



CATÓLICA

CBQF · CENTRE FOR BIOTECHNOLOGY  
AND FINE CHEMISTRY ASSOCIATE LABORATORY

PORTO

2022



**CBQF**

Annual Report



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# 1. INTRODUCTION

## Letter from the Board of Directors

With the easing of the COVID-19 pandemic, 2022 brought normality to our daily lives at CBQF and our core activities could resume as usual. We have been preparing ourselves to grow our scientific excellence by implementing our strategic plan and enhancing the efficiency and flexibility of work processes. This enabled us to deliver a solid collective performance and impressive scientific outputs, contributing to drive Portugal's innovation, science and economy to international standards - supporting environmental stewardship, improved sustainability practices, and circular economy values.

We are pleased to share a snippet of CBQF's main achievements of 2022. The Environment and Resources group developed, for example, a new biofertilizer concept, which was awarded "Rising Innovator" prize (2nd edition of the Amyris Innovation Big Impact Award). Policy analysis of the new Common Agricultural Policy revealed how it could support legume production in Portugal. CBQF scientists assisted the European Commission in revising the European Directive on Urban Wastewater Treatment. They developed a colorimetric method for determining nickel in water with similar features to those displayed by high-profile atomic spectrometric methods.

In the Food and Nutrition group, significant progress was achieved for producing "Clean Label" meat products without adding nitrite. Novel sustainable solutions for additive/sugar/fat replacements for reforming different foods were identified. Novel strategies contributing to a sustainable circular economy were delivered, such as applying mild coupled to less severe thermal treatments in processing and producing high-quality and safe juices or developing more sustainable packaging.

The Biobased Biomedical Products group developed *in-vitro* models to validate the bioaccessibility and prebiotic potential of different bioactive or food products. The company ETSA started its project to build the first factory in Portugal to produce peptides with functional value from animal by-products thanks to a fruitful collaboration with CBQF. The patented technology for producing sericin-based *in situ* forming hydrogel was used to create a new bioink for cell encapsulation and biofabrication. An image analysis semi-automatic system for colony-forming-unit counting was developed.

The Fermentation Solutions group delivered a new yeast strain to produce carnosic acid, with known antimicrobial activities, for use as a food and cosmetic preservative. They also transferred fermentation technology of farnesene and artemisinic acid, to DSM and Huvepharma. It successfully implemented cutting-edge methodologies to test and validate ingredients and formulations as effective dermo-cosmetic solutions and established collaborations with the Maio Clinic, Grupo Luz or Hospital São João.

CBQF scientists deserve applause: we published 228 articles in 2022, secured funding with 12 new research projects involving 4.7 M€. It is a pleasure to witness the ever-growing number of internal and external collaborations that make our centre an appealing ecosystem of knowledge creators.

Nature has given us all the pieces required to live on a safe planet that nurtures the environment as much as personal comfort and health. CBQF must put these pieces together and deliver solutions for a better planet for every citizen, making these solutions available and inclusive. The Board remains here to help CBQF move even further in this direction, and to support its staff's personal and professional growth.

## BOARD OF DIRECTORS

CBQF is coordinated by a directive board, whose members were appointed in 2020.



**MANUELA PINTADO**  
 CBQF Director



**ANTÓNIO RANGEL**  
 Head of External Relations and Post-Graduation Activities



**MARTA VASCONCELOS**  
 Head of Scientific Strategy and Internationalization



**FRENI TAVARIA**  
 Head of Infrastructure and Scientific Platforms



**JOÃO CORTEZ**  
 Head of Funding, Sustainability and Career Development

## ADVISORY BOARD

The External Advisory Board is composed of worldwide experts in CBQF’s thematic areas, to ensure scientific excellence through the right steering of activities and yearly critical evaluation of performance, with suggestions for the future of the Centre.



**JOSÉ TEIXEIRA**  
 Full Professor  
 UMinho



**MARGARIDA OLIVEIRA**  
 Full Professor  
 UNL | ITQB NOVA



**MARIA ASCENÇÃO REIS**  
 Full Professor UNL |  
 LAQV@REQUIMTE |  
 UCIBIO



**MARK VAN LOOSDRECHT**  
 Full Professor  
 TU Delft



**PAUL INGLAS**  
 Head of the Food Databanks  
 NationalCapability,  
 Quadram Institute

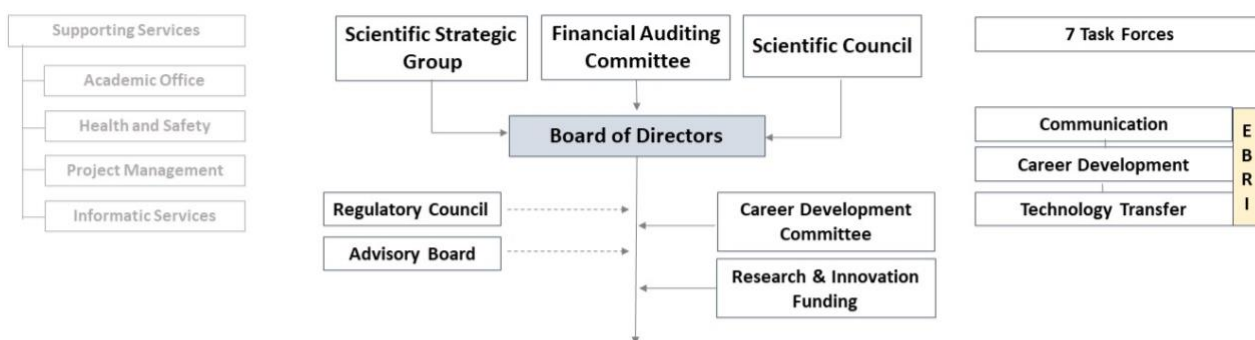


**ROBERT HALL**  
 Deputy Business Unit  
 Manager Bioscience  
 Wageningen  
 University, Professor



**LUIS MESQUITA DIAS**  
 President AHSA

## Governance



### THEMATIC LINES

#### Environment and Resources

Automation and Miniaturization  
 Bacterial Ecology  
 Environmental Biotechnology & Resources  
 Plant Nutrition & Biotechnology for Sustainability

#### Food and Nutrition

Food Safety & Microbiology  
 Food Processing & Engineering  
 Nutrition and Health

#### Biobased and Biomedical Products

Biomaterials & Biomedical Technology  
 Bioactives & Bioproducts Research  
 Metabolomics

#### Fermentation Solutions

Strain Design & Fermentation  
 Biomolecules Innovation  
 Valorisation of Fermentation Byproducts

### RESEARCH PLATFORMS

Analytical Chemistry  
 Structural Analysis

Consumer & Sensory  
 Bioactives

Packaging & Materials  
 Kitchen Lab

Cell Culture & Molecular Biology

## 2. CBQF IN NUMBERS

### PEOPLE

CBQF is only as rich as the people that work in the Centre, the remarkable men and women who push the boundaries of science and technology with their creativity, knowledge and determination.



**247**  
 RESEARCHERS



**3% INCREASE**  
 FROM 2021

**119** RESEARCHERS WITH PHD

**7** ARE COLLABORATORS

**11** TECHNICIANS



### STUDENTS



**75 PhD**  
 Students



**63 MSc**  
 Students  
 concluded



## TRAINING

**177** TOTAL OF PARTICIPANTS IN  
CBQF ADVANCED TRAINING SESSIONS

### COURSES ORGANISED DURING 2022:

- ✓ How can Digital Marketing and Social Media help promote my career and CBQF?
- ✓ Intellectual Property in Project Implementation
- ✓ Emotional intelligence and social skills
- ✓ Research Project Management
- ✓ Horizon Europe: Opportunities for CBQF
- ✓ Patent applications: descriptive sufficiency and inventive step
- ✓ Preparation for Horizon Europe Project submission
- ✓ Basic Life Support

