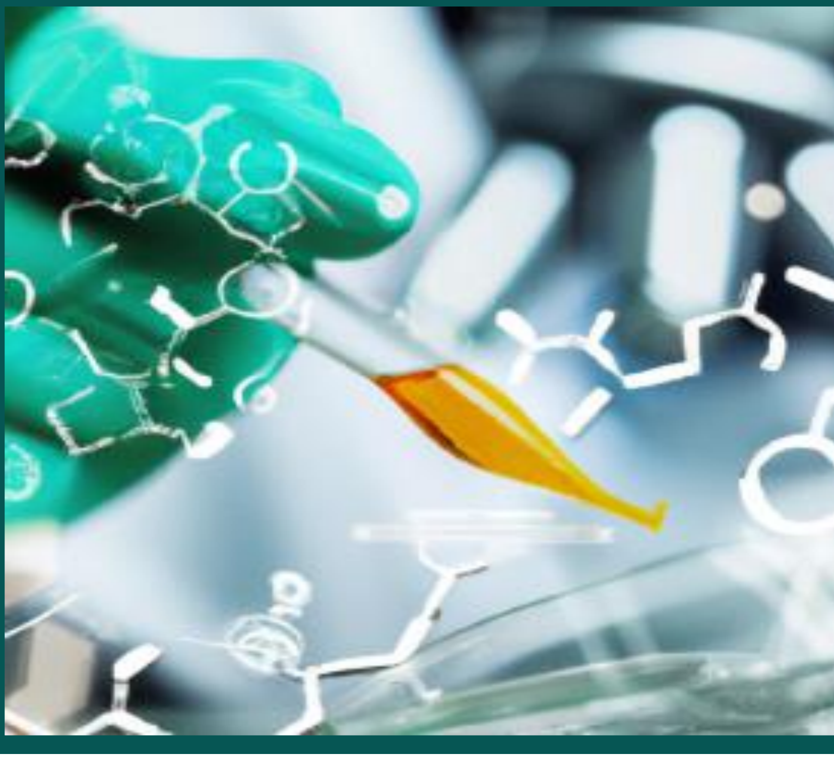
SITUATION ANALYSIS REPORT

Bridging the Gap Between Biotechnology and Industry: Integrating Design Thinking and Flipped Learning



Co-funded by the European Union

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Project Information

Project name	Bridging the Gap Between Biotechnology and Industry: Integrating Design Thinking and Flipped Learning	
Project acronym	BIOTE(A)CH	
Project number	2022-1-TR01-KA220-HED-000085597	
IO1 – Lead partner	UNITUS	
Document title	Situation Analysis Report	
Dissemination level	Public	
Version number	**Date released**	**Authors and contributors**
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1. Executive Summary

The BIOTEACH project stands at the intersection of academia and industry, addressing the evolving landscape of biotechnology and its impact on the future workforce. Recognizing the critical role universities play in equipping students for successful careers, the project fosters a collaborative environment where academics and industry professionals work together. This synergy aims to bridge the divide between theoretical knowledge and the practical skillset demanded by agricultural biotechnology sectors.

Through a comprehensive analysis of both academic and industry perspectives, BIOTEACH seeks to identify current trends, knowledge gaps, and potential challenges faced by graduating students entering the workforce. Ultimately, the project aspires to contribute to the development of a well-rounded undergraduate curriculum in biotechnology. This curriculum will ensure graduates possess a comprehensive skillset and the necessary knowledge to smoothly transition from academia to industry, becoming key players in shaping the future of bio-innovation.

Objectives

The partners of BIOTE(A)CH identified the objectives of the questionnaire and the workshop as follows:

1. To identify the innovations and challenges in the bioeconomy and agricultural biotechnology through the lenses of academicians and private sector representatives.
2. To understand the current knowledge and skills the university students studying in biotechnology areas should have when they start their profession.
3. To understand the difficulties university students studying in biotechnology areas will encounter in the industry when they start their profession.
4. To contribute to the preparation of the curriculum for the undergraduate students in biotechnology areas as the first intellectual output.

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Table of Contents

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2. Introduction

Biotechnology is a rapidly growing field that combines biology, engineering, and technology to solve practical problems and develop innovative products and processes. There is a growing awareness of biotechnology education to provide graduates with the necessary skills and knowledge to succeed in the biotech industry. However, recent graduates often suffer from a lack of practical experience, industry-specific knowledge, and social and analytical skills in finding employment. As a result, the transition from school to work is hard for them.

One of the main challenges that recent graduates face is the lack of practical experience. Hence Biotechnology employers expect recent graduates to possess technical skills otherwise they spend time and money on training. Laboratory techniques such as sequencing, basic molecular biology methods, cell culture, cloning, and bioinformatics tools are essential for undergraduate programs to ensure that students receive hands-on laboratory training and experience with relevant equipment. Therefore, University Departments can encourage students to participate in research projects and internships that emphasize analytical and social skills. Through the internships, students probably will have a first experience to meet professionals in various levels. By participating in a research project, students learn to work as a team where members share responsibilities to complete the project. Eventually, students gain new skills and learn how to improve themselves.

In addition to technical skills, graduates are expected to possess analytical and soft skills, including effective communication, problem-solving, time management, and entrepreneurial skills. Biotechnology employers require graduates to have the ability to analyze and interpret experimental data, troubleshoot experimental problems, and propose solutions, as well as attention to detail and accuracy in data recording and analysis. Graduates must also have effective written and oral communication skills, the ability to present scientific data and concepts clearly and concisely, and the ability to work in teams and collaborate with colleagues from diverse backgrounds.

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The several courses involved in fortifying and elevating student skill strength appear to be significant for the university departments' curriculum to address these challenges. Many departments have the following courses: scientific writing and presentation, entrepreneurship or innovation, project management and planning into coursework, workshops and training programs in communication and public speaking and offer hands-on laboratory courses along with the core courses. By doing so, students can gain valuable soft skills and develop their professional abilities. On the other hand, Biotechnology departments collaborating with the industry can offer students industry-specific knowledge, and problem-solving experience once they incorporate a spesific training programs.

Moreover, promoting entrepreneurship and innovation can enable students to identify and pursue opportunities for growth and innovation in the biotechnology industry. By exposing students to the business side of biotechnology, biotechnology departments can prepare them to be entrepreneurs and innovators who can create new products and technologies that can benefit society.

While the solutions mentioned before, such as internships, industry-specific courses, and laboratory training, can help students acquire the necessary skills and knowledge to succeed in the biotechnology industry, they also have their limitations. Not all students have access to good internships due to limited availability and competition for placements. Additionally, projects may have limited resources to include all interested students, and laboratory facilities and the advisory role of student projects may also be limited. Furthermore, the high number of students in classes can limit the effectiveness of the courses, as instructors may have limited time to provide individualized attention and feedback. Therefore, while these solutions can be effective, they may not be accessible or feasible for all students. To address these limitations, it is important to explore additional solutions that can help all students acquire the necessary skills and knowledge to succeed in the biotechnology industry.

In conclusion, to address the challenges, our project aims to create a curriculum that enhances the transition from higher education to the labor market in agricultural biotechnology. Using design thinking principles, our project will incorporate recent technological achievements to develop teaching materials that support course delivery designed with flipped learning. Our main objective is to equip students with the necessary skills and knowledge to succeed in the biotechnology industry, while also addressing the limitations of traditional approaches. By offering a comprehensive and innovative curriculum, we hope to provide students with the tools and resources they need to succeed in the biotechnology industry and contribute to global challenges such as food security, healthcare, and environmental sustainability.

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3. Survey and Workshop Methodology

Biotechnology finds application in numerous industrial sectors, including environment, health, energy, agriculture, and food. The BIOTE(A)CH project consortium consists of academics with primary research interests in food, environment, and agricultural applications. As such, the survey that was prepared for the consortium focuses on these areas, with questions designed to shed light on the challenges and solutions in the biotechnology field, as well as to gather data on the practices of those working in this field.

During the survey's preparation, consortium partners first exchanged views via email before jointly developing and refining the questions in an online working document on G-Drive. At the first face-to-face meeting in Çanakkale, the partners discussed each question in detail to finalize the survey. They decided that the survey would be conducted in English since the target group was expected to be proficient in the language. Translation into the partners' languages was deemed unnecessary, but interested partners were invited to do so.

The survey was duplicated on Google Forms, one for each partner country, and shared with academics and industry representatives working in the field of biotechnology who are part of the target group. The survey received responses from:

Turkey: 38

Croatia: 23

Slovenia: 21

Italy: 22

Greece: 18

resulting in a total of 122 respondents. The survey included open-ended, closed-ended, multiple-choice, and yes-no questions. The answers to these questions were analyzed separately in each partner country, and the results were presented in tables and paragraphs in the analysis report. A general conclusion was

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also provided after a detailed analysis of the questions. The report design facilitates the comparison of data obtained in partner countries.

During the kick-off meeting in Çanakkale, workshops were planned. It was decided that the workshops would invite a minimum of 8 and a maximum of 15 participants, and that they would be organized into one or two mixed groups consisting of academics, industry representatives, and students studying biotechnology. Partners collaborated to develop a workshop report template and workshop questions. The workshops were divided into two sessions, with the morning session focusing on the challenges faced by the industry and students transitioning into the industry, and the afternoon session discussing potential solutions to these problems. The workshops were held locally on dates determined by the partners, and the data obtained was recorded. The recorded data and workshop process were evaluated in the workshop report. A section containing the general results of the workshop analysis was also added to this report. This allowed all analysis results that will form the basis of the HE curriculum to be compiled into a single document.

4. Participants / Sampling in the Survey

4.1 Number of Participants

Partner Country	Number of Participants
CROATIA	23
GREECE	18
ITALY	22
SLOVENIA	21
TÜRKİYE	38
TOTAL	123

Table 1 – Number of Participants

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5. Demographic Features

5.1 Current Role

Partner Country	Number of Participants/ Responders	Academician	Industry Employer/Employee	Other
CROATIA	23	14 (60.9%)	6 (26.1%)	3 (13%)
GREECE	18	11 (61.1%)	6 (33.3%)	1 (5.6%)
ITALY	22	9 (40.9%)	9 (40.9%)	4 (18.2%)
SLOVENIA	21	14 (66.6%)	4 (19.0 %)	2 (9.5 %)
TÜRKİYE	38	26 (68.4%)	9 (23.7%)	3 (7.9%)

Table 2 – Current Role

In Slovenia, two respondents marked the option "other". One respondent is a teacher at a vocational high school and one is a director of a spinout company.

In Italy, 4 people answered ‘other’: a government researcher, an agronomist researcher in a cooperative that deals with agricultural research, a PhD student and a freelancer.

5.2 Years of Experience

Partner Country	Number of Participants/ Responders	Less than 1 year	1-5 years	6-10 years	More than 10 years
CROATIA	23	2 (%4.3)	5(%21.7)	3(%13)	14 (%60.9)
GREECE	18	0(%0)	2 (%11.1)	5 (%27.8)	11(%61.1)
ITALY	22	2 (9.1%)	5 (22.7%)	7 (31.8%)	8 (36.4%)
SLOVENIA	20	1 (4.8%)	5 (23.8%)	5 (23.8%)	9 (42.9%)
TÜRKİYE	38	3 (%7.9)	8 (%21.1)	7 (%18.4)	20 (%52.6)

Table 3 – Years of Experience

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5.3 Importance of Biotechnology in Participants' Industry

Partner Country	Number of Participants/ Responders	Very Important	Somewhat Important	Not very important	Not Important at All
CROATIA	23	11 (%47.8)	9 (%39.1)	2 (%8.7)	1 (%4.3)
GREECE	18	11 (%61.1)	5 (%27.8)	2 (%11.1)	0 (%0)
ITALY	22	8 (40.9%)	11 (50%)	1 (4.55%)	1 (4.55%)
SLOVENIA	20	10 (50.0%)	9 (45.0%)	1 (5.0%)	0

Table 4 – Importance of Biotechnology in Participants' Industry

5.4 Main Applications of Biotechnology in Participants' Work

Partner Country	Number of Participants /Responders	Crop Improvement	Recombinant Enzyme/Protein Production	Bio-pharmaceuticals	Gene editing and synthetic biology	Animal Breeding	Other
CROATIA	23	0	5 (%21.7)	8 (%34.8)	2 (%8.1)	0	8 (%35.4)
GREECE	18	1 (%5.6)	1 (%5.6)	3 (%16.7)	3 (%16.7)	1 (%5.6)	9 (%49.8)
ITALY	22	13 (59.1%)	4 (18.2%)	1 (4.55%)	3 (13.6%)	0	1 (4.55%)
SLOVENIA	20	11 (55.0%)	0	1 (5.0%)	3 (15.0%)	2 (10.0%)	3 (15..%)
TÜRKİYE	38	11 (%28.9)	4 (%10.5)	4 (%10.5)	3 (%7.9)	0	16 (%42.1)

Table 5 – Main Applications of Biotechnology in Participants' Work

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In Croatian sampling, only one additional answer was received where a participant said that he is working in applying biotechnology in lignocellulose valorization. In Slovenia, three respondents marked the 'other' option"; one respondent uses biotechnology in wine production, one in relation to climate change and renewable energy and in teaching about the principles of biotechnology.

