed for quality validation. Crop production yield and fruit quality found significant differences between treatments. *Mycorrhizae* promote the growth of tomato plants increasing the N uptake, regardless the N dose applied to the soil. This innovative agriculture practice presents an alternative for the use of higher doses of mineral N fertilizer inputs and reduces the nitrogen footprint of tomatoes' production.

Keywords: crop production, fertilization, Mycorrizae, nitrogen footprint, tomato

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Decreasing Nitrogen Footprint of Vineyard Production

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Abstract

Nitrogen (N) is a key nutrient in crop production and crucial in vineyard management. When excessive reactive N is present in the environment, it may not only reduce crop production and increase pests and diseases incidence but can also be a serious environmental and human health problem. Agriculture is one of the more important activities where action can and must be taken to promote N losses mitigation and create awareness about the impact of excessive N inputs. The efficient use of N as fertilizer was tested in several field experiments to produce wine of low N-footprint. Conventional fertilization practices in each farm served as control and three other rates of N inputs were applied to vineyards located in two different regions in Portugal (Viseu and Évora). Innovative soil probes were set up in the field, at two different depths, to monitor the nitrate leaching potential risks. Several samples of soil, plants and fruits were collected for chemical analysis along the growing cycle of each vineyard farm. At the harvest time, grapes of each treatment were collected, weighted and vinified to produce a type of wine per treatment. Different N fertilizer management practices applied in the field of each farmer found no significant differences in fresh grapes production yield and quality. Wine of low nitrogen footprint were produced with a very good quality and taste.

Keywords: agriculture, nitrogen footprint, vineyards, wine

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Modelling In-vessel Composting Under Difference Bulking Agents

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Abstract

Home and community composting of food waste, an essential component of every bio-waste management strategy, is gradually succeeded by in-vessel composting which allows a more efficient and hustle-free process, especially in the urban environment. While in-vessel, or otherwise autonomous composting units (ACUs) solve most of the technical problems associated with home composting, the non-standard characteristics of bulking agents introduce uncertainties which are difficult to quantify during the composting phase. Here we model the behavior of 5 different bulking agents that are typically used in ACU applications in Mediterranean countries as they are readily available or they can be produced using a commercial wood-chipper: wood chips (WC), wood shavings (WS), pine bark (PB), wood pellets (WP) and olive leaves and cuttings (OC). Bulking agent samples were analysed for their content in soluble (Ss), hemicellulose/cellulose (Sc), lignin (Sl), inert substrate (Si), and moisture (Ws) after Sluiter et al. (2010). Mix ratios of food waste vs bulking agent were used to produce mixtures and end-mixture physical properties (density and moisture) were estimated. Variables were introduced to in-vessel composting model of Woodford (2009), modified to match the specifications of an experimental 3 m^3 ACU constructed by Dialynas S.A. Results show that at a 1:1 ratio, all bulking agents except WP reached temperatures over 50 ^oC for a total period of over 4 days. WS, followed by PB, were the quickest to reach temperatures over 50 ^oC, in 102 and 114 hours respectively, with maximum temperatures reaching 56.3 and 58.1 ^oC, respectively. Results were successfully validated in the experimental ACU.

Keywords: Autonomous Composting Units

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Index

1

100 Intelligent Cities Challenge 157

A

acidification 94
acidogenic fermentation 145
acid whey 76
acid whey utilization 72
ACU 202
adsorption 93, 134
adsorption ability 92
agricultural residues 92
Agricultural-waste 151
agriculture 236
agri-food systems 27
agro-industrial waste 223
Agroindustrial wastewaters 226
Alginate 99
Alternative food networks 36
Anaerobic co-digestion 210
Anaerobic digestion 31, 223
anaerobic digestion 145, 207, 221, 226
animal feed 128, 190, 191, 193
anthocyanins 121, 126
antioxidant 135
antioxidant activity 91, 99, 105
Antioxidant capacity 77
antioxidants 138
antioxidants. 111
apple seeds 134
Autonomous Composting 203
Autonomous Composting Units 161, 237
avocado based beverage 72
awareness 42
awareness. 44
Awareness raising 174

B

bacteria 190
Bacteria magnetization 80
bargaining power 52
basification 94
beef industry 41
beetroot crown 135
behavior 38
behaviour change theory 48
bench scale unit 143
best before 39, 40
best practices 64
betalains 135
Bioactive compounds 113
bioactive compounds 79, 109, 129
bioactive peptides 85
bioactive properties 124
bio-based materials 152
biochar 92
bio-circular economy 92
bioconversion 179, 188
biodegradable MSW 32
biodegradable polymers 141
Bioeconomy 31
bioeconomy 23, 27
biofuel 212
biogas 207, 218, 221, 223
biogas production 210
biological agent 230
biomass 97
biomass conversion 147
biomethane 151, 213
bioplastic 139, 141, 142
bio-plastics 143
Biorefinery 31, 107
bioresidue 124
bioresidues 119, 121
bioresource policy 151
bioresource policy. 213
Biosolarization 228
biostimulants 85
biosurfactant 96, 97
biosurfactants 94
biowaste 202
Bio-waste 203
BioWEconomy 23
Blackthorn bioresidue 126
Blockchain 149
Blueberry bagasse 124
broilers 177
byproducts 109