**Plus...Christmas Cookies Decorations!**

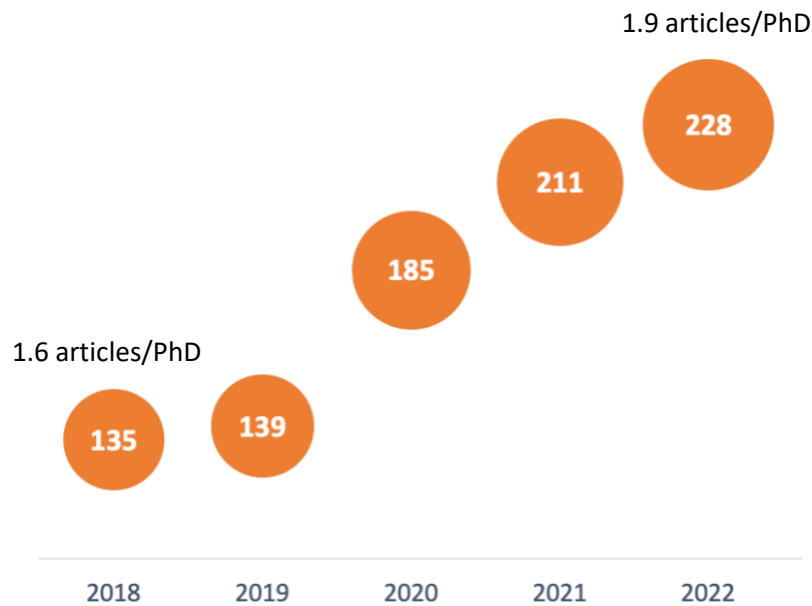


# PUBLICATIONS

Data from 31 December 2022



**228** ARTICLES IN INTERNATIONAL INDEXED JOURNALS



**85%** IN COLLABORATION WITH  
NATIONAL/INTERNATIONAL ENTITIES



**>12,800** CITATIONS (2022)



**66%** OPEN ACCESS

**91%** are in Q1+Q2



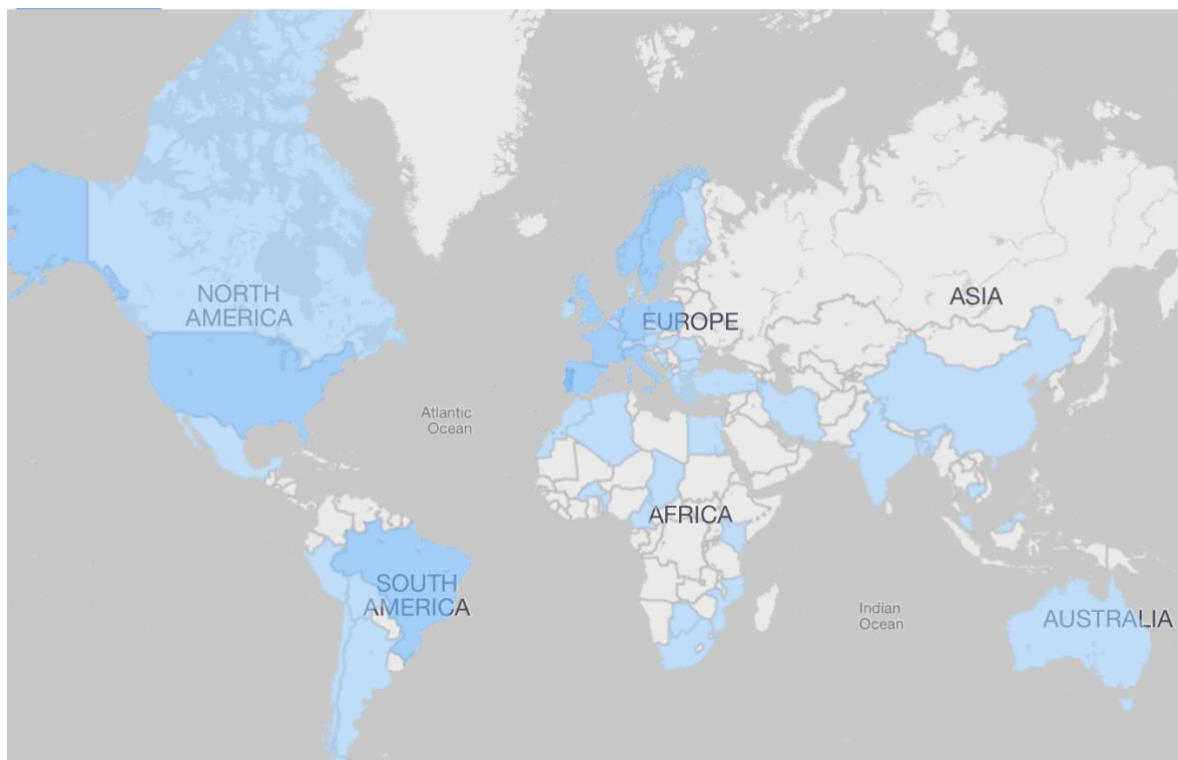
**29** BOOKS/CHAPTERS

CBQF HAS AN H-INDEX OF **112**



# INTERNATIONALISATION

International collaborations resulted in 228 indexed peer reviewed papers in 2022, 84% of which were in collaboration with other institutions. This collaborative culture contributes to a fertile environment that generates multi- and interdisciplinary knowledge in a multinational and culturally diverse context.



**247** INSTITUTIONS   **15** CORPORATE   **54** COUNTRIES

**84%** were in collaboration  
**40%** with Portuguese institutions and  
**44%** with international partners



**22** international researchers  
**13** countries

# LEADING INNOVATION

**13** New patents applications submitted in 2022

**43** Active Patent Families

**26** Prototypes developed

## INNOVATION PROGRAMMES (number of teams)

Ecotrophelia Europe: 2  
 Born from Knowledge: 1  
 Comendador Arménio Miranda Award: 5

## ENTREPRENEURSHIP PROJECTS

78 MSc Students and 36 Researchers involved  
 38 Prototypes and proof-of-concepts delivered

Leading knowledge transfer projects for 3rd countries (Erasmus+):



**3Boost** aims to transfer scientific and technological knowledge in the areas of Agri-Food Biotechnology and Biomedicine/Health. The project's main objective is to boost the economic valuation of R&D results in the areas of bioeconomy, by reinforcing the transfer of scientific and technological knowledge to the business sector and strengthening the conditions for start-ups, through the transformation of innovative ideas and technologies generated by researchers, PhD and MSc students, from the UCP's regional centres of Porto and Viseu. Among other activities it focuses on training researchers, students and current and future entrepreneurs; development of proofs-of-concept and prototypes; and elaboration of patentability studies.

## 3. CUTTING EDGE RESEARCH

Currently, activities are supported by thirteen Laboratories structured in four Thematic Lines that embrace societal challenges related to sustainability, society wellbeing and global economy.

### ENVIRONMENT AND RESOURCES

The Environment and Resources Thematic Line aims at developing innovative approaches to environment and sustainability challenges, working towards specific national interests and internationally relevant topics in frame of the UN 2030 Sustainable Development Agenda goals. Research includes: i) identifying emerging chemical and biological hazards and associated risks in human impacted habitats and developing mitigating methods; ii) developing strategies for wastewater and soil treatment contributing to foster opportunities to move towards a circular economy model; iii) devising integrated strategies to plant production in face of new biotic and abiotic environmental challenges. The thematic line is organized in four laboratories:

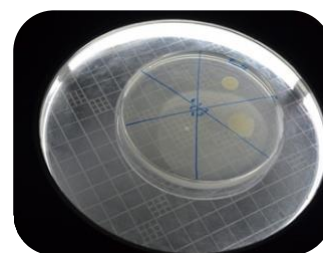


#### Automation and Miniaturization

Develops novel sample processing and sensing methods for monitoring key environmental parameters and emerging pollutants.

#### Bacterial Ecology

Explores the bacterial diversity in the interface humans-environment, with special emphasis on the impacts caused by humans and associated risks for human health and wellbeing.



#### Environmental Biotechnology and Resources

Microbial based processes for pollutants degradation and wastewater treatment and valorisation, focused on aerobic granular sludge technology; phyto-management of soil; and bioinoculants for sustainable crop production.

#### Plant Nutrition and Biotechnology for Sustainability

Works in the areas of plant nutrition and biotic stress, understanding the mechanisms that control nutrient uptake, transport and storage, simulating current and future climate change scenarios.



# Main Achievements in 2022

## Environmental Biotechnology and Resources

The Environmental Biotechnology and Resources Lab contributed with several outputs for two environmental compartments: soil and water.

A survey of native metal-tolerant plants (metallophytes) suitable for the restoration of contaminated sites was conducted in a mining area. Metal-tolerant bacterial strains were isolated from the rhizosphere of metallophytes and the most promising with plant-growth-promoting traits were used to produce new bioinoculants. These strains were deposited in the bacterial collection of ESB-CBQF. Hydrogels were tested in pot experiments as a delivery system for bioinoculants and as water retainer and fertilizer. Findings suggest its efficiency in enhancing bioinoculants' effects on plant biometric parameters and soil quality, and were tested in two field trials: i) in an industrial contaminated site, with high biomass trees and perennial grasses, and ii) in a vineyard, mixed with cover crops. Two pre-established field trials with inoculated vineyards were monitored for microbiome and enzymatic activity analysis, mesofauna samples for identification and grape must for quality assessment. The microbiota assisted phytoremediation abilities of sunflower in heavy metal contaminated soils was monitored, and the potential of the produced biomass to produce biofuels (oil, bioethanol, biodiesel and methane-rich biogas) was evaluated. Sustainability (Life Cycle Analysis) of the remediation process coupled with energy generation processes were assessed, indicating the suitability of such strategies for brownfields valorisation. In collaboration with the company PipeMasters, the Freetilizer technology was developed, targeting the production of organic fertilizers from plant or animal by-products, intended for agricultural or forestry applications.

The applicability of granular sludge systems based on bacteria and/or microalgae for treating and valorising wastewater, especially targeting food industry effluents, was explored at lab- and pilot-scale. A continuous flow bacterial granular reactor successfully treated recirculating freshwater aquaculture streams at pilot-scale during the dry season. At lab-scale, microalgae attachment to bacterial granules allowed to produce effluents with adequate chemical quality and oxygen levels for water reuse in fish farms. Also, at lab-scale, an aerobic granular sludge reactor showed its capacity to deal with fluctuations in the wastewater composition collected at a fish canning industry. An alternative approach to assess effluent quality parameters using quantitative image analysis-based methodology was developed. Bacterial strains from CBQF collection showed their ability to degrade contaminants of emerging concern (e.g., the hormone  $17\beta$ -estradiol and the neonicotinoid insecticide thiamethoxam) and the metabolic pathways of degradation were elucidated. The toxicity evaluation showed that the degradation was accompanied by the decrease of toxicity/estrogenicity, indicating that these bacteria could be effective in bioremediation strategies.

**Major scientific outcomes in 2022:** The application potential of granular systems based on bacteria and/or microalgae as an integral part of recirculating aquaculture systems, allowing for water reuse. New bioinocula formulations were developed comprising beneficial microorganisms such as plant growth-promoting bacteria (PGPB) and arbuscular mycorrhizal fungi (AMF). These microorganisms were incorporated





in a commercial hydrogel to increase nutrient uptake and promote soil water holding capacity and water use efficiency of crops. This hydrogel showed to be an effective carrier for microorganisms and reduces the need for irrigation. Bioinocula formulations were tested in several experimental trials with vineyards, cereals (maize), trees (poplar and willow), and high-biomass grasses (vetiver). A new biofertilizer idea was also awarded the prize "Rising Innovator" in November 2022 at the 2nd edition of the Amyris Innovation Big Impact Award, an Innovation Contest in Biotechnology.