In Greek sampling, 9 other answers were received that involved the following fields: fermented foods, quality improvement, food production and biotechnology, and culture production.

In Turkish sampling; 17 answers were received. The answers included the following applications of biotechnology in their work: Microbial enzyme production for organic wastes, antimicrobial biomaterials, DNA barcoding, nanotechnology, biosensor, plant development breeding to stress conditions, tissue culture, plant tissue and cell culture, micropropagation, metabolite production, genotoxicity tests, algal biotechnology, food biotechnology, functional food production, genetics and biotechnology applications in animal breeding.

In Italian sampling the only answer ‘other’ was received from a Europlanner, with experience in preparing applications for European calls in cross-cutting sectors.

5.5 Problems that can be solved through the involvement of Biotechnology

Partner Country	Number of Participants/Responders	Yes	No
CROATIA	23	12 (%52.2)	11 (%47.8)
GREECE	17	8 (%47.1)	9 (%52.9)
ITALY	22	16 (72.7%)	6 (27.3%)
SLOVENIA	20	12 (60.0%)	8 (40.0%)
TÜRKİYE	37	24 (%64.9)	13 (%35.1)

Table 6 – Problems that can be solved through the involvement of Biotechnology

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In Croatian sampling, 8 responses were received where participants described following problems that they believe biotechnology can address:

- obtaining recombinant plants that have improved characteristics
- development of bioprotective cultures
- problems related with the accumulation of the large quantities of lignocellulose biomass which is hard to decompose. Applying biotechnology towards biorefinery development could serve as a tool for sustainable biomass valorization.
- water purification
- improving the yield of desired fermentation derived molecules
- culturing specific microorganisms for xenobiotic degradation
- bioprocess improvement in general
- anaerobic digestion process which is considered to be effective and environmentally attractive technology for energy recovery from biodegradable organic waste

In Greek sampling, 6 participants responded according to which the problems that biotechnology can contribute to and address are as follows:

- Substitution of chemically obtained surfactants.
- Enhanced productivities.
- Improvement of the technological properties of food through the use of probiotic bacteria.
- Production problems in bakery products, such as bread, can be solved through the use of bakery enzymes.
- Improving specific properties of microorganisms.
- The use of bioinformatics to narrow down the pool of potential molecular pathways responsible for a specific disease, thus limiting experimental time and expenses.

In Italian sampling 16 participants responded according to which the problems that biotechnology can contribute to address are the following:

- Maintain/reproduce difficult germplasm via in vitro techniques, create new genetic variability by genetic engineering, open new possibilities next to classical plant breeding approaches
- Water use efficiency on wheat is a good solution on the south of the country
- Improve bread and durum wheat cultivars to face climate changes
- Genome editing and, in general GMO, would allow to obtain similar results in crop improvement, but faster

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- Plant susceptibility to diseases and environmental stress
- The use of biotechnology could reduce the time for breeding crops for target traits
- In vivo demonstration of the existence of oligogalacturonides by using a transgenic plant
- Crop improvement in product and resistance to pest and drought will be fundamental in the next future to guarantee there will be enough production to satisfy the food demand of the planet
- Air-born fungi's issues on the crop. More limited access and use of chemicals thus biotechnology-based products can help to force the issue.
- Biotechnologies are essential to produce commercial quantities of products useful to humans, to improve plants and animals or to develop microorganisms useful for specific uses.
- FHB tolerance on durum wheat
- Reduce the time to obtain improved plant genotypes
- Increase the plant production of our protein of interest through the use of Agrobacterium tumefaciens

In Turkish Sample; 22 answers were received. The participants identified the problems can be solved through biotechnology as follows:

- Through multidisciplinary work
- Problem: Biomaterial infections
- Solution: Antimicrobial biomaterials
- Problem: Oil pollution
- Solution: Microbial oil bioremoval
- Biotechnological methods are combined with tissue culture techniques.
- Transfer of formulations developed in the industry into practice
- Our studies involving cell biology research can be solved with the help of gene biotechnology/gene editing. These studies comprise an important part of our research.
- The use of large and complicated devices in the detection of the substances that need to be analyzed causes a loss of time and may cause other problems as well. POC technologies, which we call point-of-care tests, can provide rapid diagnosis in many fields such as health, food and environmental analysis in a short time without the need for an expert. Biosensors, which are the application area of rapidly and exponentially developing biotechnology, will evolve in harmony with daily life and become devices that facilitate human life.
- Many problems can be solved with biotechnological techniques.

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- With micropropagation, production is carried out towards the name free from disease and virus.
- Development of markers against disease resistance in pepper
- Use of haploid technology in plant breeding
- Biotechnology-based equipment used in product development
- Production of some ornamental plants, which are difficult to produce, can be easily produced in high quantities by tissue culture.
- To obtain basic physiological and biochemical data for the use of Recombinant DNA technology in the elimination of yield losses caused by environmental stresses, in the production of new genotypes.
- Intra- and inter-species genetic relatedness
- The need for bioreactor systems
- Our research is in this direction. Increasing the production of target chemicals by changing the production conditions, etc.
- analytical thinking
- Regulation of gene expression.
- Herd breeding follow-up with genetically known sperm
- Production of products that protect the ecological balance (an accelerating test process thanks to enzymes, thus protecting the ecological balance by using less electricity)
- Ensuring low cost and high yield enzyme production by recombinant enzyme production
- Crisp CAS9

In the Slovenian sample, 11 out of 12 respondents explained their answer. The respondents mentioned the following problems that can be solved by biotechnology:

- the use of baker's yeast as an accelerator or catalyst of the chemical process of decomposition of hydrogen peroxide, instead of the classical catalyst potassium iodide or even more environmentally harmful potassium manganate,
- quantity and quality of crop yields through the use of symbiotic microorganisms,
- interactions of rhizosphere microorganisms with the plant and vice versa,
- Induction of male sterility for hybrid wheat development,
- interspecific hybridization, embryo rescue culture,
- tolerance to various abiotic and biotic stresses,
- production of important chemicals using biotechnology,

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- resistance of plants to diseases,
- in plant improvement and breeding,
- marker-assisted selection,
- uncompleted fermentations.

6. Section A

6.1 Do you use pro/prebiotics in your company/research?

Partner Country	Number of Participants/ Responders	Yes	No
CROATIA	23	5 (%21.7)	18 (%78.3)
GREECE	17	15 (%88.2)	2 (%11.8)
ITALY	22	0 (0%)	22 (100%)
SLOVENIA	18	4 (22.2%)	14 (77.8%)
TÜRKİYE	29	9 (%31)	20 (%69)

Table 7 – Distribution by percentage

6.2 Do you use commercially available or self-proprietary probiotic strains in your company/research? What do you think are the challenges in employing novel microbial strains in your activities?

In Croatian sampling, 8 participants answered that they do not use probiotic strains in their research/company and 4 answered that they do use it, but only commercially available strains. As the main challenge in employing novel microbial strains, the participants stated that *working with new strains of microorganisms may require the acquisition of new equipment, training of personnel, development of methods, and so on. But it also offers an opportunity to develop science.*

In Greek sampling, 5 participants answered that they use only self-proprietary probiotic strains, 2 participants commented that they use commercially available and self-proprietary probiotic strains in their company/research. Finally, 3 participants stated that they use neither commercially available nor self-proprietary probiotic strains in their company/research.
The main challenges raised by the participants were:

- Microbial characterization, safety assessment, EFSA approval and evidence of action should be taken into consideration.
- Increased cell tolerance using *in vivo* matrixes should be verified.
- Successful incorporation of probiotic strains in food matrixes and clinical evidence of functional properties should be considered.
- Development of novel functional foods.

In Italian sampling, most of the participants (18 0f 20) answered that they do not use probiotic strains. The remaining answered as follow:

- we use to improve the resistance to biotic and abiotic stress commercial products containing Trichoderma and other microorganisms to horticultural plants especially tomato
- Commercial, the cost to get it is much less

In the Slovenian sample, 6 respondents answered that they do not use probiotic strains in their research/company, and 3 answered that they do. One respondent stated that they use both; commercially available and their own strains, one uses only commercially available strains and one respondent answered that they are just starting to use them. The biggest challenge is lack of money and consequently

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adequate laboratory safety and equipment. Another challenge is to manage the growing conditions so that there is no stress and mutation of the strains. The last challenge mentioned was in the by-product.

In Turkish sampling, 4 participants stated that they do not use commercially available or self-proprietary probiotic strains in their company/research. However, 8 participants commented that they use it. The challenges the participants stated include supply, development of the strains, cost and vision regarding the use of probiotic strains:

- *Yes, but the supply is either from abroad or through acquaintances.*
- *In order to understand the reliability of the strains services procurement is required, and the costs are high.*
- *their development is difficult and takes a long time*
- *We completed a project on this subject, as a team, we isolated local commercial probiotic water, produced it in large scale, dried it and made a capsule formula. However, we could not produce it nationally and within the university. There is a lack of vision in this regard.*

One of the participants above indicated that they supply the strains either from abroad or through acquaintances. Besides, another participant stated that services procurement is required to understand the reliability of the strains and the costs of the services is high. Another problem was that the development of the strain was difficult and took time. One participant also claimed that he was involved in a project about it. Although they isolated local commercial probiotic water and produced it on a large scale, dried it and made a capsule formula, they could not produce it nationally and within the university. He explained the reason with a lack of vision. Another challenge on the participants stated was about publishing:

- *We isolated a new probiotic strain; we are trying to publish its article in a good journal.*

  The participant stated that they isolated a new probiotic strain, and they are now trying to publish in a good journal.

  Two of the participants' answers to this question was stated as follows:
- *The study has been completed on the identification of Bacillus strains that can be fish probiotics.*
- *We use standard gene editing bacterial strains. E. coli etc.*

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6.3 Does your company produce/do you perform research on traditionally fermented foods without commercial starter cultures?

In Croatian sampling, all the participants (19 responses) answered that they do not produce/perform research on traditionally fermented foods.

In Greek sampling, 4 out of 10 participants answered that they do produce/perform research on traditionally fermented foods.

In Italian sampling, most of the participants (18 of 21) answered that they do not produce/perform research on traditionally fermented foods. Three participants answered as follow:

- we do actually product in the traditional way
- yes
- Yes, we work on sourdough

In the Slovenian sample, all (12) except one respondent answered that they do not produce/perform research on traditionally fermented foods. However, one of the respondents stated that they plan to use them in the future, as they have done in the past.

In Turkish sampling, although 24 (% 85.7) participants stated that they do not produce/perform research on traditionally fermented foods; 4 (%14.3) participants stated they produced/performed.

6.4 If yes: Have you ever analyzed the microbiome of your products/samples? Did you do the analysis in your company/lab

In Croatian sampling, all the participants (19 responses) answered that they do not produce/perform research on traditionally fermented foods.

In Greek sampling, 9 participants answered this question. Eight participants answered that they analyze the microbiome of their products/samples and 2 of them in their lab. Only 1 participant stated that does not perform such an analysis.

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In Italian sampling, most of the participants (8 of 9) answered that they do not produce/perform research on traditionally fermented foods. Only one participant answered that he/she has analyzed the microbiome of her/his products/samples.

Only one respondent in Slovenia confirmed that they analyze the microbiome of their own products, but did not say whether they do this in their own laboratory.

In Turkish sampling, 13 participants answered this question. 11 (%84.6) participants answered they did not analyze the microbiome of their products/samples. Only 2 (%15.4) participants stated that they did.

6.5 If yes: Have you tried to isolate novel strains from your traditionally fermented products/samples or other sources?

In Croatian sampling, all the participants (19 responses) answered that they do not produce/perform research on traditionally fermented foods.

In Greek sampling, 5 participants answered that they tried to isolate novel strains from their traditionally fermented products/samples or other sources and 2 participants answered that they did not carry out such efforts.

In Italian sampling, all the participants (7 responses) answered that they do not produce/perform research on traditionally fermented foods.

In the Slovenian sample, one respondent stated that they had done this in the past and might do it again in the future.

In Turkish sampling, 9 (% 42.9) participants stated that they tried to isolate novel strains from their traditionally fermented products/samples; 12 (% 57.1) participants stated that they did not.

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7. Section B

7.1 Can you identify the main current soil problems and their impact on food security? Can you name and specific plants that can contribute to eliminating these problems? Do you use these plants? If so, how? If not, why not?

