

FRIETS Project: Sustainable optimization of the value chain of added-value fresh and dried berries through the integration of Precision Agriculture management strategies and innovative dehydration and edible coating

KARAMOUZI E.¹, ANGELIS-DIMAKIS A.^{2,*}, DARRA N.³, FOUNTAS S.³, GOGOU E.⁴, KROKIDA M.⁵, LAGONIKOU M.¹, MANGANARIS G.⁶, OIKONOMOPOULOU V.⁵, PANOPOULOS P.¹, PAPADAKI S.⁷, SERIFI O.⁸, GALEA D.⁹, SOCOL C.¹⁰, SPELLA M.¹, VALANIDES N.¹¹, VALDRAMIDIS V.¹², VODNAR D.¹³

¹European Research & Development Rezos Brands, 26504 Patras, Greece

²School of Applied Sciences, University of Huddersfield, Queensgate, HD1 3DH, UK

³Laboratory of Agricultural Machinery, Department of Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, 75 Iera Odos Str., 11855 Athens, Greece

⁴NFA (Natural Food Additives), Laboratory of Natural Extracts Development, 6 Dios st, Tavros, 17778 Athens, Greece

⁵School of Chemical Engineering, National Technical University of Athens, 9, Iroon Politechniou Str., Zografou Campus, 15780, Athens, Greece

⁶Cyprus University of Technology, Department of Agricultural Sciences, Biotechnology & Food Science, Lemesos, 3603, Cyprus

⁷DIGNITY PRIVATE COMPANY, 30-32 Leoforos Alexandrou Papagou, Zografou 157 71, Athens, Greece

⁸KPAD Ltd., Francis House 2 Park Road, Barnet, London, England EN5 5RN, UK

⁹Mgarr Farms, Fortress St, Mosta, Malta

¹⁰CENCIRA Agrofood Research and Innovation Centre, 400650, Cluj-Napoca, Romania

¹¹Mountain Berries, Pitsilia, Troodos, Cyprus

¹²Department of Food Sciences and Nutrition, Faculty of Health Sciences, University of Malta, MSD 2080 Msida, Malta

¹³University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 400372, Cluj-Napoca, Romania

*corresponding author:

e-mail: A.AngelisDimakis@hud.ac.uk

Abstract. FRIETS project aims in training crossdisciplinary scientists from 5 European countries, in collaboration with international SMEs, for the development and marketization of personalized, nutritious and innovative, soft fruit smart snacks that contain no added sugar, sodium or chemical preservatives, as a palatable way to increase daily fruit consumption. FRIETS smart snacks will include novel processed berries (strawberry, raspberry, blueberry, and blackberry) with superior quality and nutritional characteristics, as well as extended shelf-life. Pre-harvest management practices will be optimized for cultivating high-quality berries. Low impact post-harvest technologies will be developed and optimised including (1) mild and energy efficient drying techniques (e.g. osmotic dehydration, freeze drying, microwave vacuum drying or their combination) using limited or no sugar or salt, and low temperatures, and (2) composite or multi-layered edible coatings, based on micro- and macro-algae components, including encapsulated or non-encapsulated natural functional ingredients. Life Cycle Analysis and socio-techno-economic analysis will be implemented for the sustainable development of new products. FRIETS implementation will be based on staff secondments, strengthening

collaborative research among different countries and sectors.

Keywords: *Smart snacks, osmotic dehydration, bioactives extraction and encapsulation, pre- and post-harvest management*

1. Introduction

Maintaining a healthy diet requires sufficient consumption of fruits and vegetables. However, nowadays, the fast pace of modern lifestyle discourages individuals from reaching their optimal daily intake via consumption of fresh fruits and vegetables, ultimately creating an increasing demand for natural, nutritive, healthy, and personalized ready-to-eat snacks. It is also an accepted actuality that there is a lack of healthy food snacks for personalized nutrition in the market. Hence, the development of such products, which can also be tailor-made to the needs of specific groups (young children, elderly, diabetic, sportive, etc.), is a long-awaited innovation (Ordovas *et al.* 2018).

Berries are an essential source of bioactive compounds with significant benefits to human health (Martau *et al.*, 2023). Their consumption contributes to maintaining a balanced diet, rich in nutrients, which benefits health and

the proper functioning of the human body. However, the seasonality of these products leads to the creation of a significant food surplus. Berries in particular have a very short shelf life, so they must be consumed within a short period of time after being harvested. Increasing the lifespan of berries is really important, as it will reduce the number of berries that ends up in the trash, contributing to the regulation of food waste and, also, there will be a better exploitation of their nutrients.

The innovative European program, FRIETS, seeks to deal with this issue. It aims to use high-precision agriculture and innovative processing methods to increase the shelf life of berries and maintain their high quality. Precision agriculture approaches will be adopted for yield monitoring and forecasting to estimate the expected yield based on factors such as weather conditions, soil characteristics, and irrigation parameters. Additionally, modified osmotic dehydration methods, using alternative osmotic agents will be applied to increase the shelf life of berries, replacing conventional salts and sugars and leading to healthier foods. In addition, the development of edible coatings will be studied as a methodology to extend the shelf life of the final products. Life Cycle Analysis and Life Cycle Cost Analysis will be applied throughout the value chain to determine the environmental impacts and identify the points that cause the most serious environmental burdens, providing sustainable solutions at a reasonable cost.