## Plant Biotechnology and Nutrition for Sustainability

In 2022 the lab has produced outputs on several fronts, mostly related to plant nutrition, plant pathology and agroecological transitions towards more legume-based systems. Herein we highlight the work regarding the expansion and valorization of legumes in Portugal and in Europe. The results of the legume cultivation analysis in Portugal and the survey of the area of the area dedicated to pulses in Portugal was conducted. A consumer survey that captured the perceptions of Portuguese consumers to adopt legumes as a protein source and as a replacement for animal-based protein was delivered and captured the responses of 922 participants. Workshops were organized, for a minimum of 100 participants, as well as two webinars, (one that reached out to 300 participants, and a second for 106 participants). We developed a participatory farmer activity to encourage legume cultivation, and the laboratory obtained 36 applications and selected six participating farmers. The total area and per legume converted for the project - minimum six ha converted by participatory farmers; two additional ha converted by other farmers joining the project, for a total area of 8 ha. We documented improvement of soil, by measuring soil morphophysiological parameters. The LeguCon consortium was added to the Agrifood Digital Innovation Hub, encompassing associated producers. Currently we have a total of 83 members registered in the Consortium, representing different sectors of the agrifood chain. The impact on social networks and media was substantial, with the number of followers on Facebook/Instagram/Twitter being 946/889/79, the number of visitors on the website: 447/month. Stakeholders come from agricultural (18%), consulting (10%), industry (18%), academy (24%), food industry (19%), milk Production (1%), seeds sector (10%). One of the main goals was to contribute to the increase of legume production in Portugal on the medium term. We observed an increase of the area of legume production between the beginning and the end of the project - 10% increase. The most recent data available from FAOSTAT is for 2021, with 2019 (10 605 ha) and in 2021 (12 318 ha). Thus, we observed a change of paradigm in legume production in Portugal, and there was an increase of 14% in the area dedicated to the production of these crops. In a complementary activity and in scope of the RADIANT H2020 project, we launched the European farmer participatory call for underutilized crops, which aims to support 45 farmers across Europe to cultivate underutilized crops, of which a large fragment is dedicated to legumes. Also, in 2021 we launched the European Underutilized Crops Cluster, open to stakeholders across Europe that want to promote the valorisation of underutilized crops and integrate these into dynamic value chains. Again, a strong focus on legumes is present. In November of 2021, a high-level event was organized by the Jeronimo Martins Group, and a presentation was given on the role of legumes in sustainable agri-food systems, and that reached out to more than 2500 participants in Portugal. An analysis of the new version of the Common Agricultural Policy (CAP) and of how it can support legume production was published and it revealed that



although the recognized importance of leguminous plants at the economic, environmental, and socio-economic level, the support in the context of the new CAP remains clearly insufficient to promote a greater adherence of producers to the cultivation of these crops. Also lacking in the new CAP are measures for the training of farmers in this specific area, for example, through training programs and technical advice.

**Major outcomes in 2022:** An increase in legume cultivation and legume awareness by the part of stakeholders in Portugal and in Europe more broadly. This resulted in several scientific publications and the development of follow up projects that helped cement the transition to legume-based systems.

## Bacterial Ecology

The work developed over 2022 is structured into three major areas: 1) comparative genomics, 2) metagenome analysis and 3) monitoring: tools and policy orientations. In area 1) the genomes of environmental and clinical multidrug resistant bacteria of the species *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* have been compared. These studies have highlighted the interplay between phylogeny and gene acquisition as major drivers for antibiotic resistance evolution. For members of the *Klebsiella pneumoniae* complex, the pangenome-wide association studies did not evidence significant differences between clinical and environmental genomes. However, the genomes of clinical isolates presented significantly more exclusive genes related to antibiotic resistance/plasmids, while the environmental isolates yielded significantly higher allelic diversity of genes related with functions such as efflux or oxidative stress. It is suggested that *K. pneumoniae* can circulate among the natural environment and clinical settings, probably under distinct adaptation pressures. In carbapenem resistant *bla<sub>VIM-2</sub>* or *bla<sub>NDM-1</sub>*, it was observed that the genes *bla<sub>VIM-2</sub>* or *bla<sub>NDM-1</sub>* are associated with different mobile genetic elements and phylogenetic lineages. Hints of inter-genera horizontal gene transfer can be inferred from the occurrence of the same mobile genetic in other *Gammaproteobacteria*, specifically *Enterobacteriaceae* and *Acinetobacter* spp. However, *bla<sub>VIM-2</sub>* or *bla<sub>NDM-1</sub>* were harboured by *P. aeruginosa* of distinct phylogenetic lineages, with diverse accessory genome features, and occurring in the different geographies. In area 2) wastewater and soil metagenomes have been analysed to assess potential impacts of wastewater irrigation in soil and overlaps. In area 2) treated wastewater and the respective irrigated soils, collected in Israel and Cyprus, were screened for the relative abundance of antibiotic resistance genes, based on metagenomic approach. It was observed that treated wastewater and soil presented distinct profiles of antibiotic resistance genes (483 in Israel and 586 in Cyprus). These analyses did not evidence clear impacts of wastewater in soil but allowed a customized inspection of possible footprint biomarkers. Genes that fulfilled these criteria included *ermF*, *mefC*, and *mphG*. The comparative soil-wastewater metagenomic analysis was expanded to 18 countries. In general, *Pseudomonadota* (*Proteobacteria*) is less prevalent in agricultural soils than in wastewater, while the opposite was observed for the phylum *Actinobacterota* (*Actinobacteria*). Also, a higher taxonomic prokaryotic diversity was suggested to be observed in treated wastewater than in agricultural soil. The relative abundance of antibiotic resistance genes seemed to be higher in soil than in wastewater, which nevertheless presented higher diversity of genetic determinants. Regarding functions associated with N metabolism, organized in the five main pathways: dissimilatory nitrate reduction, assimilatory nitrate reduction, denitrification, nitrogen fixation and nitrification, it was observed a higher number of nitrogen metabolism genes in the agricultural soil metagenomes in comparison with the effluent core metagenomes. Although most genes, were shared by both types of sample, although represented by



distinct alleles. Area 3 aimed to deliver monitoring solutions for end-users in line with the recent revision of the EU Urban Wastewater Treatment Directive (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:541:FIN;10.1080/10643389.2022.2085956>).

A total of 139 metagenomes (30 influent, 30 sludge, 21 effluent, 58 freshwater) from 24 countries were analysed, using assembled-based and reads-based methods. The results showed that different water types shared a large number of antibiotic resistance genes. The core resistomes of each type of sample were determined and 60 antibiotic resistance genes were listed as putative biomarkers. In parallel, a set of ten antibiotic resistance biomarkers (*int11*, *sul1*, *ermB*, *ermF*, *aph(3'')-Ib*, *qacEΔ1*, *uidA*, *mefC*, *tetX* and *crAssphage*), selected based on predefined criteria, were tested in DNA extracts of raw wastewater, activated sludge, treated wastewater and surface water (upstream and downstream of UWTPs) of samples collected in the Czech Republic, Denmark, Israel, The Netherlands, and Portugal. The results show the usefulness of this approach to implement cost-effective and technically accessible qPCR-based monitoring of wastewater and downstream environment.

**Major Outcomes in 2022:** Expert assistance to the European Commission for the Revision of the European Directive on Urban Wastewater Treatment that resulted in the inclusion of the request for antibiotic resistance monitoring in treated effluents of wastewater treatment plants with > 100 000 p.e. (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:541:FIN;10.1080/10643389.2022.2085956>).

## Automation and Miniaturisation



Regarding flow-based methods, methodologies for the determination of chromium (VI) in recreational waters, nickel (II) in natural waters, and iron and manganese in soil leachates were proposed. An FCT project (Moppwater) on this topic was concluded in 2022, receiving a top mark and praise from the evaluation panel. The method for nickel determination should be emphasized for reaching a rather good detection limit, similar to those displayed by atomic spectroscopic methods. It should also be stressed the possibility to quantify the contaminant chromium (VI) in saline waters. The methods for the determination of iron and manganese allowed direct sampling from the soil column leachate and involved reagents with lower toxicity.

Concerning the design of microfluidic paper-based devices (micropads) for bioanalysis, several works were developed, in which extremely small volumes of samples were applied to paper supports with immobilized reagents. This enabled on-the-spot, inexpensive, disposable sensors without loss of accuracy. Methods were developed targeting urine as a biological fluid of non-invasive collection and determining nitrate and iron as important potential indicators of infection and metabolic malfunction, respectively. A microPAD for magnesium determination in saliva was also developed and its direct correlation with the magnesium levels in blood proved to enable effective biomonitoring. From a different perspective, the determination of phenolic compounds in wine samples was also addressed.

**Major Outcomes in 2022:** Use of dimethylglyoxime for the spectrophotometric flow-based determination of nickel in natural waters. *Comment:* development of a colorimetric method (very few are available) for nickel in water with similar features as those displayed by high profile atomic spectrometric methods.

# FOOD AND NUTRITION

The overall objectives of this Thematic Line are centred on promoting the health and wellbeing of the citizen - focusing on the EU priorities for high standards of safe, nutritious and affordable food, aligned with the 2030 Agenda goals. Challenges throughout the food chain are tackled using innovative research, education and outreach strategies by a multidisciplinary team focused on: i) Microbiological quality and safety of foods; ii) The interface between public health nutrition and food science/technology; iii) High quality and safe foods, through development and optimization studies using engineering as a tool.