In Croatian sampling, 15 responses were collected. Some of the participants could not identify main soil problems. Among those who could, the main problems are as follows: pollution by pesticides, fungicides and similar chemicals that enter the soil and then the plants, and pollution with hormone disruptors and heavy metals. Only one participant stated that they tried several plants for phytoextraction and tried to use seed priming for phytoextraction improvement.

In Greek sampling,8 participants answered the question. Four participants could not identify the main current soil problems and their impact on food security. Three participants were not familiar with the topic. Finally, one participant commented as follows:

- *Yes, soil can be contaminated with both spoilage and pathogenic microorganisms that can worsen the quality of foods once transferred to the raw materials used to manufacture foods. There are a number of plants, mainly herbs, producing phytochemicals with antimicrobial action.*

In Italian sampling, 11 of 18 participants answered the question identifying the following soil issues:

- Low organic matter content, low soil fertility. I don't think there are plants but agronomic strategies to adopt
- Nutrient depletion, Environmental pollution.
- Soil erosion and scarcity of lands.
- we do not have specific problems on our soil both from the point of view of fertility and food safety, we carry out organic fertilizations and four-year rotations
- Drought stress, microbiome composition that influences cereal production with grain quality
- Salt concentration due to drought. Developing crops resistant to salinity and drought. I use in growing chamber but it is not allowed to test and grow them in open field
- We used brassica Juncea & Raphanus sativus as green manure in order to integrate organic matter and force the soils problems thanks to their exudates.
- Not enough soil in the country

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- Reduction of microbial biodiversity
- A soil problem: Climate change. A specific plant: There is no single species to solve the problem
- The two main soil problems with impact on food security; the first one is the treatments that are carried out on the plants. Poor soil creates an unhealthy state for the plant, which can lead to lower production or open the door to disease. To counteract it, the farmer is sometimes forced to use protective or promoter products that can be harmful to humans. The second one is largely beyond the control of the farmer: the presence of certain toxic substances in the soil, sometimes due to its nature and other times due to contamination, can manifest itself in the food that reaches our table. This is due to plant physiology, which can accumulate these substances in fruits and various tissues of the plant. We contribute to eliminating these problems by using the crop rotation with nitrogen-fixing crops including the legume family with taxa such as clover, soybeans, alfalfa, lupins, peanuts, and rooibos. We do not use these plants because we work on a small scale, at the greenhouse level with controlled temperature and humidity conditions.

In the Slovenian sample, 9 participants answered this question. Seven of them mentioned the following current soil problems: general reduction of soil fertility (dead soil) and soil degradation due to the prevailing mineral fertilization, the excessive use of pesticides (the presence of pesticide residues in the soil) and the use of unsuitable (too heavy) agricultural machinery. In their opinion, the accumulation of heavy metals and other pollutants due to the use of wastewater is one of the problems, as well as the lowering of the pH and the lack of organic matter (humus) in the soil. As a solution to reduce the listed problems, respondents suggest the use of bioaccumulator plants - wild species that behave like high accumulators or fix and stabilize the hazardous chemicals in the soil. Phytoremediators - e.g. *Salix caprea*, *Salix* sp. *Populus* sp., some wheat species, *Thlaspi* sp., *Arabidopsis* sp. Also different mixtures of cover crops of different botanical origin, the use of indigenous varieties and varieties suitable for organic farming. None of the respondents indicated whether they use these plants themselves.

In Turkish sampling, 21 participants answered the question. Many of them stated that one of the soil problems is heavy metal pollution. Phytoremediation using plant species such as safflower, vetiver, sunflower, fern, Brassicaceae family members (cress and arugula) was suggested as a solution for this problem. Agrochemical residues based on pesticides and excess fertilizer was stated as another soil problems. The participants suggested using bio preparations consisting of bacteria with PGPR (biofertilizer and biopesticide) properties that can be applied to all kinds of plants and help to eliminate such problems.

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The algae were also suggested to improve soil nutrients as fertilizer. Besides, the nitrogen-fixing legumes was also advised to enrich the soil. The microbial load in soil that may contain pathogens was raised as another issue through the questionnaire. Rotating different crops and tissue culture-based applications were recommended to solve this problem. Some of the participants claimed that drought was one of the problems of soil problems; since it causes nutrient deficiency cause salinization etc.

7.2 Have you worked with students or young professionals entering the labor market for the first time? How would you rate their professional and transferable skills? What would you advise that should be included in the education of young people for their readiness to face modern challenges in biotechnology?

In Croatian sampling, a total of 16 responses were collected. As a main guidelines for the education of young people following actions should be included:

- improvement of skills such as communication, teamwork, analytical abilities, responsibility, innovativeness, positivism, independence and resourcefulness.
- more field work and more collaboration with the industry to solve current problems and obstacles
- application of “Good Laboratory Practice” (GLP) and “Good manufacturing Practice” (GMP) principles
- more examples in learning process that refer to ongoing practice and an overview of opportunities expected in the future
- more students’ internships and more tasks formed as projects

In Greek sampling, 11 participants answered that young professionals are usually enthusiastic to quickly apply new ideas and practices to their work, have an excellent theoretical background, a high level of basic knowledge and their skills are quite satisfactory.

For the further training and development of young professionals, the following guidelines were mentioned:

- Research and industry collaboration.
- Increased laboratory practice in addition to a solid scientific background.

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- Industrial internships or undergraduate rotations in industrial settings can contribute significantly to their training.
- Demonstration in pilot plants by the Universities.
- Use of modern and new educational technologies in their field.

In Italian sampling, a total of 19 participants answered the question. Nine have no experience with students or young professionals. Most of them consider the professional and transferable skills very limited, although they have a good theoretical preparation.

In the Slovenian sample, a total of 8 respondents answered this question. Half of them have no experience with students or young professionals entering the labor market, while the others believe that their professional and transferable skills are not sufficient. They suggest more interdisciplinarity during studies and learning from practical examples, preferably in the form of face-to-face teaching. One of the respondents wrote: "Young people lack the courage to make changes in crop production. They often use cultivation methods and plants that their parents already used."

In Turkish sampling, 22 participants answered the question. 5 participants stated that they did not work with students or young professionals entering the labor market for the first time. However, only 2 participants stated that they had a chance to work with them. Although other participants did not state clearly whether they worked with students or young professionals, they made suggestions about preparing young people for their readiness to face modern challenges in biotechnology. Participants' failure to disclose whether they are working with young people can be explained as follows:

They either worked with young people and did not state in the questionnaire or they did not work with young people previously; However, although they did not work with young people before; they can anticipate the difficulties that newcomers may experience since they have an experience in biotechnology.

Findings revealed that one of the participants expressed that young people are willing and competent. Another participant also claimed that if the students are curious, they do well in the lab. However, some of the participants indicated that they incompetent in the following issues such as; mathematical calculations, basic chemistry terms, transferring their skills and they have lack of practice. Besides, one of the participants also stated that they have a lack of basic knowledge, and they are inadequate in terms of carrying out research and inquiry. The following suggestions are made to improve young people:

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- Apart from theoretical training, training should be given on what they can encounter in the labor market such as; problem solving, ethical values, time management and most importantly communication.
- More practice
- Emphasis should be placed on chemistry, mathematics and statistics during their education
- Practical training on microbial enzyme and vaccine production should be included in the curriculum
- Practical work on application, taking part in industry cooperation projects and being an intern
- Better education programs on molecular biotechnology can be created
- Updated educational plans on Biotechnology/Bioengineering subjects should be taught and used in practice.
- Cooperation with Technology Transfer Offices and sustainability in Teknokent / Technopark studies
- Even if they do not have the opportunity to apply the latest technology, they should have a competence theoretically regarding the subject.
- The number of applied courses in education should be increased and taught more effectively.

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7.3 In which areas is your company that deals with symbiotic soil organisms (arbuscular mycorrhizal fungi and/or nitrogen-fixing bacteria) active: (multiple answers are possible)

Partner Country	Number of Participants	Detection...	Characterization...	Selection...	Production...	Commercial...	Testing...	Other
CROATIA	13	2 (%15.4)	0	0	3 (%23.1)	0	2 (%15.4)	7 (%53.8)
GREECE	8	0	0	0	1 (%12.5)	0	4 (%50)	3 (%37.5)
ITALY	15	1 (%6.7)	0	1(%6.7)	1 (%6.7)	0	5 (33.3%)	9 (%60)
SLOVENIA	13	4 (30.8%)	2 (15.4%)	2 (15.4%)	3 (23.1%)	0	7 (53.8%)	2 (23.1%)
TÜRKİYE	14	3 (%21.4)	3 (%21.4)	3 (%21.4)	2 (%14.3)	1 (%7.1)	8 (%57.1)	4 (%28.6)

Table 8 – Distribution by percentage

In Croatian sampling, among those who answered that they work in other areas, all participants stated that they are working in other fields non related to soil organisms. The same as in Croatia also applies to the Slovenian respondents - they do not deal with soil symbionts.

In Greek sampling, participants who answered that they work in other areas reported on symbiotic microorganisms of food origin or that they have not worked with any of the above.

In Italian sampling, among those who answered that they work in other areas (9 of 15), 7 participants stated that they have not worked with symbiotic soil organisms. One participant works on improving plant development by using these products. The last one produces naturally leavened foods and uses self-produced sourdough.

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In Turkish sampling, participants who answered that they work in other areas, stated that they work on making mass production optimizations of PGPM (Plant Growth Promoting Microorganisms) bacteria and fungi at laboratory, making formulations with long shelf life after production, algae and nitrogen-fixing cyanobacteria and reproduction of salep orchids

8. Section C

8.1 Which of the following approaches to plant biotechnology do you believe holds the most promise for improving crop yields and food security?

Partner Country	Number of Participants/ Responders	Marker-Assisted Breeding	Transgenic Plants (GMO)	Plant Tissue Culture	Other
CROATIA	18	5 (%27.8)	5 (%27.8)	5 (%27.8)	3 (%16.7)
GREECE	11	3 (%27.3)	5 (%45.4)	2 (%18.2)	1 (%9.1)
ITALY	21	8 (%38.1)	11 (%52.4)	0	2(%9.5)
SLOVENIA	15	5 (33.3%)	2 (13.3%)	5 (33.3%)	3 (20.0%)
TÜRKİYE	33	13 (%33.3)	6 (%18.2)	13 (39.4)	3 (%9.1)

Table 9 – Distribution by percentage

In Croatian sampling, among those who selected the answer “other”, all participants answered that they do not know any specific approaches that could improve crop yield for food safety.

In Greek sampling, one of the participants who selected the answer “other” believes that novel approaches for genetically modified organisms (CRISPR gene editing) constitute one of the most promising techniques for improving crop yields and food security. In addition, construction of genetically modified microorganisms that can be effectively used to transform plants and genetically modified seeds were also mentioned.

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In Italian sampling, one of the participants who selected the answer “other” stated that they do not deal with these issues. Besides, one participant stated that Genome Editing could improve crop yield and food security.

Of the Slovenians who chose the "other" option, one stated that fungi are the key to improving crop yields, one believes that microbes that can change the microbiome of plants are most important, and one said the most important thing is: "understanding the microbiome of plants and soils and their interactions (metabolomics, proteomics and other omics) that explain what is going on in this vast living world".

In Turkish sampling, one of the participants who selected the answer “other” stated that all approaches above to plant biotechnology he believes hold the most promise for improving crop yields and food security. Besides, one participant stated that gene editing research could improve crop yield for food safety.

8.2 Please explain the target biotech products can be produced to use these approaches.

In Croatian sampling, 5 answers were collected but none of participants could explain the target biotech products that can be produced using mentioned approaches.

In the Greek sampling, 4 participants answered and were placed as follows:

- Construction of genetically modified microorganisms that can be efficiently used for plant transformation.
- Genetically modified seeds.

In Italian sampling, 19 of 22 participants answered the question identifying the following target products:

- Plant photosynthesis, atmospheric N fixation in cereals
- Novel more performant and improved genotypes
- Plants with specific traits, "Breeding by design" approach
- Selection of plants with greater resistance to abiotic and biotic stresses, evolutionary genetic improvement, protection of agro biodiversity, effective cultivation techniques with low environmental impact

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- Fhb resistance on wheat
- Most of monogenic characters can be easily changed by genome editing
- Mineral content, protein quality
- Vegetable species for food and industrial use
- Ds RNA
- Enriched foods, higher yields, more resistant plants
- Biofortified products; foods with reduced toxic compounds; products with greater digestibility; plants resistant to factors such as drought, phytopathogens
- Increase bioactive compounds (beta carotene, resistant starch, flavonoids etc).

Slovenians (9 respondents) believe that target products could be: enzymes from plants and microorganisms, antibodies and other relevant proteins, brand new edible products consumed by a large part of the population, various technologies for modifying plant tissue - such as gas plasma, rapidly and vegetatively propagated plants in the laboratory, microbial preparations, interspecific hybrids, secondary metabolites, GM -resistant varieties and markers.