C

catalysis 226
catalytic membrane reactor 147
cats 183
cell-wall production 129
challenges 22
cheese whey 193
chemometrics 152, 154
children behaviour 166
Chlorophylls 119
Circular Bioeconomy 107
circular bioeconomy 25, 88, 109, 113
circular economy 82, 89, 115, 118, 128, 132, 151, 157, 168, 172, 196, 200, 205, 213
Circular Economy 31, 204
circularity 22
climate neutrality 25
coffee grounds 230
coffee-grounds 234
coffee waste 146
coffee wastes 210
Cold storage 51
collagen peptides 118
colourimetric sensors 152, 154
colouring formulations. 121
Comparison 62
Complementary foods 86
compositional analysis 189
concentration reduction 190
confrontation culture 230
Consumer behavior 50
consumer needs 172
Consumer Waste 43
contact angle 96
cookies 81, 138
Corfu 157
corn steep liquor 96
corn stream 93, 94, 97
cosmetics 113
Covenant of Mayors. 157
COVID-19 23, 54
Covid-19 48
COVID-19 pandemic 51
Crete 194
crop production 235
custard apples 109
cyclic voltammetry 156
Cyprus 168

D

Date labeling 50
date labelling 39
Date labelling 40
date seed powder 81
digestibility 177, 178, 184
digital tool 34
digital transformation 157
dogs 184, 185
domestic food waste 152, 154
dried food residues 183-185
dry anaerobic digestion 211

E

Earthworm 188
earthworm meal 179
education 166, 170
Education for sustainable development 174
end of waste 205
energy 212
energy recovery 215
environment 205
environmental management 44, 46
environmental protection 202
enzyme inhibition 105
EU methodology 36
European Green Deal 157, 204
experiential learning 170

F

Factor Analysis 67
fatty acids 74
feed ingredient for livestock 188
feed source 179
feedstock recycling 209
fermentation 139, 185
fertilization 235
fibers 138
Figl leaves 86
Figl (Raphanus sativus L) 182
fish by-products 85
fish waste 232
flour substitution 81
food colorant 126
food freshness 156
food ingredient. 124

food labelling 39
food law 205
food loss 38, 52
Food management 51
Food packaging 50
food preferences 101
Food prevention 174
foodservice 189
Food-Service 163
Food Services 43
food source 179
Food Supply Chain 149
food supply chain 58
food waste 22, 34, 39, 40, 42, 54, 60, 64, 69, 82, 132, 143, 145, 147, 164, 172, 177, 178, 209, 216, 219, 228
Food waste 50, 51, 67, 163, 174
Food Waste 43, 149, 204
food waste amounts 65
food waste assessment 70
food waste management 216
food waste prevention 37, 58, 70
From Farm to Fork Strategy 204
fruit and vegetables 52
Fruit and vegetable waste 179
fruit byproducts 113
Fruit Vegetable Waste 188
fruit waste 207
functional food 101
Fusarium 230
future scenarios 215

G

galacto-oligosaccharides 76
Germany 164
germination 234
Girgir (Eruca sativa L) 182
GIS 151, 213
glucan-based cell-wall compounds 129
grape pomace 105
grapes 96
Greece 60, 189
green and smart energy 157
green and smart mobility 157
Green Deal 25
green deal 200
green economy 151
Green extractions 111
green solvents. 119
green waste 232
growth 234
growth performance 177, 178

H

Haskap 121
health 205
health issue 154
healthy food 170
high phenolic content 104
histamine 156
hospitality. 191
hospitality sector 34, 189
hotel food waste 194
Household 42
Household food waste 36
household food waste 48
household food waste management 158
housing conditions 175
HTL 209
Hydrochar 102
Hydrodesulfurized diesel oil biodesulfurization 80
hydrophobicity 96
hydrothermal liquefaction 216, 219
Hydrothermal liquification 209
Hydrothermal treatment 102

I

ICC 157
Industry 4.0 149
Information asymmetry 50
innovative technologies park 196
in-store waste 37
Intelligent food packaging 172
Internet of Things 149
IoT 161
isomerization 146

J

juices 97

K

Karkade calyx 182
Karkade (Hibiscus sabdariffaL.) 182
Karkade seeds flour 86
kinetic analysis 133

kinetic models 134
kitchen waste 211

L

label 164
levulinic acid 147
Life cycle assessment 191
life cycle assessment 216
life cycle extension 88
LIFE Food-4-Feed project 198
LIFE IP CEI Greece 64
living circumstances 175
L-lactic acid 139
local authorities 168
Long-term care 163

