

FUNGUSCHAIN EU Project: Extracting Value from the Agricultural Offcuts of Commercial Mushroom Farming

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Abstract

FUNGUSCHAIN project is implementing valorisation concepts of mushroom (*Agaricus Bisporus*) agricultural residues. Therefore, novel cascading approaches will be designed, in order to obtain innovative procedures to receive high value bio-based additives (antioxidants, antimicrobials and proteins), bioplasticizers by lipid conversion as well as biopolymers production from polysaccharides (glucans and fermentable sugars), using the remaining side streams and substrates. Final remaining substrates still being used by composting and/ or biogas synthesis, closing the agricultural cycle accordingly. The demonstration within a new biorefinery, including economical extraction methods, will attempt the industrial viability. At the end of the project, more than 65% of the emerged mushroom by-products/ waste will be valorised into high-value additives. Three key chains within European economy, namely, food, cleaning/cosmetic and plastic market will characterise and further validate the applicability of the obtained products within their production processes under compliance with legal EU and market requirements.

Keywords: agricultural cycle, by-products, biorefinery, cascading approach, extraction methods

Introduction

The growing number of population worldwide, is accompanied with a huge amount of food waste/ agro- waste due to an increased need of food and food production. This is in the common way a huge disposal problem for the corresponding industry, while the wasted agricultural by-products could also serve as a source of valuable compounds (carbohydrates, proteins, lipids etc.) or as substrate for other commercially important metabolites (Karak et al., 2012; Ravindran et al., 2016; Dietrich et al., 2016). FUNGUSCHAIN project is addressing the topic BBI.VCR.D5-2015- "Valorisation of agricultural residues and side streams from the agro- food industry" being focused on

the demonstration of viable valorisation concepts from food residues to high value bio-products. Thus, guaranteeing an appropriate use of residues and side-streams (CORDIS, EC (1)). The projects consortium consists of 16 partners transferring knowledge from 10 European countries (CORDIS, EC (2)). Each week more than 60,000t of mushroom by-products are generated in Europe (FUNGUSCHAIN, 2016). Mushrooms, known for their biologically active compounds' content, serve as valuable source for innovative valorisation processes and will result in several future applications (Ramos et al., 2019). Nutritionally, mushrooms contain up to 65% carbohydrates (e.g. the bioactive compound beta glucan, which has a

therapeutic effect), up to 35% proteins and very low-fat content of up to 6%. The nutritional interest in using mushrooms as part of innovative compounds such as part of nutraceuticals or pharmaceuticals considers to a high number of rumoured therapeutic purposes (e.g. cancer or nervous disorders) (Rathore et al., 2017). Moreover, mushroom proteins display a high-quality amino acid profile, which has an enormous nutritional effect (Manzi et al., 1999, Rathore et al., 2017). Besides the macronutrient content of mushrooms, other molecules like bioactive compounds (especially proteins and peptides with impact on gut microbiota), terpenes, antioxidants (phenolic compounds, carotenoids), beta- glucans as well as fibres have been found and reviewed during the last decade (Rezaeian et al., 2016; Rathore et al., 2017).

FUNGUSCHAIN project aims with the valorization of agricultural residues from mushroom (*Agaricus Bisporus*) farming residues to set up new cascading possibilities to extract high value bio-based additives (antioxidants, antimicrobials, proteins), conversion of lipids into bioplasticizers as well as polysaccharides (glucans and fermentable sugars) into biopolymers throughout promising, suitable, scalable and cost-effective extraction procedures. The agricultural cycle will be finally closed throughout composting and/ or biogas production. The obtained additives will be further applied and validated as ingredients within three key value chains in the European economy (food, cleaning and plastic sector). The projects ingredients will be modified and adapted continuously according to the market needs. Thus, safe, sustainable, economically viable and attractive products will be developed always under the premises of legal EU and market requirements (FUNGUSCHAIN, 2016).

Materials and methods

FUNGUSCHAIN project is presenting a new concept of biorefinery, which will be created to valorise mushroom outcomes by a four-steps cascading approach. This approach will succeed the following pattern: 1. Microwave-assisted extraction (MAE), as a fast and reliable extraction technique based on heating, induced by microwave radiation. MAE will obtain molecules like antimicrobials, antioxidants, polyols, etc. which can be further inserted in the cleaning, food and/or plastic industry. 2. Pressurised hot-

water extraction (PHWE), which represents a powerful extraction technique using high pressures to maintain aqueous solvents in liquid state at high temperatures. The method will result bioactive proteins as well as polysaccharides to be applied mainly in food industry as part of food supplements with functional properties. 3. During saccharification fermentation (SF), a deconstruction methodology of biomass into a sugar platform, as starting point for the production of fermented biopolyesters, is going to be applied in order to develop new bioplastics. Finally, within step 4, the anaerobic digestion (AD), the remaining biomass will be employed to generate compost and biogas, due to different chemical reactions and microbes. Thus, closing the agricultural cycle.

Results and discussions

FUNGUSCHAIN project concepts generates molecules such as antimicrobials, antioxidants or polyols by MAE applied in the cleaning, food and/ or plastic sectors. Furthermore, bioactive proteins and polysaccharides received by PHWE can be directly used as food supplement for elderly population. The demographic change, which includes the aging population growth within the next decades, and thus considering the increase of age-related diseases as well as growing consciousness of healthy aging, the nutritional supplement market is expected to grow within the next decades. With respect to 6.5 million elderly living in European nursing homes nowadays, nearly 1.0-1.2 million are in need to prevent malnutrition and in reverse are having a high demand on visually appealing dietary food solutions (health- promoting, texture modified food, supplemented food) (Forstner et al., 2015), especially protein supplementation, which can tackle the problems of a number of age-related diseases such as sarcopenia (age related loss of muscle mass) and moreover malnutrition (Rusu et al., 2020).

The global dietary supplements market is expected to attain nearly \$ 231 Bln until 2027 with a CAGR of 8.2%. Especially the protein supplement market is expected to reach a CAGR of nearly 13% within the determined years (Grand View Research, 2020). Within FUNGUSCHAIN project, the obtained proteins and bioactive compounds will be validated as part of special elderly nutrition products, being incorporated in enriched

texture modified food (smoothfood), followed by characterisation and validation methods. Powder formulation processes being applied (e.g. spray drying, agglomeration processes) for modulating specified key properties (e.g. bulk density, particle size, solubility, stability, sensorial, etc.). Possible modification strategies being also directly communicated with related partners.

Conclusions

The FUNGUSCHAIN project will obtain high value molecules/ products using mushroom agro-wastes, applicable in a wide range of products as well as closing the whole agri-cycle working close to end-user requirements (legal and market). The extractable compounds show high nutritional potential (health-promoting effects, high-value protein and carbohydrate source) within the supplement and/or nutraceutical market, which is steadily growing worldwide. Finally, responding legislation have to be considered for further applications and developments, within the project.

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