8.3 Please explain the main barriers to produce the target product?

Partner Country	Number of Participants	Regulatory Hurdles	Societal Concerns	Technical Expertise	Patenting	Other
CROATIA	15	6 (%40)	3 (%20)	2 (%13.3)	1 (%6.7)	2 (%13.3)
GREECE	10	4 (%40)	3 (%30)	2 (%20)	1 (%10)	0
ITALY	20	6 (%30)	5 (%25)	8 (%40)	1 (%5)	0
SLOVENIA	13	3 (23.1%)	2 (15.4%)	8 (61.5%)	0	0
TÜRKİYE	32	13 (%40.6)	5 (%15.6)	12 (%37.5)	0	2 (%6.3)

Table 10 – Distribution by percentage

In Croatian sampling, only one additional answer was collected and the participant stated that he believes that the combination of all mentioned barriers is the obstacle to target product production.

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In Greek sampling, regulatory hurdles (40%), social concerns (30%) and lack of technical (20%) were mentioned as the main obstacles on the production of the target products.

In Turkish sampling, two additional answers were collected, and the participants stated that lack of economic support and infrastructure are the barriers to produce target products.

8.4 For what purpose are plant tissue cultures used in your company?

Partner Country	Number of Participants	Virus-free plants	Micro propagation	Secondary metabolites	Plant breeding	Haploids	Other	No-use in the company
CROATIA	18	0	0	2 (%11.1)	0	0	2 (%11.1)	14 (%77.8)
GREECE	10	0	1 (%10)	1 (%10)	0	0	1 (%10)	7 (%70)
ITALY	21	1 (%4.8)	0	0	4 (%19)	1 (%4.8)	0	15 (%71.4)
SLOVENIA	15	10 (66.7%)	7 (46.7%)	1 (6.7%)	7 (46.7%)	1 (6.7%)	0	2 (13.3%)
TÜRKİYE	23	0	5 (%21.7)	3 (%13)	9 (%39.1)	1 (%4.3)	5 (%21.7)	0

Table 11 – Distribution by percentage

In Croatian sampling, only one additional answer was collected and the participant answered that he does not know for which purpose plant tissue cultures are used in his company.

In Greek sampling, the majority of the companies don’t use plant tissue cultures by the answers.

In Turkish sampling, two of the participants who answered “other” stated that they do not use plant tissue culture in their company. Besides, one of the participants stated that he is a researcher, and he does not work on this subject. Only one participant claimed that they use plant tissue culture for germination of inoculated seeds and for healthy seedling growth in his company.

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9. Section D

9.1 What kind of enzymes do you use in your company/research?

Partner Country	Number of Participants	Proteases	Lactase	Other
CROATIA	15	4 (%26.7)	2 (%13.3)	9 (%60)
GREECE	12	9 (%75)	1 (%8.3)	2 (%16.7)
ITALY	16	3 (%18.8)	0	13 (%81.3)
SLOVENIA	12	5 (41.7%)	1 (8.3%)	6 (50.0%)
TÜRKİYE	18	9 (%50)	1 (%5.6)	8 (%44.4)

Table 12 – Distribution by percentage

In Croatian sampling, 7 additional responses were collected and the participants answered that they use the following enzymes: laccase, lipase, xylanase, amylase, pectinase, pepsin, glucansucrase, aldolase, dehydrogenase etc.

In Greek sampling, 2 responses were collected and the participants answered that they employ several enzymes in experimental protocols referring mainly to cell lysis.

In Italian sampling, 13 additional responses were collected and the participants answered that either they do not use similar products or use restriction enzymes, cell wall modifying enzymes, amylases, glucosidases, glycoside hydrolases, oligosaccharide oxidases and dehydrogenases.

Respondents from Slovenia either do not use enzymes in their companies or in research, or they use pectinases, lytic enzymes to combat plant pathogenic fungi and bacteria, pectinases, DNA polymerase or amylases.

In Turkish sampling, 7 additional responses were collected and the participants answered that they use the following enzymes: Laccase, amylase, phosphatases, peroxidases, restriction enzymes, protease, lipase, DNA restriction enzymes Proteinase K, Rnase A, Taq Polymerase

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9.2 What are the challenges you encounter during enzyme applications?

Partner Country	Number of Participants	Cost of enzymes	Remaining enzymes in the final product	Lack of reusability of the enzymes
CROATIA	15	7 (%46.7)	1 (%6.7)	7 (%46.7)
GREECE	12	9 (%75)	1 (%8.3)	2 (%16.7)
ITALY	11	7 (%63.6)	2(%18.2)	2(%18.2)
SLOVENIA	12	9 (75.0%)	0	3 (25.0%)
TÜRKİYE	19	17 (%89.5)	1(%5.3)	1 (%5.3)

Table 13 – Distribution by percentage

9.3 Have you ever searched for a biotechnological-based solution for the limitation listed above, please describe.

In Croatian sampling, 7 responses were collected but no specific answer was obtained for a biotechnological-based solution.

In Greek sampling, 5 responses were collected, but only 1 specific answer was obtained that involved the utilization of crude enzyme consortia.

In Italian sampling, 11 stated that they did not search for a biotechnological-based solution for the limitations listed above. Only one of them advised heterologous expression as a solution.

Of the 7 responses from Slovenians to this question, 5 answered that they have not yet looked for a biotechnological solution to the above limitation, one said that they could do so for their own products, and one wrote: "Only theoretically! For GM enzymes that are resistant to environmental factors during their use."

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In Turkish sampling, 4 participants stated that they did not search for a biotechnological-based solution for the limitations listed above.
Only one of them advised recombinant enzyme production as a solution.

In the survey conducted in Slovenia, we have added some questions in section E that relate specifically to wine production.

Q1: In what proportion of fermentations do you use selected yeast?
Q2: Do you monitor yeast assimilable nitrogen substances in grape juice during harvest?
Q3: What temperature range do you most often use for fermenting white and rosé wines?
Q4: Which type of maceration do you use for red grapes?

Q1 (N=13)		Q2 (N=12)		Q3 (N=5)		Q4 (N=5)	
In all cases	4 (30.8%)	Yes, NH4+ only	0	10–14 °C	0	Classic maceration (7–10 days)	5 (100.0%)
> 80%	0	Yes, YAN analysis	5 (41.7%)	14–17 °C	4 (80.0%)	Extended maceration (> 10 days)	0
> 50%	0	No	7 (58.3%)	17–20 °C	1 (20.0%)	Carbonic maceration	0
Not use	9 (69.2%)					Thermo-maceration	0

Table 13a – Enzymes in winemaking (in percentage)

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9.4 Do you have the capacity to produce enzymes?

Partner Country	Number of Participants	Yes	No
CROATIA	18	9 (%50)	9 (%50)
GREECE	14	11(%78.6)	3(%21.4)
ITALY	21	4 (%19)	17 (%81)
SLOVENIA	14	0	14 (100.0%)
TÜRKİYE	32	6 (%18.8)	26 (%81.3)

Table 14- Distribution by percentage

In Slovenian survey, we added some questions in section C that relate specifically to wine production.

Q1: In what proportion of fermentations do you use selected yeast?

Q2: Do you monitor yeast assimilable nitrogen substances in grape juice during harvest?

Q3: What temperature range do you most often use for fermenting white and rosé wines?

Q4: Which type of maceration do you use for red grapes?

In Greek sampling, the majority of the respondents (78.6%) answered that the have the capacity to produce enzymes**.**

Q1 (N=13)		**Q2 (N=12)**		**Q3 (N=5)**		**Q4 (N=5)**	
In all cases	4 (30.8%)	Yes, NH4+ only	0	10–14 °C	0	Classic maceration (7–10 days)	5 (100.0%)
> 80%	0	Yes, YAN analysis	5 (41.7%)	14–17 °C	4 (80.0%)	Extended maceration (> 10 days)	0
> 50%	0	No	7 (58.3%)	17–20 °C	1 (20.0%)	Carbonic maceration	0
Not use	9 (69.2%)					Thermo-maceration	0

Table 14a – Enzymes in winemaking (in percentages)

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10. Section E

10.1 Mutational breeding uses genetic variations to rapidly develop large populations of improved crops. Are you aware about the differences between classical mutagenesis methods and the so-called "New Breeding Technologies" (NBTs) in plant breeding?

Partner Country	Number of Participants/ Responders	Yes	No
CROATIA	18	2 (%11.1)	16 (%88.9)
GREECE	11	0	11(%100)
ITALY	21	12(%57.1)	9(%42.9)
SLOVENIA	10	6 (60.0%)	4 (40.0%)
TÜRKİYE	29	23 (%79.3)	6 (%20.7)

Table 15 – Distribution by percentage

In Croatian as well as in Slovenian sampling, no specific answer was obtained in the section where the difference between classical mutagenesis method and so called NBTs had to be described.

In italian sampling, the participants (9 of 12) stated the differences as follows:

- Speed, accuracy, cost
- Classical mutagenesis deals with chemical or physical agents producing random mutations across the whole genome. NBT often relies on genome editing that specifically modifies a target nucleotidic sequence with a reduced interference on the rest of the genome.
- NBTs represent a series of different tools (e.g., (synthetic genomics, breeding-by-editing, reverse genetics via mutagenesis) to accelerate the introgression of new traits that with classical breeding could not be achieved or in cases only in a long time.
- Targeted mutagenesis using CRISPR/CAS9

- In NBT only the target gene is changed whereas in mutational breeding the change is extensive and needs backcross to get rid of undesired mutations.
- With NBT it is possible to perform a precise genome editing by inserting a mutation in a predefinite site, without other undesired mutations.
- Classical mutagenesis is based on the use of chemicals or physical agents to induce mutations in the genome. New breeding technologies are based on modifying specific target DNA regions of plants or other organisms.
- New breeding techniques (NBTs) make specific changes within plant DNA in order to change its traits, and these modifications can vary in scale from altering a single base, to inserting or removing one or more genes.
- NBTs are site specific

In Greek sampling, all respondents answered that they were not aware about the differences between classical mutagenesis methods and the so-called “New Breeding Technologies (NBT) in plant breeding.

In Turkish sampling; the participants stated the differences as follows:

- Classical mutagens perform population variations randomly without targeting for example: radiation, chemicals, etc. In modern methods, genotype differences, molecular characterization takes place and breeding is done by identifying the target.
- There is not much difference between the two methods. New breeding technologies naturally require much more scientific and technological infrastructure.
- Variation is increased with classical mutagenesis, but it takes a long time until the desired plant is obtained; In addition to the desired feature, undesirable characters may also develop (such as lack of resistance to disease, short stature, lack of grain, low yield...)

10.2 Crops obtained through NBTs bring both benefits for the environment, human, and plant health as well as economic opportunities for producers and consumers. What are the challenges in further developing or adopting NBTs in agriculture?

In Croatian sampling, 6 answers were collected but participants do not have enough experience/knowledge to provide a more in detail answer.

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In Greek sampling, 3 answers were collected, but the participants do not have experience/knowledge or they were not familiar with the topic.

In Italian sampling, 15 participants answered this question. They claimed that:

- The challenge is to find genes that impact significantly on the crop productivity
- Together With the increase in the knowledge of plant biology NBTs will greatly accelerate plant improvement for all the traits of interest.
- Still technological. Cultural acceptance in different countries.
- Change consumer's mindset
- To make them accepted by social community and this can be reached if they are not classified ad GMO, since they are not
- Regulation, consumer opinion
- The public opinion perception of this new technology
- Teaching and proving that NBTs bring benefits (environmentally and economically) to the lowest part of the agriculture chain (growers, producers etc.)
- Acceptance by society and politicians
- Legal burdens
- The legislation bequeathed ethical factors and environmental biodiversity and a lack of knowledge of the effects on health over time.
- Improvement of nutritional quality, increase of resistance in cultivated varieties with consequent reduction of the use of chemical inputs, improvement in the efficiency of absorption of nutrients and in resistance to drought

In Slovenia, three responses were collected on the challenges of implementing NBT:

- I do not know NBT, but probably the process would need to reduce costs to be widely applied. On the other hand, it is a question of public relations or how to convince farmers to use NBTs,
- Use less pesticides in production and achieve higher yields and better product quality,
- An evaluation of the long-term performance of the varieties is needed (as it was/is the case for varieties obtained with classical methods).

In Turkish sampling, 7 participants answered this question. They claimed that among the challenges in further developing or adopting NBTs in agriculture are: social consciousness, limitation of project support, legal/Legislation barriers, infrastructure, lack of technical information and economic challenges

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10.3 Could NBTs bring benefits/opportunities to your sector/field of interest? If yes, could you please provide a specific example? If not, could you explain why?

In Croatian sampling, 6 answers were collected but participants do not have enough experience/knowledge to provide a more in detail answer.