## Food Microbiology

Focus on safety and quality, including the adaptation, survival and virulence of microorganisms to stresses imposed by the food supply chain, microbial ecology studies, biological control strategies and impact of microbial metabolites.

## Food Processing and Engineering

Contributing to high quality and safe food products via development and optimisation studies using engineering as a tool. Transport phenomena and kinetics are studied to improve thermal and non-thermal processes (osmotic dehydration, UV radiation, ozone treatments, ultrasound), packaging systems as well as shelf-life prediction. Novel technological approaches are used in developing added value foodstuffs with extended shelf-life.

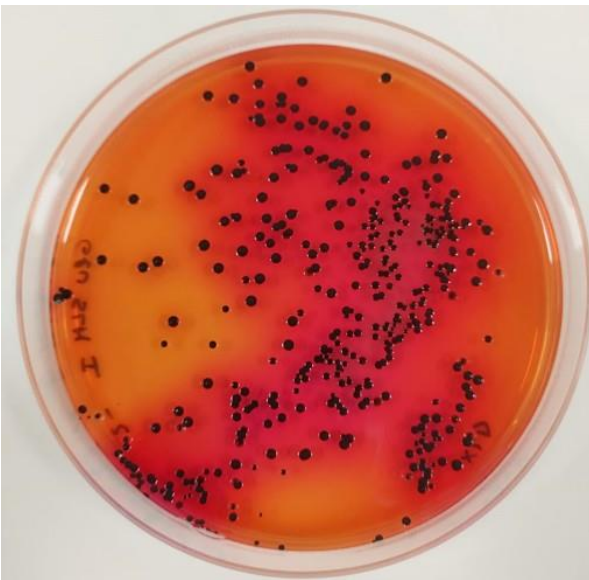


## Nutrition and Health

Focusing on firming research at the interface between public health nutrition and food science/technology, thereby maximizing research translation including dietary assessment tools improvement, setting of links between dietary intake and health, study of new functional products with food bioactives (algae/legumes/cereals) and their impact on biological function including gut microbiome. New encapsulation approaches are studied for bioactives/next generation probiotics.

## Main Achievements in 2022

### Food Microbiology



Studies on biocontrol strategies (phages, bacteriocins, organic acids and plant extracts), targeting the main foodborne pathogens, have been continued. Studies focusing on the production of “Clean Label” meat products without the addition of nitrite were particularly relevant. The most promising strategy has been the use of plant-based nitrate sources as substrate for starter cultures for nitrate reductase production. The impact of these new formulations on the microbiome of the human gut of potential consumers is currently being evaluated.

In the scope of the FCT-funded project RapidPhageSensing, significant results have been achieved in the use of bacteriophages for the rapid and specific detection of *Listeria monocytogenes* and

*Campylobacter* spp. in food samples, using phage nanoparticles as probes for pathogens coupled to magnetic nanoparticles and electrochemical sensing.

In 2022, the FCT-funded project "GenoPheno4trait - Genomic and phenotypic traits contributing to persistence of *Listeria monocytogenes* in food processing environment" has allowed the continuation of genomic characterisation studies of food and clinical isolates of *L. monocytogenes*. To date, more than 1000 genomes have been sequenced, which will allow Food Microbiology LAB to strengthen its national and international position in the study of this pathogen.

Additional knowledge on consumer behaviour along the food journey - from food choice to consumption - on pathogens was achieved and widely disseminated.

As for the line of wine quality and wine protection, our studies aimed to evaluate the ability of specific inactive dry yeasts (IDY) derived from non-*Saccharomyces* yeasts to protect wines against oxidation, enlarging the pallet of solutions to wine producers. IDY prepared from strains of *Hanseniaspora guilliermondii* and *Torulaspora delbrueckii* were found to confer resistance to oxidation of white wine.

The influence of manual and mechanical grape harvest on Merlot wine composition was studied. Results indicate that mechanical grape harvesting does not negatively affect wine composition.

An assay on wine packaging and related sustainability issues was done, having, as output, the publication of a chapter in a book about Improving Sustainable Viticulture and Winemaking Practices. The optimization of the production lines of a wine company through Lean tools was performed.

In total, the laboratory has published 20 articles in peer-reviewed journals, 3 chapters in books and presented several communications at national and international conferences.

## Nutrition and Health

Within the HSoil4Food project: (i) study of population's pro-environmental behaviours showed that the potential health benefits of organic food can explain organic products consumption, yet such was not affected by soils concerns. Although environmental awareness is not greater among consumers with children, their organic foods purchase pattern increased upon having children; (ii) an ongoing quasi-experimental clinical study assessing the effect of a polyphenol-rich organic olive oil on clinical parameters of 30 healthy adult volunteers generated four dissemination events. In cross-cut teamwork with the Plant Biotechnology for Sustainability Lab the role of lentils on cardiovascular health and associated morbidities was studied via an extensive nutrient profiling of different varieties and the development of a muffin, which impact was tested on diabetic patients. Breakfast cereal products consumption patterns in Portugal, consumers' choice drivers, and their awareness on fibre content and its health benefits were assessed jointly with the Bioactives and Bioproducts Lab (BBL).

Pre-hydrolysis and fermentation of cereals, combined with legumes or nuts, influenced positively protein digestibility of tailored functional foods and *in vitro* systems/human trials revealed good faecal *Bifidobacterium/Lactobacillus* groups modulation and that glycaemic index variation depended on cultivar, hydrolysis degree and ingredient conjugation. Further understanding of functional dairy matrices and lipid profiles showed: (i) specific dairy products (low-fat and avocado/coconut/pomegranate oils replacement of milkfat and associated cheese/yogurt) could positively modulate lipid (hepatocytes/adipocytes) metabolic properties and anti-inflammatory response; (ii) linolenic-enriched substrates increased the efficiency of microbially-produced CLNA-enriched probiotic fermented milk; (iii) hybrid dairy yoghurt and cheese systems using plant proteins from cereals/tubers with improved functionality and nutritional profiles were developed; (iv) growth under modulated temperature stress of *Nannochloropsis oculata* enhanced its lipid-associated biological properties and extracts may be safely used to develop new foods. Novel sustainable solutions for additive/sugar/fat replacements toward reformulation of different foods were identified and associated proof-of-concepts developed jointly with the Food Microbiology and the BBL Labs. Layer-by-layer encapsulation and chocolate incorporation strategies for *Akkermansia muciniphila* enabled good survival at atmospheric conditions; *A. muciniphila* and *Faecalibacterium duncaniae* strains demonstrated good inhibitory activity against gastrointestinal pathogenic bacteria.

A series of online programs to ameliorate both emotion regulation and cognitive function of Covid pandemic-impacted university students, integrating psychology, nutrition, health care and arts strategies were put in action. +20 publications with +5 partners from 4 countries.



## Food Processing and Engineering

Strategies contributing to a sustainable circular economy. Application of mild processes such as ultrasound coupled to less severe thermal treatments in processing and production of high quality and safe juices (e.g., kiwi and blueberry). Valorization of the residues of several fruits (avocado and kiwi are examples) throughout transformation into edible forms such as dehydrated flours with interesting rheological properties, meeting current trends in gluten-free flours with high nutritional value. Transformation into pastes for use as a fat substitute in several pastry recipes due to the high fibre content.

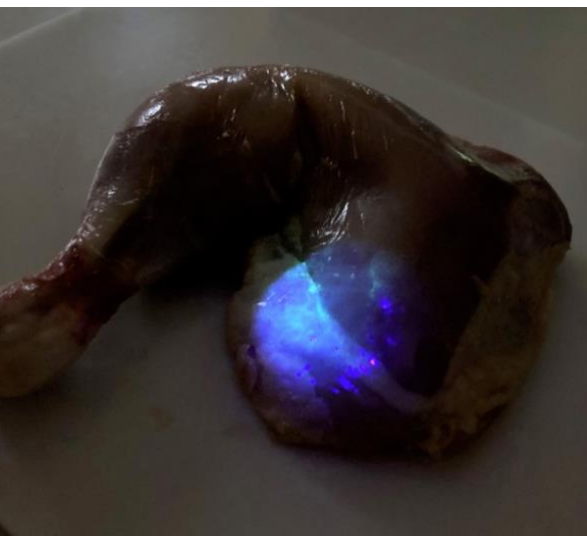
Natural mixed fruit leathers combine the benefits of different fruits as healthy snacks with long-term storage, answering the increasing demand of consumers seeking healthier and more natural products.

A smart data-driven tool using Machine Learning to improve the traceability of the ripening process of Hass avocado pears. Work developed in cooperation with the Laboratory of Metabolomics & Signal.

Extraction and purification of bioactive compounds from olive oil pomace were performed and optimized in collaboration with the Bioactives and Bioproducts laboratory of the Biobased and Biomedical Products Research Group. Extraction methodologies, such as hydroalcoholic maceration, ultra-turrax, ultrasounds, enzymes, were tested, the microwave extraction being one novel method explored as well. Tyrosol, hydroxytyrosol and catechol were some of the bioactive compounds identified and /or quantified by TLC and HPLC. Algae started being studied as well, as a potential source of important bioactive compounds. Regarding the studies on microalgae, PETmet/PE and PE-LD materials were tested for packaging and preservation of powder extracts (freeze-dried) from several species of microalgae.

Application of novel processes to recycle polypropylene packages (super critical fluids) and evaluation of the chemical safety of the processes have been studied. Development of more sustainable packaging based in cellulosic materials using lignin and olive industry wastes have been performed pursuing the improvement of barrier properties and including active components to enhance preservation.