The FRIETS project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101007783. The FRIETS project has a duration of 48 months and involves 13 partners from universities and companies, from five different countries (Greece, Cyprus, Malta, Romania, England). Within the framework of the research program, 116 exchanges of research members will be carried out, with a total duration of 529 months. These exchanges promote mobility between researchers of the European Union and contribute to the exchange of knowledge and experience between universities and companies, as well as the exchange of experience and work mentality between people.

2. FRIETS Objectives

- Identify pre-harvest indicators for management practices of berries and develop technologies that will be exploited for yield monitoring and forecasting, taking into account weather, soil and irrigation parameters.
- Development of dehydration processes with no added sugar and salt as preservatives.
- Development of novel smart (prototype) edible coatings by micro/macroalgae.
- Recovery and characterization of bioactive compounds from plants and herbs, using sustainable processes.
- Encapsulation of bioactive compounds to increase their bioactivity and controlled release.
- Model based process optimization based on safety and shelf-life assessments.
- Environmentally sustainable and economically feasible solutions.

3. FRIETS Innovations

- Develop a new production system based on precision agricultural practices, using digital monitoring technologies and finding the best practices to achieve high quality berries, while achieving a sustainable production.
- Develop innovative, green extraction techniques for the sustainable recovery of bioactives from plants and herbs.
- Develop innovative technologies for protecting bioactive substances.
- Develop modified osmotic dehydration techniques, using alternative agents to increase the shelf-life of several berries, replacing conventional salts and sugars, leading to healthier foods.
- Develop edible coatings with advanced and improved carrier properties, taking advantage of the significant properties of micro- and macroalgae.
- LCA and LCC analysis will be applied throughout the whole value chain for determining the environmental impacts and identifying the hotspots, providing sustainable solutions at a reasonable cost.

4. FRIETS Implementation

To achieve the FRIETS strategy, a project duration of 48 months with 8 work packages (WPs) is foreseen.

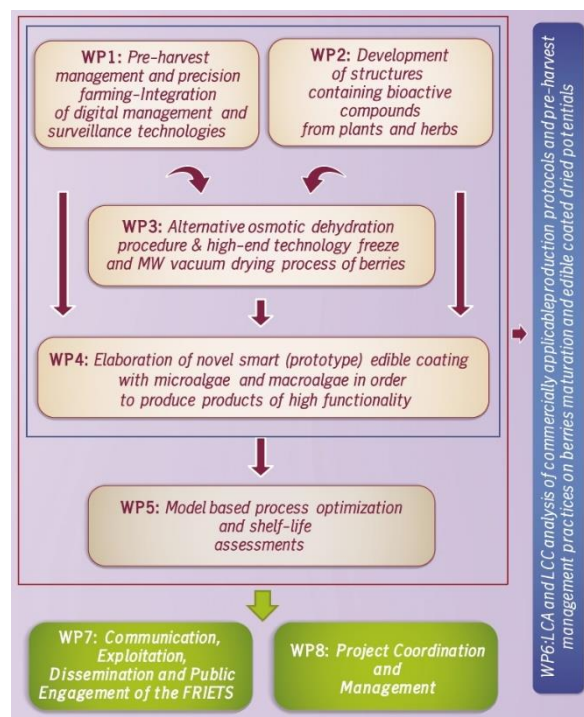


Figure 1. FRIETS project Work Packages (WPs)

FRIETS establishes technologies that will enable the development of unique products, fulfilling consumers' requests for increased nutritional features, functionality, and seasonal availability. By integrating remote sensing technologies and precision agriculture practices pre-harvest indicators will be calculated to provide valuable information about the crop's health, maturity, and yield potential, allowing growers to make informed decisions

regarding sustainable management practices. Exploration of the combination of mild drying procedures with edible coatings to ensure long shelf-life will add value to the current state of the art and close the knowledge and, hence, literature gap. The addition of extracts from plants and herbs containing beneficial chemicals, either in the osmotic solution or in edible films, is a research area that will boost the proposal's originality. To achieve the aforementioned goals, the project process is divided into various steps:

Step 1. Precision farming-Integration of digital management and surveillance technologies.

Step 2. Recovery of bioactive compounds.

Step 3. Encapsulation of bioactive compounds.

Step 4. Dehydration processes.

Step 5. Novel (prototype) edible-coated berries using micro/macroalgae components - production of functional smart snacks.

Step 6. Shelf-life determination.

Step 7. Business modelling & Life Cycle Assessment.

Step 8. Risk management.

5. FRIETS Impact

- Young researchers will receive high-quality training in areas not normally found in the workplace.

- The secondees will increase their geographical mobility within the EU, gain new research and transferrable skills, be exposed to new research environments, and have their career opportunities broadened.
- Researchers will thoroughly understand the industry's needs, transforming knowledge into next-generation goods and services.
- SMEs will use research findings to improve and add value to their goods and processes, as well as potentially increase their intellectual property and/or product line.

Aknowldgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101007783.

References

- Martau, G.A., Bernadette-Em"oke, T., Odocheanu, R., Soporan, D.A., Bochis, M., Simon, E., Vodnar, D.C. (2023), Vaccinium Species(Ericaceae): Phytochemistry and Biological Properties of Medicinal Plants, *Molecules*, **28**, 1533.
- Ordovas JM, Ferguson LR, Tai ES, Mathers JC., (2018) Personalised nutrition and health, *BMJ*, Jun 13;361