In Greek sampling, 4 answers were collected, but participants do not have experience/knowledge or they were not familiar with the topic.

In Italian sampling, 17 responses were collected. Three participants stated that they do not have knowledge, while the others provided the following examples:

- My field is plant genetic improvement.
- In plant breeding could really bring innovation and novelties. For many applications not only strictly linked to food safety and security.
- Developing new idiotypes to face climate changes
- Developing of improved crops in short time, and maintenance of genetic background
- Increasing plant resistance to diseases
- Producing improved crop genotypes resilient to biotic and abiotic stresses
- Generation of crops with improved commercial traits
- Economic benefits (cost reduction) from an improved production and quality
- NBTs can be used to search for new virulence factors in plant pathogens
- NBT could help to decrease pollution producing and applying bacteria/plants that can degrade specific pollutants.
- Making specific changes within plant DNA in order to change its traits
- NBTs could increase and accelerate the development of new traits in plant breeding. Resistance against established insect resistance (IR) and herbicide tolerance (HT) traits are developing rapidly; use natural resistance genes of plants to introduce them in other cultures.
- Increase in the nutritional quality of products deriving from soft and durum wheat, production of varieties resistant to the main wheat pathologies to develop more sustainable supply chains under environmental and economic aspects

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In Slovenia, three responses were obtained: one respondent said that NBTs do not bring benefits to his/her area of interest, while two other respondents indicated benefits. One said that the benefits of NBTs are related to the reduced use of pesticides in production and the achievement of higher yields and better product quality, and the second respondent emphasized the higher resistance of NBTs to pests, diseases and adverse weather conditions.

In Turkish sampling, most of the participants stated that NBTs bring benefits to their sector. They explained that NBTs save time and money with fast breeding. Besides, for example through NBTs on the breeding of Stevia rebaudiana, we can improve the flavoring quality of the herb much more easily.

10.4 What are the challenges and new developments in traceability strategies to be used for tracing plants obtained through NBTs in your sector/field?

In Croatian sampling, 5 answers were collected but participants do not have enough experience/knowledge to provide a more in detail answer.

In Greek sampling, 3 answers were collected, but participants do not have experience/knowledge or they were not familiar with the topic.

In Italian sampling, 12 participants answered this question. Six of them do not have enough experience/knowledge while the others provided the following answers:

- In the next future, plants derived from NBTs will be not distinguishable from those derived from classic approaches. The challenge for Genome Editing related NBTs is to develop a cleaner transformation protocol for example based on the use of ribonucleoproteins for gene targeting.
- Depends on the NBT applied. In some cases this is more difficult and/or problematic than others.
- Extensive use of high throughput SNP detection
- Fast detection methods based on molecular biology
- Several strategies are already available
- They are not easily traceable. Their characteristics might be confused as natural mutations/variability

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Only one respondent from Slovenia answered this question. The respondent stated the challenge as: "designing genomes with marked changes and efficient and accurate DNA and protein markers to confirm the presence of the change in the genome".

In Turkish sampling, participants explained that qualified personnel and equipment, using the plant identification system inefficiently as well as high costs of the device and tool and equipment are among the challenges.

11. Section F

11.1 Does your company/research group use/produce any type of biofuel (bioethanol, biohydrogen, bioethanol, biodiesel)?

Partner Country	Number of Participants /Responders	Yes	No
CROATIA	20	10 (%50)	10 (%50)
GREECE	14	1 (%7.1)	13(%92.9)
ITALY	20	3(%15)	17(%85)
SLOVENIA	12	0	12 (100.0%)
TÜRKİYE	31	24 (%77.4)	7 (%22.6)

Table 16 – Distribution by Percentage

In Croatian sampling, the participants believe that following obstacles are the main problem in biofuel application/production:

- lack of knowledge
- research equipment
- small capacities for production and profit
- industrial waste
- price
- the fact that motors are not yet ready for those fuels

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- using food as raw material for biofuel production

In Greek sampling, the participants believe that the following obstacles are the main problem in biofuel application/production:

- Feedstock availability.
- Consumers' low education on biofuels.
- Cost competitiveness.
- Know-how and the production in industrial scale.
- Underfunding strategies for green approaches in public universities.

In Italian sampling, 10 of 12 respondents who stated that their company/research group does not use or produce biofuels answered this question. We have collected the following answers on the main barriers:

- Food security concern. Using crop derived wastes could be a solution.
- This does not represent the business of my company involved in the seed sector.
- We do not use them and we do not even produce them because we are a small company with limited agricultural areas and therefore, we do not need to produce it. We don't use it both for the small quantities of diesel we use and for the difficulty of finding it.
- We don't have the right equipment to produce biofuel
- The lack of extensive fields
- Sustainability
- Installing the production system (set up and higher costs) to produce biofuels in an existing company is the main obstacle.
- Regulatory framework
- The main obstacle in the production of biofuels is the risk of use of vast land areas for the production of them that might be subtracted to the production of food and increase food price.

In Slovenia, 5 out of 12 respondents who stated that their company/research group does not use or produce biofuels answered this question. We have collected the following answers on the main barriers:

- We do not need biofuels,
- The nature of our work,
- We do not currently have the possibility to use biofuels,
- It is not our field of research,

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- The production of raw materials for biofuels is limited by agricultural production - the country's agricultural policy.

In Turkish sampling, the participants indicated the following barriers regarding producing/using biofuel as below: Continuity of the production, legal regulations, high costs, lack of experts, financial support, raw materials, technology and sustainability of R&D studies as well as investment.

Besides, one of the participants also pointed out that the availability of fossil fuels, the availability of alternatives and the absence of legal obligations slows down the use of biofuels.

11.2 Does your company or you personally produce and/or use compost?

Partner Country	Number of Participants	Yes	No
CROATIA	19	9 (%47.4)	10 (%52.6)
GREECE	14	0	14(%100)
ITALY	20	2(%10)	18 (%90)
SLOVENIA	12	7 (58.3%)	5 (41.7%)
TÜRKİYE	31	26 (83.9)	5 (%16.1)

Table 17 - Distribution by Percentage

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11.3 If yes, mark the key problems when it comes to composting and how important is to overcome some of them.

Partner Country	Number of Participants	Smell...	Lack of information...	Difficult to execute...	Quality and application of...	Other
CROATIA	10	3 (%30)	0	0	6 (%60)	1 (%10)
GREECE	3	0	1(%33.3)	2(%66.7)	0	0
ITALY	3	0	0	0	3 (%100)	0
SLOVENIA	8	1 (12.5%)	0	1 (12.5%)	5 (62.5%)	1 (12.5%)
TÜRKİYE	7	1 (%14.3)	1 (%14.3)	2 (%28.6)	3 (%42.9)	0

Table 18 – Distribution by percentage

In Croatian sampling, lack of space was also addressed as a key problem when it comes to composting.

The respondent from Slovenia pointed out the need to find new approaches to make compost products richer in microorganisms.

11.4 If your company is producing wastewater, what are the strategies in their treatment and what do you consider the bottleneck of the process?

In Croatian sampling, 6 answers were collected. Among those who answered that they do produce wastewater the participants stated that the strategies that they apply depend on wastewater content but in general most applied methods are biological treatment, removal of potential active substances and neutralization. As the major bottleneck the participants stated is the lack of information on wastewater treatment and the fact that the output of data collected during purification is not standardized.

In Greek sampling, 3 answers were collected, but only 1 participant reported that they are developing a system for better treatment of cheese production plant wastewater.

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In Italian sampling, 7 participants answered this question. Six of them stated that their company is not producing wastewater. One of them indicated that the strategy in wastewater treatment is microalgal remediation, whereas the bottlenecks are related to algal cultivation.

Only one respondent from Slovenia stated that their company produces wastewater and that this is a big burden for the company.

In Turkish sampling, 4 participants answered this question. 3 of them stated that their company is not producing wastewater. One of them indicated that the biggest challenge of producing wastewater is the lack of investment in wastewater management.

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12. OVERALL FINDINGS

TURKEY

Insights into Biotechnology: An Exploration of the Turkish Industry and Emerging Environmental Concerns

We conducted a comprehensive survey to understand the dynamics of Turkey's burgeoning biotechnology industry. The objective was to examine the current landscape, assess the challenges, and identify areas of opportunity that could accelerate progress.

The survey revealed an active interest in several biotechnological applications, with significant attention on traditionally fermented foods, symbiotic soil organisms like arbuscular mycorrhizal fungi, and nitrogen-fixing bacteria. Notably, plant tissue culture and marker-assisted breeding were identified as key technologies that hold promise in improving crop yields and enhancing food security.

Despite this potential, our respondents reported numerous barriers that constrain progress. These ranged from regulatory hurdles to societal concerns, and from limited technical expertise to financial constraints. The survey further underlined the need for a greater focus on developing the professional and transferable skills of young entrants in the field, a factor crucial to the long-term growth and evolution of the biotechnology sector.

Alongside these general insights, a recurring theme across the responses was the intersection of biotechnology with environmental sustainability, particularly in the domain of waste management. A significant percentage of participating companies were engaged in biofuel production and composting, pointing to an industry focus on sustainability and resource optimization.

However, several challenges were identified in these areas. These included issues with composting execution and the costs associated with biofuel production. The issue of wastewater management was also raised, with a lack of investment in this area being a significant concern.

In essence, the survey illuminated the extensive potential of biotechnology to address a myriad of societal and environmental challenges, with waste management emerging as a key area of focus. The study underscores the need for an enabling environment that nurtures innovation, facilitates skill development, and advances practical solutions for environmental sustainability. Overcoming these challenges is essential for Turkey's biotechnology sector to fully realize its potential and contribute effectively to a sustainable and prosperous future.

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CROATIA

Summary results of the survey conducted in Croatia

The survey, designed to provide insight into the current state, perceptions and future development of biotechnology, was conducted in Croatia in April 2023. Of all participants, 47.8% believe that biotechnology has a very important impact on the industry, and 52.2% have encountered a problem in their work that they believe could be solved through the application of biotechnology. The problems identified are mostly related to obtaining recombinant plants, developing bioprotective cultures, developing biorefineries, purifying water, improving the yield of desired molecules derived from fermentation, degrading xenobiotics, improving bioprocesses and anaerobic digestion processes, all of which are emerging areas in biotechnology and environmental engineering.

In analyzing the results in each section of the survey, participants identified several challenges and gaps that could likely be addressed with biotechnology.

Many of the participants unfortunately did not have enough experience with the use of probiotic strains. However, those who have them emphasized that the challenges in using novel microbial strains that could be solved by biotechnology are related to acquiring new equipment, training personnel, developing methods, etc.

According to a survey, the most important problems related to soil quality and its impact on food safety are contamination by pesticides, fungicides, and similar chemicals that get into the soil and then into crops, as well as contamination by hormone disruption and heavy metals. Possible solutions to these problems should focus on discovering symbiotic soil organisms, producing inoculum, and testing the beneficial effects of symbiotic soil organisms *in situ*.

When participants were asked to identify approaches/gaps and issues related to crop yield improvement, food security, and new breeding technologies (NBTs) in plant breeding, no specific responses were collected because the majority of participants are not familiar with these topics.

On the other hand, the vast majority of participants are well acquainted with production and application of enzymes. Although the application of enzymes as green biocatalysts is well known, participants believe that there are still problems such as the price of enzymes and their reusability that should be solved before industrial application.

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Regarding problems related to environmental biotechnology, i.e., biofuel and compost production and water purification, most participants were familiar with the technologies and various approaches used to address specific problems in the above areas. When asked why biodiesel and compost are not more widely used, participants emphasized issues such as lack of knowledge, low production and profit capacity, industrial waste, price, the fact that engines are not yet ready for biofuels (produced from food), odor, and quality of the product.

The most important thing for the application of biotechnology in industry is people. Therefore, participants were asked to identify the most important skills, competencies and knowledge that their future colleagues should possess after study, and special emphasis was placed on improving skills such as communication, teamwork, analytical skills, responsibility, innovativeness, positivism, independence, and resourcefulness. In addition, several participants emphasized the need for more fieldwork and more collaboration with industry to solve current problems and obstacles, that students should have more examples in the learning process that relate to ongoing practice and provide an overview of opportunities expected in the future, and that students should have more internships and more assignments in the form of projects, all of which form the core of the Biote(a)ch Project. All of this justifies the project and provides good guidelines for future work.

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GREECE

Regarding the survey carried out in Greece, the research was designed and carried out with the goal to gather information about the problems and ideas for the future development of a biotechnology curriculum. Eighty percent of the participants believe that biotechnology can play a very important role in the industry, while 50% are convinced that it can significantly contribute in solving problems.

The main applications of biotechnology in the participants' work included the following areas: biopharmaceuticals, gene editing, fermentation of foods using synthetic microbial consortia, food production, quality improvement and agriculture production.