Studies focused on using sensory and consumer science, as they apply to food, to establish and explore the sensory properties of food products, to decode consumer's product experience and to predict products performance in traditional and new markets. Prototyping different Products and Processes, including different technical and economic viability studies, looking forward to possible opportunities for knowledge transfer opportunities. Scale-up studies developed based on patented technologies focusing on the ongoing valorisation processes. Master and PhD were involved in promoting awareness to the knowledge and technology valorisation and transfer processes concerned with applied research.



# BIOBASED AND BIOMEDICAL PRODUCTS

The Biobased and Biomedical Products Research Thematic Line has been organized to combine CBQF capacity to respond to National and EU priority for future growth of Bioeconomy and Circular Economy, reinforcing capacity and opportunities on the bio-based products. The thematic line focuses on these challenges by exploring novel bioactives and bioproducts from renewable sources (including byproducts), promoting added value applications for food, quality of life and biomedical sectors and using metabolomics approaches to understand biological systems or processes. The thematic line involves a multidisciplinary team to respond to R&I challenges with a wide range of competences. Besides the thematic line receives regularly foreign researchers (ca. 10/year), reflecting the internationalization capacity and consolidated network with academia and industry, with technology transfer of eighteen patents. The thematic line is organized in three laboratories:



## Bioactives and Bioproducts Research

Working on integrated solutions to obtain value-added molecules/products from renewable sources, including microalgae, and several agri-food by-products and losses, using bio-refinery approach and revealing composition and bioactive and functional properties to define sustainable and high added value applications towards different industrial synergies.

## Biomaterials and Biomedical Technology

Research on biomaterials and biopolymer engineering for biomedical applications, focusing on wound healing and regeneration and on effective technologies for the terminal sterilization of sensitive biomedical polymers.



## Metabolomics and Signal

Focused on a transversal knowledge detained by CBQF, applied to different biological systems to enable a better understanding of phenomena through signal processing. Several synergies with other internal laboratories have been established to promote CBQF value.



## Main Achievements in 2022

### Bioactive and Bioproducts Research

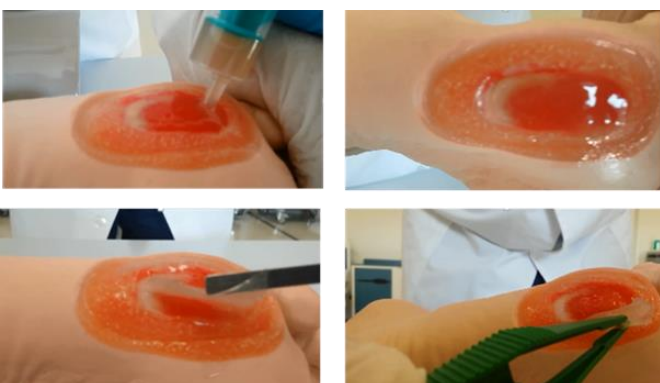
The **Bioactive and Bioproducts Research Laboratory** has expanded the results towards developing new solutions to obtain value-added molecules/products from renewable sources and their applications. Several techniques such as polyelectrolyte precipitation and HPP treatment were tested to obtain high-quality vegetable oils and polyphenols, Ohmic treatment to extract polyphenols and carotenoids from brewing spent grain and tomato, respectively, and membrane technology were used. Different sources for antioxidants have been explored in enriched matrices in polyphenols. The bioactive value of carotenoids in tomato bagasse extracts has been explored, as well as the phenylethyl Isothiocyanate as part of watercress byproducts. Functional proteins and bioactive peptides have been studied, namely using new enzymes (ficin, chicken pepsin, new fungal proteases) to obtain bioactive hydrolysates from dairy sources (casein and whey). Besides, new proteins and peptides from new marine sources were obtained namely from sardine cooking water and from microalgae, namely *Chlorella vulgaris*, and different properties have been studied, mainly the antioxidant and promotion of cardiovascular and gut health and prebiotic potential. Functional lipids from avocado and coconut oils were also explored as anti-obesity molecules.



**Major Outcomes in 2022:** *In vitro* models to validate bioaccessibility and prebiotic potential. The group has achieved a great impact in publications using the simulated gastrointestinal model (Infogest) to understand the bioaccessibility and bioavailability of different bioactives or food products. Several publications of the group have shown different applications, namely of melon peel flour and juice powder, fibre and phenolic-rich flour from Isabel grape by-products as ingredient and incorporated in goat yoghurt, functional oils (coconut, avocado and pomegranate) isolated and incorporated in yoghurt, Quercus ilex leaf extract and brewer's spent grain flour. The prebiotic potential of melon peel flour, skim milk, microbial-fructo-oligosaccharides, flour from Isabel grape by-products and brewer's spent grain flour, demonstrated health benefits by modulation of gut microbiota.

In 2022, the company ETSA started its productive innovation project to build the first factory in Portugal to produce peptides with functional value from animal by-products. This project originated from the MOREPEP research project, developed in our research group and whose results allowed demonstrating the value of the new ingredients that encouraged the company to proceed with a new innovative factory. Furthermore, this new innovation platform allowed the creation of 3 new projects ongoing in 2022 in the group that encourages new ingredients and products based on functional protein hydrolysates: from fish and meat to petfood (Healthypetfood), from insects to petfood (Bugs@pets) and from fish skins (Fishcollbooster). This shows how the research in by-product valorisation can transform the economy.

## Biomaterials and Biomedical Research



The ongoing research on silk biomedical materials for wound treatment and skin tissue regeneration has progressed substantially. The previously developed and patented technology for producing sericin-based *in situ* forming hydrogel was applied to create a new bioink for cell encapsulation and biofabrication. Several silk-based particulate systems have been developed to be applied as therapeutic dressings in low thickness wounds. Sericin/hydroxyapatite nanoparticles were developed using a new oscillatory flow reactor for

its continuous fabrication, in a partnership with Porto University and Tufts University in the USA. In a different system new silk-based bioaerogel particles incorporating adenosine have been produced to be applied to exudative wounds. Adenosine is known to promote angiogenesis during tissue regeneration. This project is in collaboration with the University of Santiago de Compostela (co-tutelle PhD) and in the frame of the COST Action AERoGELS. Silk-based particles have also been incorporated in innovative textile-based wound dressings, as vehicles for the delivery of therapeutic molecules and anti-bacterial agents (TEX4Wounds: “Development of Advanced Textile based Materials for the Treatment of Wounds” (POCI-01-0247-FEDER-047029)). This project is developed in collaboration with CITEVE and companies Somani and Fourmag.

A recent project in the BBT Lab explores the potential of a highly sulfated exopolysaccharide (EPS) extracted from marine microalgae *Porphyridium cruentum* for wound healing and regeneration. This project is being developed in collaboration with company AllMicro, one of the biggest national producers of microalgae, in a sustainable way.

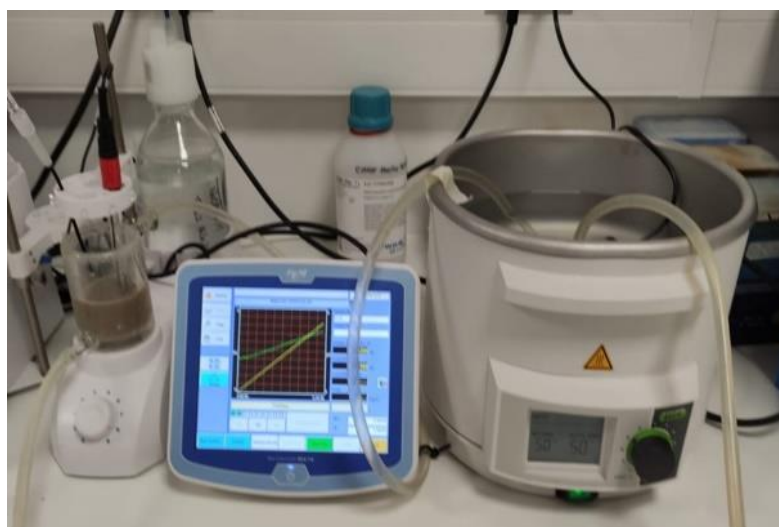
Supercritical CO<sub>2</sub> technology continues to be explored to assist in the decellularization of biological tissue. In this particular project the main objective is to obtain innovative decellularized placental-based biomaterial as a tissue microenvironment, to create new hydrogels for *in situ* skin tissue engineering. This research line has fostered new collaborations with several partners in the academia, (Maastricht University, The Netherlands, the Medical School of the University of Porto) and the industry sector (Company Novasterilis, USA). Also new possibilities were raised in the frame of PRR project BE@T for the decellularization of suine-based biological tissue to produce functional an instructive scaffold material for tissue regeneration. This project has the collaboration of company Seara as the biological tissue supplier.

Oro-dispersible films containing post-probiotics to control unwanted microbial proliferation and to modulate oral microbiota are being formulated. The use of antimicrobial textiles for the control, modulation and amelioration of skin conditions through its microbiota is also being evaluated in the context of the PRR project Be@t, in collaboration with several research institutions and companies. Skin wound healing applications through immunological boosting by b-glucans derived from the mushroom *Coriolus versicolor* are being studied, but the process of extraction and purification of the b-glucans, is still being optimized.

In a collaboration with the Signal and Metabolomics Laboratory, an image analysis semi-automatic system for colony-forming-unit counting was developed and later a smart-data-driven tool was also created that enables the discrimination of different colony types while counting.