M

maceration 119
Machine-to-Machine 161
manure 232
marine collagen 82, 132
marine collagen biomaterial 128
mass spectrometry 105
material flow analysis 41, 215
meat quality 177, 178
mechanical tests 89
Mediterranean Agro-wastes 218
Mediterranean diet 56
membrane technology 93, 94
mental health 175
metallo-porphyrin 156
methane 207
methodologies 60
methodology for monitoring 69
methylene blue dye 133
microalgae 221
microbiota 183, 184
microwave 135
Mineral bioavailability 86
mobile app 158
moderation effect 54
molecular dynamics 142
molecular simulation 142
Monosaccharide analysis 77
Montenegro 69
municipal solid waste 200
mushroom 79
Mycorrizae 235

N

naked-eye evaluation 154
networks 166
next generation sequencing 228
nitrate loading 231
nitrogen 234
nitrogen footprint 56, 235, 236
nitrogen loss 56
Node.js 161
novel feeds 194
nutraceuticals 85, 109
nutrient circularity 215
Nutritional optimization 86
nutritional value 121

O

olive cake 133
Olivemill wastewater 102
olive oil residue 104
organic residues 223
organic wastes 210
osmotically dehydrated pumpkin 72
oxidation 146

P

pandemic 23
Participatory workshops 174
pastry product application. 126
PAYT 202
Pectin extraction 77
phenolic 135
phenolic compounds 124
phenols 101
Phenols 102
photobioreactor 221
physical stabilization 89
physicochemical composition 91
physicochemical properties 97
Phytogenesis 80
phytohormones 92
pigs 178
PLA 141
PLC 161
PLLA 143
Polyhydroxynaphthoquinones 111
polyhydroxynaphthoquinones 115
polylactic acid 142

Polyphenolic compounds. 77
polyphenols 88, 105
Pomegranate peel and seeds 91
Postharvest handling 182
poverty 175
practices 58
prebiotics 76
pre-treatment 93
prevention 34, 38, 48, 64, 65
Prevention 67
prevention measures 69
process optimization 129
process simulation 219
producer-retailer interface 52
protein 99
psychosocial needs 175
Punica granatum L. 91

Q

qualitative expert interviews 52
Quality of Life 163
quantification 42, 60
Quantification 36, 62
questionnaire study 48

R

raw earth building components 89
recycling 151
reduction 29
Reduction 62
regenerative medicine 132
regional food 164
Renewable energy 151
residues 99
resource recovery 93
response surface methodology 129
restaurant 44, 46
retail 29, 65
retail food waste 37
reusable 167
revalorization 109, 113
Romanian consumer 38

S

Saccharomycopsis fibuligera 129
Salmonid by-products 74
school canteens 166
SDG 12.3 36
SDGs 70, 170
sea urchin 118, 128, 132
Sea urchins 115
seaweeds 99
Sequential fractionation 232
sewage sludge 232
shelf life 40
shelf-life dates 39
smart labels 152
SNAP7 161
social issues 175
solar drying 190, 191, 194, 223
Solid anaerobic digestion 218
solid waste management 200
Sonication-assisted extraction 91
source separation 202
Spain. 43
spent coffee ground 138
spent coffee grounds 211, 231
spread 104
Statistical analysis 62
Supercritical CO2 111
Supercritical CO_2 extraction 74
supermarket records 37
supermarkets waste 209
Super paramagnetic iron oxide nanoparticles 80
surplus 167
sustainability 44, 46, 89
sustainable agriculture 228
sustainable development 200
sustainable transition 82

T

tea 231
tea quality 231
techno-economic assessment 219
The contribution of innovative and intelligent packaging to the loss and generation of food waste. 55
Theory of Planned Behaviour 67
thermal drying 193
TiO2 226
tomato 235
tomato peels 213
toxicity 226
TPB 54
treatment 226

trend 38

U

ultrasound-assisted extraction 119
Units 203
Universities 43
unrecorded food waste 37
unripe grapes 101
urban 203
use by 40

V

valorisation 151
valorization 88, 104
valorization. 99
value chains 107
vegetable residues 193
vegetables 234
vineyards 236
virtual nitrogen factor 56
volatile fatty acids 228
volatile fatty acids (VFAs) 145

W

waste. 46
Waste4Think 32
Waste citrus fruit debris 80
waste hierarchy 70
waste management 41, 139, 157, 196
waste oil 212
waste utilisation 81
waste valorization 118
wastewater treatment 221
we can 28
wheat straw 133
wine 236

Z

zeolite 134
zero waste 167

B

β-galactosidase 76
β-glucans 79

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