Referring to the difficulties the industry faces today, the participants concluded that biotechnology can solve the problems by contributing to increased productivity, improvement of the technological properties of food through the use of probiotic bacteria, improvement of specific properties of microorganisms, improvement of bakery products (such as bread) through the use of bakery enzymes, and substitution of chemically obtained surfactants. In addition, the use of bioinformatics may help limit the possible molecular pathways associated with a particular disease and/or function, thus limiting experimental time and expenses.

It was impressive that 88% of the participants owe experience in probiotics, using either only self-proprietary, or both self-proprietary and commercially available probiotic strains. However, the main challenges raised by the participants were: (i) microbial characterization, (ii) safety assessment, (iii) consideration on EFSA approval and evidence of action, (iv) verificatifon of increased cell tolerance using in vivo matrixes, (v) successful incorporation of probiotic strains in food matrixes, (vi) clinical evidence of functional properties should be considered, and (vii) development of novel functional foods.

Moreover, microbiome analysis and the effort to isolate new strains from traditional fermented products/samples is an important issue for approximately 48% of the responders, yet only approximately 25% of the participants reported that they conduct research on traditional fermentation and fermented products and try to isolate new strains from their fermented products or samples.

Unfortunately, regarding the soil-linked problems and their impact on food security, half of the participants that answered this question could not identify the main current soil-associated problems, while 3 out of 8 participants reported that they were not familiar with the topic. Based on the answers, half (50%) of the main sectors in which companies dealing with symbiotic soil organisms (mycorrhizal mycorrhizal fungi and/or nitrogen-fixing bacteria) are still in trials, while 37% of the “another sector”

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responders, reported that they involved the use of symbiotic microorganisms of food origin.Regarding the plant biotechnology approaches, the most promising sectors associated with improving crop yields and food security are transgenic plants (GMO) (45.5%) and assisted breeding (27%). According to the participants' answers, novel approaches for genetically modified organisms (CRISPR gene editing) constitute the most promising techniques, while construction of genetically modified microorganisms that can be effectively used to transform plants and genetically modified seeds were also mentioned. In relation to the main obstacles on the production of the target products, regulatory hurdles (40%), social concerns (30%) and lack of technical personnel (20%) were mentioned. The majority of the companies do not use plant tissue cultures.

Regarding the use of enzymes, extensive reference was made to the challenges and problems limiting their use, mainly the high cost. However, the majority of the industries use mainly proteases or crude enzyme consortia in their applications, according to the answers and they have the capacity for own enzyme production.

Concerning the differences between the classical mutagenesis methods and the so-called “New Breeding Technologies (NBT) in plant breeding, all participants answered that they were neither aware nor had experience/knowledge about the topic.

As far as biofuel applications/production is concerned, the participants believe that the main obstacles are feedstock availability, consumers' low education on biofuels, cost competitiveness issues, know-how and the production in industrial scale, and underfunding strategies for green approaches in public universities. However, a participant reported that they are developing a system for better treatment of cheese production plant wastewater.

An important point of the research was the general conclusion that young professionals are usually enthusiastic about applying new ideas and practices in their work and they have an excellent theoretical background, a high level of basic knowledge and their skills are quite satisfactory. However, for the further training and development of young professionals, the following guidelines were suggested:

- Research and industry collaboration.
- Increased laboratory practice in addition to a solid scientific background.
- Employment of industrial internships or undergraduate rotations in industrial settings that can contribute significantly to their training.
- Demonstration in pilot plants and use of modern and new educational technologies in their field.

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ITALY

The survey carried out in Italy intended to gather information about the current state of biotechnology, its impact on industry as well as about biotechnological based actions that might be undertaken in the attempt to solve actual social problems. Almost 41% of participants were academic researchers whereas another 41% were employed in the private sector. The majority of them (90.9%) claim that biotechnology is important in industry and 72% encountered a problem in their work that they believe could be solved through the application of biotechnology. Since 60% of the survey participants ascertain to work on crop improvement, among problems indicated as that biotechnology can contribute to address were related to creating new genetic variability by genetic engineering, water use efficiency on wheat, improving bread and durum wheat cultivars to face climate changes, plant susceptibility to diseases and environmental stresses.

None of participants used pro/prebiotics in their research while only few had experiences with traditionally fermented foods or the microbiome of their products/samples, including interactions with symbiotic soil microorganisms.

The most promising biotechnological approaches indicated as most promising in improving crop yields and food security are transgenic plants (GMO) (52.4%) and marker-assisted breeding (38.1%).

The majority of the participant companies do not use plant tissue cultures nor have capabilities in producing enzymes nor biofuel, whereas 57.1% were aware about the so-called “New Breeding Technologies (NBT) in plant breeding. These techniques might be used for producing improved crop genotypes resilient to biotic and abiotic stresses, with improved commercial traits favoring economic benefits (cost reduction) derived from improved production and quality of agricultural products.

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SLOVENIA

Almost all respondents in Slovenia stated that biotechnology has an important impact on their industry, and more than half of them believe that problems they face in their work can be solved through the use of biotechnology. Among the areas of biotechnology, respondents highlighted the importance of crop improvement through plant-rhyzosphere interaction (symbiosis) or through microbial preparations, plant breeding through induction of male sterility, embryo rescue culture and marker-assisted selection, plant tissue culture and biotechnology in wine production.

Most of the respondents had no experience with probiotics and prebiotics or with traditionally fermented foods.

In addressing soil problems, respondents mentioned phytoremediators – certain plants that bind and stabilize pollutants in the soil – as a biotechnological application that can help eliminate soil degradation. Phytoremediators – e.g., *Salix caprea*, *Salix* sp. *Populus* sp., some wheat species, *Thlaspi* sp., *Arabidopsis* sp. and the use of mixtures of cover crops of different botanical origins, the use of indigenous varieties and those suitable for organic farming are also mentioned as contributing to solving the problems of degraded soils.

Companies dealing with arbuscular mycorrhizal fungi and/or nitrogen-fixing bacteria mainly test microbiological preparations (54%), detect them (31%) and produce them (23%), while fewer companies characterize and select these microorganisms (15%). None of the companies surveyed are involved in commercialization.

More than a third of Slovenian respondents consider marker-assisted breeding and plant tissue culture to be the most promising biotechnological approaches, while only 13% believe that the production of transgenic plants can contribute the most to improving crop yields and food security. The proportion of these respondents is significantly lower than in some other countries (28-52%). According to the results, the main obstacle to obtaining the target products is the lack of technical expertise.

In companies where dealing with plant tissue culture, the method is mainly used for the production of virus-free plants, micropropagation and plant breeding.

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The companies involved in the study do not produce enzymes themselves, but mainly use lytic enzymes to combat plant pathogenic fungi and bacteria, pectinases, DNA polymerase or amylases and proteases in their work. They pointed out that the high price of enzymes is a limitation for their use.

The survey carried out in Slovenia included some additional questions specifically related to wine production. According to the results, the majority of winemakers (69%) do not use selected yeast in the fermentation of grape juice, a good half (58%) do not monitor the yeast assimilable nitrogen substances in the grape juice during harvest, a full 80% of them carry out fermentation at temperatures between 14 and 17 degrees and macerate red grapes in the classic way - 7 to 10 days.

The difference between the classical mutagenesis methods and the so-called "New Breeding Technologies" (NBTs) in plant breeding is known to 60% of the respondents, but none of them described the differences, and only two respondents wrote down the advantages of NBTs.

Respondents are not familiar with biofuel, but 58% of respondents indicated that their company or respondents personally produce and/or use compost. When it comes to composting, most questions relate to the quality and application of compost.

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13. WORKSHOP RESULTS

CROATIA

On September 28, 2023, a workshop was held at the University of Zagreb, Faculty of Chemical Engineering and Technology as part of the Biote(a)ch project. As highlighted in the invitation to the workshop, the aim of the workshop was to gather information about the challenges encountered in the transition from university to industry and how to solve the related problems:

- To identify the innovations and challenges in the bioeconomy and agricultural biotechnology from the perspective of academics and private sector representatives
- To understand the current knowledge and skills that university students studying in biotechnology fields should have when they begin their careers
- To understand the difficulties that university students studying biotechnology will encounter as they begin their careers in industry
- To contribute to the development of the curriculum for the undergraduate students in biotechnology as an initial project outcome

A total of 15 participants attended the workshop, one from industry, two students and the rest were academic staff from two faculties, Faculty of Chemical Engineering and Technology and the Faculty of Food Technology and Biotechnology. Anita Šalić was the moderator of the workshop and opened the workshop with a short introduction about the Project in general, the goals and the Project activities so far.

In order to achieve the goals of the workshop, the questions during the workshop were divided into two sections. The first section consisted of demographic questions to gather information on how many students are employed in the industry each year, what sectors the graduates work in, whether the students receive further training after they are employed, what the content of the training is, what budget

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is allocated for training new graduates, etc. The industry representative said that her company hires a significant number of graduates each year for a probationary period, but she does not know the exact number. She said that each employee goes through a training process that can last anywhere from a few months to a year.

During this probationary period, new employees learn about the company's work, the specifics of the new job, etc. The company usually does not make an additional investment in the trainee's training, but once the probationary period ends and the person is hired, it invests significantly in their training. Participants from the Faculty of Chemical Engineering and Technology emphasized that their faculty uses a survey to record where their students are employed after graduation. According to the survey conducted, the majority of graduates from the Faculty of Chemical Engineering and Technology work in the so-called real sector, followed by trade and services, faculties and scientific institutions in Croatia, etc. The participants of the Faculty of Food Technology and Biotechnology emphasized that they do not know exact data, but most of the students are employed in the first year after graduation, but for some of them it is often a transitional job before a longer employment. Participants at both institutions emphasized that, based on feedback from their former students, they usually go through a period of "treeing" where they go through different parts of the production process (from R&D to manufacturing to sales, etc.) before getting a specific job.

The second set of questions in this section was directed at participants from academia and was as follows:

1. Do you encourage your students to work in industry after graduation? If so, please explain how?
2. Do you have courses in your curricula that cover different areas of biotechnology?
3. In what ways do you introduce your students to different areas of (e.g., mandatory internship, field trips to the private sector, etc.)?
4. Do you collaborate with a biotech company? If so, does this collaboration help your students;

   - to get a job in the industry?
   - to develop the skills needed for industry?

All participants from academia emphasized that they personally do not encourage their students to work in a specific field after graduation. They believe that it is the student's personal decision based on their desires and abilities. However, they also agreed that it would be desirable to have an internship or some work experience in industry before beginning an academic career. This would give academic staff insight into how things work in industry, what the potential requirements are and, very importantly, build a broad

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network of acquaintances as a basis for further collaboration. Both groups of participants from academia emphasized that they have degree programmes that cover different areas of biotechnology, and that they feel their students are gaining enough knowledge to deal well with the various challenges in the field of biotechnology.

Knowledge is transferred in classrooms through animations, videos, presentations, student projects, hands-on lab work, industry visits, etc. When asked about collaborations with industry, most participants emphasized that most collaborations are based on participating in various scientific projects and performing measurements, various feasibility studies, elaborations for industry partners, etc. When asked if they thought this was sufficient, all participants agreed that more collaboration should be established, but they believe that the biggest obstacle to fruitful collaboration is the speed with which the university delivers answers/solutions to industry. This is often too slow for industry itself, so industry looks elsewhere for answers. Also, when analysis is done for industry, students are not involved as it very often involves data confidentiality, but similar examples are then mentioned in the lectures.

The second group of question was related to the transition of students transfer from university to industry, and the following questions were asked to all participants:

1. What are the innovations and challenges in the bioeconomy and agricultural biotechnology?
2. Can you explain the knowledge and skills currently required of graduates in the biotech industry?
3. What are the issues/challenges in transitioning from academia to industry?
4. Can you give examples of knowledge-based challenges?
5. How can these challenges be overcome?
   - What should universities be doing?
   - What should industry employers do?
   - What should students be doing?
6. Do you have any other suggestions for improving the quality of undergraduate education in biotechnology areas (e.g. in terms of curriculum, content, internships, etc.)?

When asked about innovations and challenges in agro-biotechnology, the following innovations were highlighted:

- **Genetically modified crops**: Genetic modification allows scientists to introduce specific genes into crops to give them desirable traits, such as resistance to pests, diseases, and environmental

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stresses (e.g., drought, salinity). This results in higher crop yields and a reduced need for chemical pesticides.