This research activity has been conducted by 2 senior researchers, 4 Post-Docs, 5 PhD researchers in 2022. The laboratory collaborated with 13 external entities, which resulted in the publication of 14 papers in international peer reviewed Journals and participation in 5 international scientific events. The laboratory was able to establish strong internal collaboration with 3 of the thematic laboratories through projects or publications.

## Biosignals and Metabolomics



Major outputs for this Lab year were: 1 Patent, 15 full paper articles: 7/15(Q1); 5/15(Q2); 1/15(Q3); 2/15(Q4), 2 Book Chapters, 2 Member of International Conferences Organizing Comities + 2 National, 3 Special Issue Guest Editor, 1 prize for the best poster in an international conference, 1 paper in conferences proceedings, 3 abstracts in conferences proceedings, Ph.D. Students (3 Supervisions + 2 Co-supervisions), M.Sc. Students' supervisions (8 supervisions and 1 co-supervision), 2 International Organizing Committees, 3 FCT projects member (1 as Leading Scientist @UCP + 2 Scientist), BfK Ideas 2022 semi-finalist with project GESTECH4I, 1 Project, Compete 181302 - 3Boost: *Transferência de Conhecimento em: Biotecnologia Agro-Alimentar, Biomedicina, e Bioinformática*, Role: Project Scientific Coordinator of Bioinformatics area.

# FERMENTATION SOLUTIONS

The Fermentation Solutions Research Thematic Line focuses on white biotechnology fermentation processes, on the resulting by-products and value-added biomolecules, using renewable sources of carbon and nutrients (e.g., sugarcane). The use of white biotechnology is essential for the future competitiveness of European industry, providing a sound technological base for a sustainable society and bioeconomy and for the development of bioindustries of the future. This line works on the development and improvement of fermentation processes for industry, on finding attractive solutions for their by-products and disruptive applications for the produced biomolecules. Applied research and market driven innovative solutions for cosmetic and skin care, pharmaceutical, food and animal feed and materials applications with strong engagement of companies at an early phase of product development. Activities are settled in a profound link and interaction with European and International industries. This thematic line involves a multidisciplinary team to respond to R&I challenges with a wide range of competences, and is organized in three laboratories:

## Strain design and fermentation

Uses in-house built software products for microorganism's design, genome editing tools, metabolic and physiological engineering to develop efficient fermentative processes, which are optimized on lab-scale bioreactors to obtain large amounts of value-added bio-products/biomolecules, e.g., high value terpenoids for the pharma, cosmetic, and food industries.



## Biomolecules innovation

Focused on understanding and unfolding the potential of different sustainable biomolecules produced via fermentative processes, aiming to create new products and business opportunities in the fields of cosmetics, pharma, nutrition and biomedicine.

## Valorisation of fermentation by-products

Focuses on the development of integrated processes to value fermentation by-products through the use of green extraction technologies, purification processes and product formulations for cosmetic, food and animal feed industries.





## Main Achievements in 2022

### Strain Design and Fermentation

The **Strain Design and Fermentation Lab** has been working with the consolidation of an integrated platform of yeast design and fermentation for efficient and sustainable production of new biomolecules for pharma, cosmetic, and food industries. New biomolecules are under development by strain design using an in-house built software for microorganism design, genome editing tools, metabolic and physiological engineering. In this line, a new yeast strain was designed, which will produce carnosic acid, a compound with known antimicrobial activities that can be used as food and cosmetic preservative. This Lab focused on the improvement of the fermentation performance and biomolecules production, by media and process optimization, in shake-flasks and 2L bioreactors, using newly engineered yeast strains, part of them designed by this Lab in collaboration with Amyris. These include, strains producing farnesene, carnosic acid, artemisinic acid, and overexpressing intracellular molecules able to aid yeast resistance to specific stress factors. Of noting, a kinetic model was applied to describe the transfer of phenolic compounds from the sustainable feedstock sugarcane syrup to the fermentation medium during farnesene production. Media optimization included the addition of antioxidant supplements produced from industrial fermentation by-products, such as peptide extracts from spent yeast. In addition, collaborations with other companies were established. Namely, the fermentation technology of farnesene and artemisinic acid, optimized in 2L bioreactors, was transferred to two companies, that visited this Lab, DSM (Delft) and Huvepharma (Bulgaria), respectively.

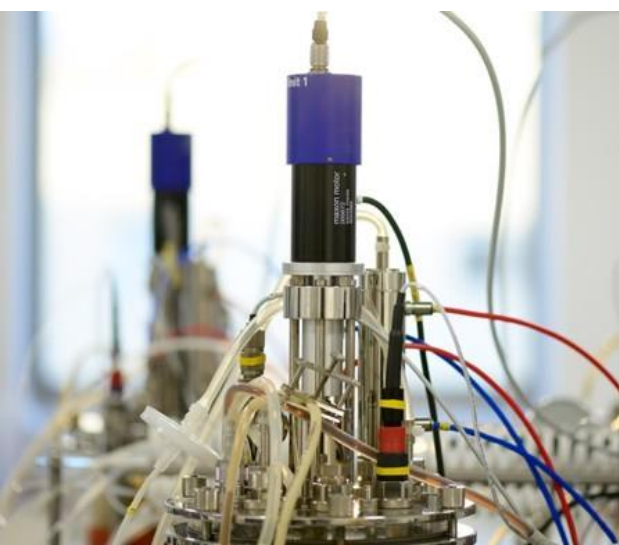
### Biomolecules Innovation

The **Biomolecules Innovation Lab** is focused on understanding and unfolding the potential of different sustainable biomolecules produced via fermentative processes, aiming to create new products and business opportunities in the fields of cosmetics, pharma, nutrition, and biomedicine. Over the last year, the group has been implementing a set of cutting-edge methodologies aiming to test and validate different ingredients/formulations as effective dermocosmetic solutions for a range of skin conditions. This has resulted in the identification of biomolecules and/or extracts with capacity to prevent or ameliorate the effects of aging on skin, ingredients with potential to tackle different skin conditions (e.g., psoriasis, erythema, atopic dermatitis...), as well as to protect skin from environmental aggressions, or to promote hair growth. The capacity to understand the impact of each ingredient upon the human microbiome has also been a main objective of our lab. Therefore, in 2022 we have also directed our endeavour to implement methods allowing to assess the effect of different ingredients/formulations on scalp and vaginal microbiome balance and diversity, aiming at assisting the development of hair and intimate care products.

Investing in external collaborations has also been a key theme to the Biomolecules Innovation Lab. Different collaborations were established aiming at supporting the different methodologies currently being implemented at our labs, as well as at backing up our desire to innovate. Organizations such as Maio Clinic, Grupo Lusíadas, Clínica Nuno Mendes, Grupo Luz or Hospital São João have associated to our lab over 2022 as strategic partners. The Lab was also successful in capturing competitive funds along last year. Projects RADBIOME - *Changes in oral, skin and gut microbiome mediated by*

radiotherapy and their potential roles in the prognosis of radiotherapy induced Dermatitis and oral mucositis: Cohort study, and EIDIR - Emerging Infectious Disease Response Toolbox, were funded by the Centro de Investigação Interdisciplinar em Saúde and the Agência Nacional de Inovação, respectively.

## Valorisation of fermentation by-products



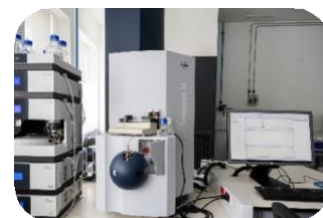
The **Valorisation of fermentation by-products Lab** is engaged in the development of integrated and cost-effective green processes to value by-products from industrial fermentation. Over the last year the group has been involved in the exploitation of fermentation and sugarcane side streams to develop ingredients for agriculture, pharma, nutraceutical, animal feed, cosmetic, packaging and biomaterials markets. Specifically for agriculture use, the Lab designed an organo-mineral soil additive, produced from Amyris fermentation side streams, which is being produced at pilot scale in a collaboration with ZeoGroup (ZeoCEL-PT and Celta Brasil-BR) for field studies. Targeting cosmetic market, an innovative formulation for the development of a biodegradable anti-aging eye patch was developed (resulting in a patent application), as well

as a lignin-based UV blocker and antioxidant. Furthermore, four ingredients based on sugarcane straw polyphenols, polysaccharides from bagasse, vinasse and distillation bottom are being validated in clinical trials for their cosmetic applications potential. Regarding the valorisation of sugarcane residues, the group explored the potential of microcrystalline cellulose as a new excipient for Pharma and Nutra applications, establishing a strategic collaboration with Nitro Química for the pilot production of this ingredient. From spent yeast, mannan oligosaccharides, peptides and glucans were extracted and validated as nutraceutical ingredients for urinary tract infections prophylaxis, carriers for iron supplements and cosmeceuticals, respectively. Lignin and mannan-based ingredients were also tested for animal feed, due to their prebiotic properties. Finally, within packaging and biomaterials, developments were achieved with a lignin-based barrier coating for food and cosmetic packaging (in collaboration with NOTPLA (UK), and with a process to transform lipid residues into polyols (one of the bases to produce polymers), to be used as substitutes for petroleum-derived compounds, which also generated a patent (Compositions and methods for the synthesis of bio-based polymers). Apart from the above-mentioned collaborations, several others were performed along this year, namely with TMG and Logoplaste for identification of automotive industry needs, with PIEP / University of Minho for consultancy in the characterization of materials, with Firmenich and Ingredion for interest in testing the Alchemy ingredients, with Minerva for identification of industry needs in the sector of animal feeding, with Unilever to exploit the interest in exploitation of lignin as SPF filter and formulation aid for sunscreens, and with *Nakheel Oman Development Company from Sultanate of Oman* which requested the Group to study the valorisation of dates. Campden BRI (UK) and Laboratório Nacional de Biorrenováveis (LNBR) were also contacted for support in the scale-up and pilot scale production of sugarcane straw/bagasse-based ingredients.



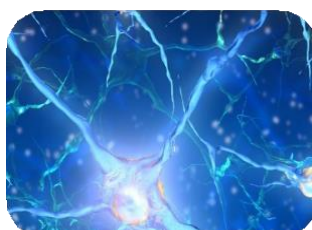
## 4. PLATFORMS

The specialized staff at the CBQF **Analytical Chemistry** platform work with a range of instrumental analysis possibilities, which approaches are based on mass spectroscopic, spectrometry and electroanalytical techniques, and flame detection methods.



The **Bioactives** platform offers the capacity to perform complete biochemical, biological and functional profiles of bioactive compounds and matrices and bioproducts, considering several different types of applications from food ingredients to cosmetic aimed for human or animal consumption.

The CBQF **Consumer and Sensory** platform focus on using science to establish and explore the sensory properties of food products, to decode consumer's product experience and to predict products performance in traditional and new markets.



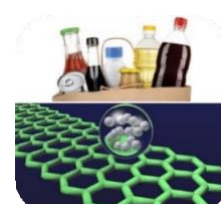
The **Structural Analysis** platform is operated by researchers in the biotechnology field and offers the capacity to perform very complete physico-chemical and morphological characterization of samples, with special focus on liquids and semi-solids aimed for human consumption or application.

The **KitchenLab** is a true atelier of food possibilities, with all needed for the design, handling and preparation of food, framed in a research center equipped with the most advanced resources in the areas of chemistry, biology, physical and sensory analysis, dedicated to food science and technology and human nutrition.



The **Cell Culture and Molecular Biology** Platform comprises: a Cell Culture Lab (screening of therapeutic or toxicological/ pathogenic activities of chemicals, materials, and microorganisms) and a Molecular Biology Lab (extraction, purification and quantification of nucleic acids, and the expression and quantification of particular genes from biological samples).

The CBQF **Packaging & Materials** Platform allows the characterisation, development and testing of materials and packages, regarding safety and food shelf-life. It hosts the Portuguese National Reference Laboratory for Food Contact Materials.



## 5. HIGHLIGHTS

### Five Researchers from the CBQF in the World's Top of the Most Cited Scientists, according to Stanford University

Célia Manaia in Microbiology / Environmental Sciences; João C. Fernandes in the area of General & Internal Medicine / Food Science; Manuela Pintado in Food Science / Microbiology; Marta W. Vasconcelos in Food Science / Plant Biology & Botany; Paula Teixeira in Microbiology / Food Science. Five researchers from the CBQF are part of the World's Top of Most Cited Scientists, according to Stanford University (USA).



### Católica is the best University in Portugal for the 4th consecutive year

Universidade Católica Portuguesa was recognized, for the **4th consecutive year**, as the **best Portuguese university** by Times Higher Education, in THE World University Rankings 2023.

### New Ambassador of The Netherlands visits Universidade Católica in Porto



The new ambassador of The Netherlands in Lisbon, Margriet Leemhuis, has visited the Universidade Católica in Porto, for a meeting with Isabel Braga Cruz, president of Católica in Porto, Paula Castro, director of the Faculty of Biotechnology (ESB), and Manuela Pintado, director of Centre of Biotechnology and Fine Chemistry (CBQF).

### Researcher Célia Manaia is one of the most cited scientists in the world

Célia Manaia, researcher at the Centre for Biotechnology and Fine Chemistry (CBQF) at Universidade Católica Portuguesa, in Porto, is, for the third consecutive year, one of the most cited scientists in the world.



## More than 30 entities join INSURE.hub

Launched in October 2021, at a public event, INSURE.hub is already fulfilling its great objective: to create a vibrant, national and international ecosystem of transdisciplinary knowledge with a circular, sustainable and regenerative scope.



## Biosensor for diagnosis of multiple sclerosis and Biofertilizer based on potato peel win Amyris Innovation Awards



The winning projects of the 2nd edition of the Amyris Innovation BIG Impact Awards are already known. The Amyris BIG Impact Innovation Award was awarded to the BrainSense project, which developed a biosensor for the diagnosis of multiple sclerosis. The Rising Innovation Award was given to the HydroPLUS project, which developed a biofertilizer based on potato skins.

## More than 500 students from elementary and high schools participate in the International Microorganism Day Fair

More than 500 students celebrated the fascinating world of microorganisms with the Centre of Biotechnology and Fine Chemistry (CBQF). Within the scope of the International Microorganism Day, celebrated on September 17th, researchers from the CBQF have promoted on September 23rd an outdoor science fair, that, with their extended expertise, prepared and dynamized several interactive activities.



## Católica in the World TOP 5 in the objective to promote “Peace, Justice and Effective Institutions” in THE Impact Rankings



Universidade Católica Portuguesa (UCP) is among the 5 institutions with the best results in the Sustainable Development Goal for the promotion of “Peace, Justice and Effective Institutions” (SDG 16), maintaining its global position in the ranking (301-400).



## Fernando Alvim records “Prova Oral” at the Centre for Biotechnology and Fine Chemistry



Fernando Alvim, radio broadcaster and comedian, came to CBQF to record an episode of the program “Prova Oral” on Antena 3. The theme was insect-based food, within the scope of the ChangeEat!, which is led by the Business and Economic Research Unit of CATÓLICA-LISBON (CUBE) and the CBQF, being an integral part of the European project SUSINCHAIN - SUStainable INsect CHAIN.

## Closing session of the Mentorship Program “Comendador Arménio Miranda”

MSc students participated in the mentoring program supported by “Comendador” Arménio Miranda, in which they developed a new product/prototype in the agri-food area in line with new food trends.



## Events

**49** Biotalks, Seminars and other Scientific Meetings and Conferences organized

## Media Reach

**503** Media News:

**20** TV News pieces

**6** National Radio News

**65** News in Printed Press

**412** News in Online Media

**11,1 M** Visualizations

**8.84 M€** Advertising Value Equivalent

## Coordination of International Projects

In 2022, CBQF run 3 international projects under its coordination:

### RADIANT - Realizing Dynamic Value Chains for Underutilized Crops



[radiantproject.eu](http://radiantproject.eu)

RADIANT is a Horizon 2020 project that aims at promoting crop diversification, the loss of genetic diversity in crops, with only a few dominant crops providing most human diet's calories and nutrition greatly contributes to food insecurity. Latest EU agricultural policy guidelines and consumer and environmental concerns will drive farmers to promote plant diversity. RADIANT proposes inclusive solutions to create Dynamic Value Chains for underutilized crops (UCs), which are currently overlooked but have a crucial role in fighting

hunger and malnutrition. RADIANT selected 20 Pilot farms, called AURORA Farms, to serve as knowledge and inspiration hubs for co-creation of new crop management alternatives and integration of UCs in value chains, bringing locally grown diversity from farmers to consumers.

In its first 18 months, RADIANT built a new Consortium specifically for UC promotion, the Underutilised Crops Cluster (UCC). The UCC is a community of practice for transformation of agriculture, gathering hundreds of stakeholders, and engaging with actors using specialised channels. One of these communication and networking channels, are the CREATOR Workshops, organised through Europe by project partners. So far, four events have been the stage for important discussions about heritage and ancient crops, new technologies for processing, and innovation in production systems.

As a multi-disciplinary project, different outputs have contributed to improve the management of UCs (Deuchande and Vasconcelos 2023, Trasoletti et al. 2022, Voutsinos-Frantzis et al. 2022); characterising UCs' functional traits (nutritional, health and environmental provisions) (Ferreira et al. 2022, Geraldo et al. 2022, Krenz & Pleissner 2022, Krenz et al. 2023, Silva et al. 2023); and delivering policy, social and governance transformation avenues to embrace diversity towards greater value and choice to consumers (Pinto et al. 2022, Vieira et al. 2022). A total of 13 project deliverables were produced, depicting the efforts towards breeding activities, with several collections already being multiplied and made available to partners for future trials (Salazar-Licea et al. 2022); the holistic sustainability and resilience analysis of multifunctional value chains (Styles et al. 2022); the development of a framework to analyse current policy and governance of agrifood systems (Balázs et al. 2022); the engagement of multiple value chain actors for UCs across Europe (Sasa 2023).

Current activities are focusing on developing, together with 45 participatory farmers that were selected via an open call, transition diaries that will showcase the benefits of introducing UCs in European farming systems.

### RECROP - Bioinocula and cropping systems: an integrated biotechnological approach for improving crop yield, biodiversity and resilience of Mediterranean agro-ecosystems

ReCROP aims to foster the sustainability and resilience of agricultural production systems in the Mediterranean region through the combined use of biotechnological tools, such as bioinoculants and environmentally friendly agronomic practices, including plant intercropping and crop rotation, application of amendments. These innovative sustainable solutions towards a more resilient and sustainable agriculture are being implemented and tested in a network of already established and newly settled experimental field trials located in Egypt, France, Italy, Morocco, Portugal, Spain, and Tunisia.



[cbaf.esb.ucp.pt/en/recrop](http://cbaf.esb.ucp.pt/en/recrop)

All experimental sites were designed to evaluate the beneficial effects of the combined use of microbial inoculants, amendments, and cropping patterns on growth and yield of the 3 target crops - vineyards, maize, aromatic/medicinal plants - growing in different climates and soils across the Mediterranean area. Special attention has been given to the impact of these practices on microbial soil structural and functional biodiversity. Several trials were already sampled for the assessment of microbial, meso- and macrofauna communities. The comprehensive characterization of soil biodiversity through the combination of classical taxonomy and next generation sequencing technologies will promote “productivity-biodiversity” binomials. Activities including workshops, questionnaires, etc, have also been carried out to characterize from a socioeconomic perspective the main drivers to encourage farmers to use greener practices. The work developed in ReCROP has been presented locally to stakeholders at national and international conferences and workshops.