- **Biofortification**: Biotechnology has been used to improve the nutrient content of crops. For example, scientists have developed genetically modified rice varieties with higher vitamin A content to combat vitamin A deficiency in regions where rice is a staple food.
- **Herbicide-tolerant crops**: Genetic modification has enabled the development of crops that are resistant to certain herbicides. This resistance allows farmers to effectively control weeds without harming their crops.
- **Disease-resistant crops**: Biotechnology has been used to develop crops that are resistant to viral, bacterial and fungal diseases, reducing crop losses and the need for chemical treatments.
- **Improved storability and post-harvest characteristics**: Genetic modification has developed crops with longer shelf life and improved post-harvest characteristics, reducing food wastage during transportation and storage.
- **Precision agriculture**: Biotechnology enables farmers to optimize their agricultural practices. Precision agriculture techniques maximize yields, minimize waste and reduce environmental impact.

and as for the challenges of agro-biotechnology:

- **Public perception and acceptance**: GMOs face significant public resistance and skepticism. Concerns about safety, environmental impacts, and ethical considerations have led to regulatory hurdles and limited acceptance in some regions.
- **Biodiversity and ecosystem impacts**: There are concerns that genetically modified crops could cross with wild varieties, leading to unintended consequences for biodiversity and ecosystem balance.
- **Pest resistance and evolution**: Pests and diseases may evolve resistance to genetically modified crops or corresponding pesticides, requiring constant innovation and adaptation in biotechnological solutions.
- **Coexistence with organic farming**: Separating GMO and organic crops to meet certification standards is a challenge, especially in regions with different farming practices.
- **Regulatory framework:** Developing appropriate regulatory frameworks that balance innovation and safety is an ongoing challenge. Different countries have different regulations, leading to complex international trade scenarios.

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- **Long-term environmental impacts**: The long-term effects of widespread cultivation of GMO crops on soil health, non-target organisms, and ecosystems are not yet fully known.

When the question was expanded to include biotechnology in general, a few more answers were added.

Innovations:

- **Gene editing technologies**: Gene editing technologies have revolutionized genetic research and biotechnological applications. They have the potential to cure genetic diseases, create genetically modified organisms for agriculture, and develop new therapies for various diseases.
- **Biopharmaceuticals**: Advances in biotechnology have led to the development of biopharmaceuticals such as monoclonal antibodies, vaccines, and gene therapies, which are increasingly being used to treat various diseases, including cancer and genetic disorders.
- **Biodegradable plastics and sustainable materials**: Biotechnology has enabled the development of biodegradable plastics and sustainable materials from biological sources. These alternatives to conventional plastics can help reduce pollution.
- **Biofuel production**: advances in biotechnology have facilitated the development of biofuels such as biodiesel and bioethanol from renewable biological resources. Biofuels offer a more sustainable alternative to fossil fuels.
- **Waste management:** the use of waste as a raw material is important for improving the resources used and reducing environmental pollution.

Challenges in biotechnology:

- **Ethical concerns**: the ability to manipulate genes raises ethical issues, so ethical guidelines and regulations are needed to address these concerns.
- **Regulatory hurdles**: The rapid pace of biotechnological advances often exceeds the regulatory framework. Establishing appropriate regulations to ensure the safety and ethical use of new technologies is a major challenge.
- **Environmental impact**: biotechnology can provide solutions to environmental problems, but mass cultivation of genetically modified crops or release of genetically modified organisms into the environment could have unpredictable ecological consequences.

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- **Biosecurity**: the possibility of bioterrorism and misuse of biotechnological processes for harmful purposes requires strict biosecurity measures and international cooperation to prevent such incidents.
- **Limited resources**: the production of bio-based products often requires significant natural resources such as water and agricultural land. It is a challenge to balance the demand for these resources with efforts to protect the environment. For this reason, waste is a good solution.

When asked about the knowledge and skills currently required of university graduates in the biotechnology industry, participants indicated that the biotechnology industry is rapidly evolving and that graduates entering this field are expected to have a variety of skills and a solid foundation of knowledge. As mentioned earlier, all participants believe that graduates have a good educational background, but more emphasis should be placed on new technologies in lectures. Also, students should do more lab exercises, but unfortunately this is often limited by space in faculty labs.

They emphasized that understanding business principles, market analysis and intellectual property rights, and awareness of entrepreneurship and commercialization processes would be good skills. In addition, skills in managing research projects, budgets, and schedules are highly desirable nowadays. They should also be aware of ethical issues related to biotechnology, including privacy concerns, the ethics of genetic modification, and the social implications of biotechnological applications. In addition, good written and oral communication skills are essential for presenting research findings, writing reports, and collaborating with interdisciplinary teams.

The ability to work effectively in teams often composed of scientists from diverse backgrounds such as biology, chemistry, engineering, and computer science is desirable, as is continuous learning and adaptability, since biotechnology is a dynamic field. Graduates should be willing to learn new techniques, keep abreast of the latest research, and adapt to new technologies and methods. They should also be able to critically analyze problems, design experiments, and develop innovative solutions to challenges in the biotechnology industry.

Regarding the challenges/problems of transitioning from academia to industry, participants emphasized that the transition from academia to industry can be a difficult and crucial stage in an individual's career. Several important issues were highlighted. The first is the lack of practical experience, as university education often focuses on theoretical knowledge and graduates lack practical experience in the real world of industry. Therefore, it is important to bridge the gap between theoretical knowledge and practical application. Internships or research projects with industry partners can provide valuable practical experience.

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The second problem is the mismatch between skills and abilities, when graduates lack certain skills or software knowledge needed in the industry. Taking online courses, attending workshops, or being mentored during the first year of employment can help provide the necessary skills.

The third problem is that many graduates lack interviewing skills and soft skills such as effective communication, teamwork, and problem solving in a professional environment. This problem can be addressed by practicing interviewing skills, attending professional development workshops, and obtaining feedback from professionals.

The fourth problem is that university graduates may have unrealistic expectations about the job, salary, or work-life balance. However, by learning about the industry and job duties and talking to professionals, they can get a realistic idea of what to expect. Being open to entry-level positions to gain experience is often a necessary step.

The fifth challenge is what is known as imposter syndrome. University graduates sometimes feel inadequate or unqualified, even though they have the necessary skills and qualifications. However, finding a mentor, talking to peers, and focusing on successes and skills can help overcome self-doubt.

When asked for examples of knowledge-based challenges and how to overcome them, participants pointed to outdated curricula that do not align with current industry needs or technological advances. Because of this, graduates may lack the skills and knowledge needed in the job market. The problem can obviously be solved by modernizing the curricula in terms of both presentation and content. Limited research funding is also a major problem. Due to the lack of funding, students are unable to conduct additional research in the laboratories. As a result, graduates lack the practical skills and experience required by industry.

The last question summarized all suggestions for improving in the quality of biotechnology undergraduate education:

1. Curricula should be adapted to the latest developments in biotechnology, including gene editing technologies, synthetic biology, and bioinformatics. Interdisciplinary courses combining biology, chemistry, computer science, and engineering should be introduced to provide a holistic understanding of biotechnology.
2. Students should gain extensive hands-on laboratory experiences that enable them to perform experiments, use advanced biotechnology equipment, and acquire practical skills. Research-oriented projects should be offered that allow students to work on real scientific problems under the guidance of faculty members.

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3. Collaboration with biotechnology companies, research institutions, and professionals should be encouraged to expose students to real industry challenges.
4. Students should be offered workshops and seminars on communication skills, project management, and teamwork to prepare them for the professional environment. Students should be encouraged to attend conferences and present research papers in the field of biotechnology.
5. To have good students, faculty members should also continue their education to keep up with the latest advances and teaching methods in biotechnology.

After the discussion ended, Anita Šalić thanked everyone for their participation and fruitful discussion. Participants were also asked to write and send Anita (after the workshop) five different challenges and five proposed solutions for bridging the gap between university and industry so that graduates can be successful in their careers and easily adapt their work. The responses were collected and grouped as follows:

1. *Challenge*: Lack of practical experience - Graduates often lack practical experience and skills required by industry.

Solutions: Establish partnerships between universities and industries to create internship and co-op programs. Hands-on experience through internships helps students apply theoretical knowledge to real-world situations.

2. *Challenge*: Limited soft skills - Soft skills such as communication, teamwork, and problem-solving are not emphasized enough in the traditional university settings.

Solutions: Incorporate soft skills development workshops into the curriculum. Offer training in communication, teamwork, leadership, and emotional intelligence to prepare students for workplace interactions.

3. *Challenge*: Outdated curricula - Rapid advances in technology and industry often make university curricula outdated.

Solutions: Establish industry advisory boards that regularly review and update curriculum. Professors and industry experts can work together to ensure students are learning the most current and relevant skills.

4. *Challenge*: Unfamiliarity with industry tools - Graduates may not be familiar with the specific tools and software used in the industry.

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Solutions: Organize networking events, seminars, and mentoring programs where students can connect with industry professionals. Guest lectures and alumni networks can help students expand their professional contacts.

5. *Challenge*: Lack of resourcefulness in finding solutions to new challenges

Solutions: Challenge students with more project assignments that require students to find solutions on their own, using all available resources

6. *Challenge*: Fear and lack of confidence toward expensive equipment

Solutions: Encourage and teach students in class to use expensive equipment themselves whenever possible, more time to practice is desirable

7. *Challenge*: Not enough practical knowledge

Solutions: Longer period of time student internships

The quality of the workshop was assessed using a quality evaluation form, and excellent results were obtained in each category. Some of the comments at the bottom of the form are:

1. "Well organized meeting with constructive discussion"
2. "The workshop was stimulating and generated good discussion among the participants. I welcome this type of workshop and wish there were more like it"
3. "Great workshop, relaxing, the workshop leader did a good job of introducing the participants to the topic"
4. "Excellent workshop, excellent presentation, and discussion about the gaps between faculties and industries, and excellent ideas about future improvements when it comes to connecting students and their professors with the challenges facing the industries."
5. "The workshop was really interesting and it made me think about some important things which I can say or advise to the students."
6. "Short but informative, to the point and overall well-rounded"

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GREECE

On 31 May 2023, the Workshop of the BIOTE(A)CH was organized online by the Department of Molecular Biology and Genetics, Democritus University of Thrace and the main issue of the discussion was "Biotechnology Education: Challenges and Solutions". Totally, 14 participants (10 academics, 1 industry representative and 3 MSc students) attended the workshop.

The main aims of the workshop were to:

- To identify the challenges in the bio-economy and Agri-food industry.
- To determine the knowledge and skills the students should acquire during their studies.
- To understand the difficulties students studying biotechnology face starting their carrier in industry.
- To contribute to the preparation of a curriculum for the undergraduate students in biotechnology, as the first intellectual input.

The participants were invited to answer a number of questions before the start of the workshop and during the meeting all aspects were developed through a productive discussion with the goal to exchange thoughts, concerns and ideas among the participants, avoiding the established formal questions and answers protocol. The reason that this form of discussion was chosen was the deeper need for highlighting the problems and challenges the young graduates face entering the labor market, as well as the role of the industry in integrating the young scientists into the working environment. The Principal Investigator of the Greek partner, Professor Ioannis Kourkoutas, was the central coordinator of the Workshop and he was the one who opened the discussion by presenting the project, its goals and actions. Then, the Vice-Rector of the Democritus University of Thrace and member of the Greek team, Professor Maria Grigoriou, commented on the "flipping learning" model, describing the possibilities and the dynamics of using this particular educational teaching model.

The key questions answered by academics and industry representatives prior the workshop are presented below:

1. **Do you encourage your students to work in the industry when they graduate? If so, explain how?**
    - *Of course, I encourage the students of my Department to work in the industry on the one hand because the public sector is now saturated and on the other hand because companies with*

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biotechnological applications provide to the graduates the opportunity to work in the subject of their studies with decent wages.

- *Absolutely. Through the course I teach, but through visits to industrial units in the area and through discussions.*
- *Through my activity as an Advisor Professor, I often discuss with my students and encourage them to enter the industry market.*
- *Yes, I encourage the graduates of my Department to work in the industrial sector. In addition to personal talks with my students and writing recommendation letters, I often mediate with companies I work with to bring them in touch.*
- *Yes, by explaining to them the needs that the pharmaceutical, diagnostic, etc, industries have for bioinformatics scientists.*
- *Yes, through discussions (and when asked for my opinion) I encourage my students to work in the industry, especially when I perceive that such a career suits them.*
- *Yes, usually with companies we collaborate with (e.g. in research projects). Many companies have the opportunity to inform our students on their needs through seminars and student internships, by inviting industrial representatives to give talks on certain courses, etc. Additionally, the students come into direct contact with the industries through the research projects at which they are working on.*

2. Do you have courses covering different areas of biotechnology in your curricula?

- *Biotechnological applications in natural production, plant protection and food.*
- *Yes*
- *No*
- *Yes, mainly courses focusing on bioreactor technology, biodegradation and microbial ecology of waste treatment systems.*
- *No, we have not included such courses in our curricula, but in the courses I teach, I make references to various fields of biotechnology.*
- *Yes, various courses, such as Applied Biotechnology, Molecular Biotechnology & Nutrition, and Principles of Entrepreneurship in Biosciences.*
- *Yes, we have two courses in the areas of Plant Genetic Improvement and Reproduction.*

3. In what ways do you introduce different areas of biotechnology to your students (e.g. mandatory internships, private sector travel, etc.)?