### **STARGATE - Sensors and data training towards high-performance Agri-food systems**

STARGATE is a collaborative project funded by Horizon 2020 through the “Twinning of research institutions” of the Widening program. It focuses on enabling the Centre for Biotechnology and Fine Chemistry (CBQF) of the Catholic University of Portugal (UCP) to become a centre of excellence at the international level in the use of sensors, multi-omics and plant phenotyping technologies and to gain

a deeper understanding of the management of desired traits that enable sustainable and resilient agri-food systems. Some of the most important outputs of the STARGATE Project achieved by the end of 2022 include: four workshops on selected scientific themes; two Training Schools involving all partners; three short-term scientific missions (STSM) of PhD students and young researchers between partners; the STARGATE Conference in Odemira, Portugal, on the 4th of October 2022; one paper was published on the cover of Trends in Plant Science (DOI:[https://lnkd.in/ejxP\\_PZR](https://lnkd.in/ejxP_PZR)), four STARGATE Newsletters; The Consortium has engaged with food-system Stakeholders through interviews and thematic events, and implemented the international Mentoring Programme for PhD students, training future scientists in this area.

## The Alchemy project

The Alchemy project is divided into 5 subprojects and is focused on the development of products and ingredients for different applications, such as cosmetics, food, animal feed and materials. Residues coming from fermentation value chain including sugarcane processing for sugar production, as well Amyris biomolecules fermentation processes are being valorised, including sugarcane straw, bagasse, and ashes, fermentation vinasse and distillation residues, and spent yeast by-product. Alchemy is also developing next-generation design platform for biofabs, using fast, user-friendly interfaces that can be used by genetic engineers inside and outside Amyris. A further objective is to develop strategies to maximize the yields of Amyris biomolecules, improving the fermentation process productivity with the least possible number of resources, and find new applications for these biomolecules.

Concerning the residues valorization projects, after an initial stage dedicated to characterize their value, develop technologies to obtain fractions and extracts, focus was on finishing the development of product prototypes, before validation, and on improving fermentation processes, as well as on valuing biomolecules applications increasing their commercial range of opportunities.

The most advanced Alchemy product, sugarcane ash cosmetic biosilica, is at industrial scale-up phase. Other highly innovative prototypes for cosmetics and skincare were developed, such as an anti-aging product rich in sugarcane straw phenolic compounds, a



cosmetic emulsifier rich in bagasse polysaccharides, and an ingredient based on biosilica microparticles as a fragrance transport, an anti-aging ingredient rich in phenolic compounds, peptides and minerals from fermentation vinasse and a lip balm based on glucans with antiherpetic properties, and a hydrogel to deliver bioactive compounds. For this application, several new biomolecules were tested showing different bioactivities - for the treatment of psoriasis, anti-aging and softening properties. Most of these products' performance will be validated using human trials to confirm the in vitro effect.

For food and nutraceutical markets, two ingredients were developed based on lipid extracts obtained from straw and bagasse and distillation residue with hypocholesterolemic, antihypertensive and antidiabetic activities. Also formulations rich in extracts of yeast manna oligosaccharides (MOS) for prevention of urinary tract infections and rich in iron-peptide complexes for supplementation and anaemia prevention. The in vivo validation was planned in collaboration with Coimbra University (IBILI).

For agriculture and animal feed products, Alchemy developed: a technology with enhanced functionalities based on carboxymethylcellulose to extend the post-harvest quality of fresh products; an hydrogel prototype based on cellulose extracted from bagasse and loaded with urea as a fertilizing agent for plant growth, such as corn seed germination; and a product based on yeast with insect repellent activity, tested with Faculty of Sciences of the University of Porto. For animal feed, different prototypes of functional ingredients were developed, prebiotic based on sugarcane lignin and vinasse for chicken feed, another based on sugarcane bagasse oligosaccharides, autolyzed yeast yeast-derived ingredient, MOS for calves and cattle based. For aquaculture, an additive based on vinasse and yeast MOS for aquaculture (sea bass) were developed. All these prototypes are being planned to be validated in animal models under collaboration with ICBAS (Vairão) and CIMAR, and Universidade de Trás-dos-Montes e Alto Douro.

In the area of materials, prototypes of sugarcane cellulose nanocrystals were developed, as well an extract obtained from distillation residue polyols to produce biomaterials, and an oil for use as a surfactant.

The next-generation design platform and software has been developing interactive and explanatory design options for yeast strains, as well as the design of guided metabolic pathways combining visualization design algorithms, experiment design, research and part selection, mutagenesis, and chemical pathways. Finally, collaborating in the conception, assembly, and selection of strains producing Carnosic Acid.

In the improvement of Amyris yeasts and fermentation processes, activities focused on the fermentation steps optimization and production of different biomolecules, and modifications on gene expression for better performance in fermentations. Extension studies of the chronological and replicative capacity of Amyris yeasts were carried out with success. Natural antimicrobials have been tested in fermentation processes to reduce microbial contaminations. For the improvement of fermentation processes by preventing the occurrence of fermentation blockages due to sudden drops in nitrogen levels, prototypes of new technologies were successfully developed. Amyris biomolecules tested showed different bioactivities; for psoriasis treatment, with a therapeutic effect like that obtained with topical corticosteroids, and for anti-aging and softening properties.

In 2022, Alchemy results dissemination resulted in 14 scientific articles, 42 oral and posters communications and the presentation and publication of 2 master's theses.

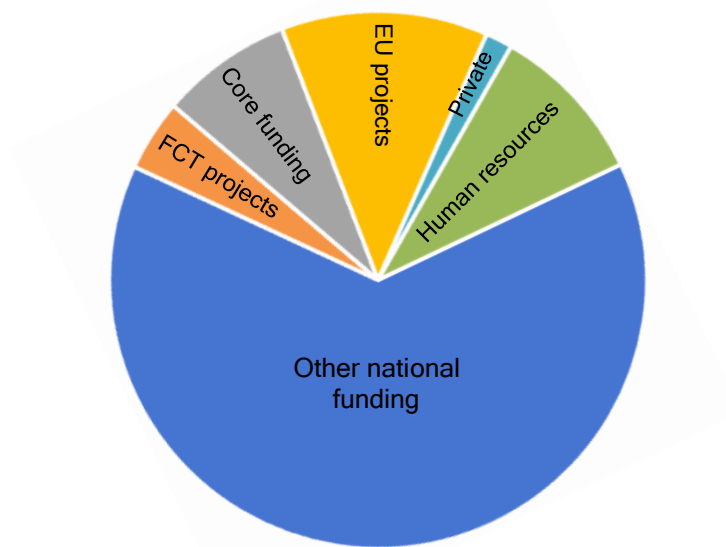
A profound and productive link between Alchemy and European and international biotechnology, pharmaceutical, cosmetic and food industries is one of the main objectives. During 2022, the team has met with R&D teams of national and international companies from different fields to show the project results.

A great synergy was the development of analysis and characterization platforms: Analytical and Structural, Metabolomics (including lipidomics), Nutritional Analysis, Technological Properties and Structural Analysis of biomolecules, extracted compounds and new products. Other platforms were very important in the characterization of the developed prototypes (e.g. the Bioactivities and Safety platform with Microbiome included). The Fermentation platform can reproduce industrial fermentation processes on a laboratory scale, and applying strategies to improve biomolecule production.

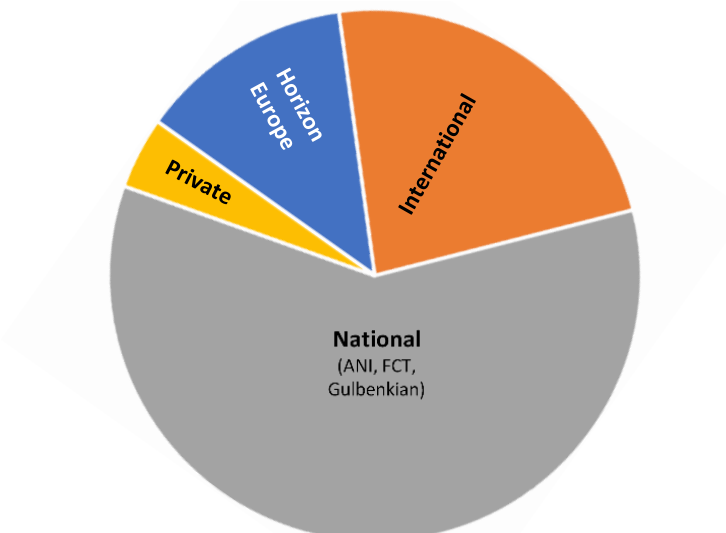
## 6. FUNDING

CBQF is supported by the Foundation for Science and Technology (FCT) and competitive funding secured from national and international sources. In the past 5 years, CBQF has been granted competitive R&D funding from national (€42.6M) and international sources (2.9M€, European Commission and other international). In line with its applied science profile, CBQF also secured >1.5M€ from private sources. In 2022, CBQF had competitive projects running with a total funding executed during the year of 5.9M€.

Competitive funding by source



Competitive funding source (number of projects)



The total secured in funding in 2022 amounted to ca. 9,56 M €, and a total budget executed above was 6M€.





CATÓLICA

CBQF · CENTRE FOR BIOTECHNOLOGY  
AND FINE CHEMISTRY ASSOCIATE LABORATORY


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