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- *At the Department of Agricultural Development at Democritus University of Thrace, internship is mandatory. In addition, information days are also organized every year and industry representatives have the opportunity to inform our students through a series of lectures.*
- *Mainly through excursions-visits to industrial units, but also through industrial internships.*
- *Through the Diploma Thesis on fermentation, biodegradation and bioremediation, and through visits to liquid waste treatment plants, food industries, wineries, etc.*
- *Through workshops, invited speakers (at graduate level), videos, internships, student participation in trade and innovation expositions, as our lab participates through funded research programs.*
- *Through applied biotechnology labs, internships and visits to industrial units.*
- *Mainly through internships.*

4. **Are you collaborating with a biotechnology company? If yes, does this collaboration benefit your students in the following ways:**

   (a) to find work in the industrial sector,

   (b) to develop the skills required for the industry sector?

- *At least in the Food Science and Technology Direction at the Department of Agricultural Development at Democritus University of Thrace, we do not work with biotechnology companies. In the past, many students participated in internships at biotechnology companies, but this action did not lead to immediate employment or demonstrated skill acquisition. My experience has shown that most of our graduates who work in biotechnology companies abroad gained access after obtaining a Master's degree also from abroad.*
- *Both informal and formal collaboration exist through research projects. Such collaborations benefit the students in both finding a job and developing their skills.*
- *Yes, with a biotechnology company focusing on producing biopesticides.*
- *(a) Yes, through the experience they gain from performing a Diploma Thesis and participating in relevant conferences.*
- *(b) Yes, through the Diploma Thesis and the attendance of laboratory courses.*
- *(a) Yes, they see the different views of the labor market and the work environment.*
- *(b) Yes, by observing and participating in such collaborations they have a better understanding of the skills required by the industry.*
- *(a) In many cases the collaboration resulted in employment.*

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- *(b) Collaboration with biotechnology companies plays a catalytic role for the development of practical skills.*

The discussion continued emphasizing on the crucial role of the industry to be more active either by industrial representatives visiting often the University Departments or by providing the opportunity to the students to come to direct contact with the work environment. Greek students possess a great theoretical background, but lack practical skills, which are considered basic elements for the integration of a new person into the labor market. Furthermore, the concept of entrepreneurship, which is directly linked to the industry, should be taught during the curriculums, even at how entrepreneurship itself can change people's lives and how people through the entrepreneurship have changed the world. It was also mentioned the need for "demonetization of profit" through education, as profit can and is the goal at every level, not only financial, but also educational, etc.

Then, the discussion was oriented to the problems and obstacles that do not allow the smooth transition of students to the industrial labor market. The lack of responsibilities undertaken combined with the fact that young people are not given the opportunities, but also the stimuli to develop them constitute a basic need for the foundation of a curriculum with a specific framework, in order to create actions for the development of the necessary skills. It was also discussed how the educational method of "flipping learning" could be a key driver in setting up a teaching model based on "real time" problems with real data that the industry face, so that the students are asked to solve real problems that go through theory into real practice.

Finally, it was proposed the creation of a Prototype Education Curriculum tailored to the industry with a specific framework that will fully describe what each company offers to an internship, the work environment, the supervisors, etc. Undoubtedly, according to all participants' opinion, the internship is the most important tool between the University and Industry and we should all work on it collectively, as it is perhaps the only means that can and does offer young students' maturity, self-confidence and connection with the real world outside the University area. The young students taking advantage of internships are exposed and realize how they can meet future work demands. The active participation of the industry to the curriculum development and their investment in training could act as a counterweight to the adverse economic and environmental environment, which is directly linked.

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ITALY

In Italy, at the University of Tuscia - Department of Agriculture and Forest Sciences (DAFNE), a workshop took place on the 5th of June 2023 as part of the Biote(a)ch project. Undergraduate as well as PhD students, researchers, professors and industry representatives took part in the meeting. As stated in the invitations, objectives of the workshop were:

1. To identify the innovations and challenges in the bioeconomy and agricultural biotechnology through the lenses of academicians and private sector representatives
2. To understand the current knowledge and skills the university students studying on biotechnology areas should have when they start their profession
3. To understand the difficulties university students studying on biotechnology areas will encounter in the industry when they start their profession
4. To contribute to the preparation of the curriculum for the undergraduate students in biotechnology areas as the first project result

In the first three hours, Prof. Daniel Savatin, Prof. Francesco Sestili and Dr. Samuela Palombieri presented:

- the Biote(a)ch project. In particular, the Biote(a)ch objectives were clearly explained together with program, partners and agenda;
- an introduction to biotechnologies and main results achieved in agriculture.

In this regard, it was clearly stated that biotechnology education means teaching and learning about the biological sciences, engineering, and technology with a focus on applying these disciplines to solve practical problems and develop innovative products and processes.

Students were informed about some of the undergraduate programs in Biotechnology in Italy, and UNITUS. They have also been asked to identify main problems related to those courses. Among the replies were: lack of hands-on experience, lack of industry-specific knowledge, lack of social and analytical skills, limited job opportunities. At the same time the industry representatives were asked to identify the main

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skills expected from recent graduate biotech students to be considered as employees in biotechnology-based industries. A range of technical, analytical, and social skills were indicated among which: technical skills (laboratory techniques such as PCR, gel electrophoresis, cell culture and protein purification as well as experience with bioinformatics tools and software); analytical skills (ability to analyze and interpret experimental data, solve experimental problems and propose solutions); communication skills (effective written and oral communication skills, the ability to present scientific data and concepts clearly and concisely); problem-solving skills (ability to identify and solve problems using critical thinking, creativity, and scientific reasoning); time management and organizational skills: (ability to prioritize tasks, manage multiple projects at once, meet deadlines, and work efficiently in a fast-paced environment).

Among the solutions proposed to fill the present gaps between university biotech students and industry were: to activate internships and training programs, to favor university and industrial collaborations, to incorporate more industry-specific courses into the curriculum and to provide guidance on available job opportunities and career paths. Also what UNITUS and DAFNE already adopt to support students in facing the discussed issues, meaning encouraging students to participate in internships in R&D companies or activating partnership with biotech companies to offer internships and research opportunities, was stated;

- an overview on plant biotechnology and its applications in the attempt to render agriculture a more sustainable practice, by improving production and resilience to (a)biotic stresses in staple crops;
- New Breeding Techniques (NBTs) as biotechnological tools for a sustainable agriculture;
- Advantages and disadvantages of utilizing NBTs in agriculture;
- The legislation on the use of crops obtained through the NBTs in Europe and extra-European countries;
- An easy to comprehend description of conventional breeding techniques and of NBTs, such as genome editing and RNA interference. Advantages and disadvantages of both kinds of techniques were evaluated in the attempt to face current agricultural challenges, i.e. providing food to all Earth habitants and save staple crop production despite climate changes;
- Risk assessment and authorization for NBT plants. On this point, differences among Europe and the rest of the world have been highlighted.

In the last part of the meeting a collegial discussion was made on the public opinion and consumer acceptance of NBTs as well as on the European legislation for cultivated plants derived from NBTs. In particular, Prof. Savatin and the other participants answer the following questions:

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- Is it safe to eat GM crops? Most of the participants showed a certain level of uncertainty, even if several scientific papers and strict controls already demonstrated substantial equivalence between worldwide commercialized GM plants and relative species. It is commonly accepted that such unfounded uncertainty could derive from the fact that GMOs are a contentious subject and not all public discussion has been informed by independent scientific evidence.
- Have GM crops caused damage to the environment? All the participants agreed on the fact that crops do not damage the environment simply because they are GMOs. Some agricultural practices, such as the excessive use of herbicides with consequent eradication of wild plants, have been shown to damage the environment. Such problems are similar for non-GM and GM crops.
- Eating GM food have an effect on my genes? All participants agreed on the fact that our digestive system breaks down all food (and included genes) without any effect on our genetic content. Our genes are made by our cells from the building blocks we get from the digestion of any food, obtained from both GM and non-GM sources. Since the first widespread commercialization of GM produce 18 years ago there has been no evidence of ill effects linked to the consumption of any approved GM crop.
- Are GM plants more dangerous than other plants? After a general discussion, all the participants agreed that there is no evidence of specific risks derived from GMOs.

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SLOVENIA

In Slovenia, at the University of Maribor, Faculty of Agriculture and Life Sciences, a workshop was held on June 2, 2023. The invitation to the workshop was accepted by representatives of four companies whose activities are related to biotechnology, as well as a representative of a farm, a representative of an associated partner in the project, a PhD student and four university professors (11 participants in total). As highlighted in the invitation, the aim of the workshop was to identify the innovations and challenges in the bioeconomy and agricultural biotechnology from the perspective of academics, students, and private sector representatives, and to identify the knowledge and skills currently required of university graduates in the biotechnology industry. The workshop was moderated by Silva Grobelnik Mlakar.

After a brief presentation of the project, its objectives and the activities carried out and planned, the participants introduced themselves. In the first part of the workshop, the participants answered demographic questions. In the second part, they answered questions about innovation in biotechnology, the knowledge and skills young employees need, the problems they face when transitioning from university to industry, and solutions that would empower them and help them succeed.

Industry representatives stated that they hire an average of two to three university graduates per year. These new employees usually come from the fields of agriculture, food science, biotechnology, microbiology, and chemistry. They also hire graduates in the fields of forestry, computer science, mechanical engineering, economics, and tourism. The companies provide training for new employees in different ways, for which they have no special resources. In most companies, short training courses and seminars are organized, or the new employees are referred to other educational institutions, in the case of computer skills, for example, to the University for Adult Education, which operates in the regions of Slovenia and offers free courses. In one of the companies, it is common for each new employee to have their own mentor who introduces them to the work. The training takes place in such a way that the new employee gets to know the activities in all phases of production – from the raw materials to the finished product. In this way, the new employee has the opportunity to apply the knowledge acquired during their studies to situations of further work in the workplace, from the simplest tasks to the use of sophisticated equipment. The owner of a small company said that his employees (including new colleagues) regularly attend scientific conferences in Slovenia and abroad, with the company covering the costs. In addition, the owner regularly uses 'flipped learning', where the new employee is given resources and literature on a problem that they later try to solve in their work environment and report on the results achieved. The company devotes about five hours a week on this type of training. Among the innovative approaches to

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training and testing the knowledge and skills of new employees, a representative of the same – development-oriented – company dealing in mushrooms mentioned the Development Essay task. As an example, the workshop participant mentioned an essay on the topic of leather, which is made from mushroom mycelium. While studying and writing the essay, the new employee acquired theoretical knowledge about the properties and various innovative uses of mycelium, the advantages and disadvantages of leather made from bio-based materials, the properties of the mycelium of different groups of cultivated mushrooms and the effects of the production environment on product properties. With this training method, the new employee shows that he or she is able to search for relevant information, summarize it, think critically, combine existing and newly acquired knowledge and write a concise report.

Participants from academia generally do not particularly encourage students to work in industry after graduation because many students come from farm backgrounds and intend to work there, and also because they feel that the decision of where to seek employment is up to them and their interests. In some cases, if they know the student and their qualities well and on the other hand academicians knows the company looking for a new employee, they make a connection between the two parties. They also inform graduates who they believe meet the requirements for employment based on their qualifications about the advertised position. The Faculty of Agriculture and Life Sciences offers a number of courses that deal with different areas of biotechnology. Such courses are, for example, FUNDAMENTALS OF PLANT BIOTECHNOLOGY, GENETICS, MICROBIOLOGY, PHYTOPATHOLOGY AND ENTOMOLOGY, PLANT IMPROVEMENT, FOOD SAFETY, INTRODUCTION TO GENETICS, APPLIED BIOTICAL CROP PROTECTION, MUSHROOM PRODUCTION, BIOLOGICAL BASIS OF LIVESTOCK PRODUCTION, AGROECOSYSTEMS AND BASICS OF BIOLOGICAL ENGINEERING, NON-ALCOHOLIC BEVERAGES, WINEMAKING, PROCESS CONTROL IN WINE AND JUICE PRODUCTION, SPECIAL WINEMAKING TECHNOLOGIES, INTRODUCTION TO BREEDING OF FRUIT PLANTS AND GRAPEVINES, AQUACULTURE. Knowledge is imparted in the classroom through presentations, videos, student projects, hands-on lab work, field trips, etc. Most participants from academia work together with industry on projects and other types of research. Students are also actively involved in some of these projects, most of whom are involved in conducting experiments. Fragments of these experiments and the topics covered are usually included in their final theses.

In the second part of the workshop, the participants highlighted the following innovations and challenges of the bioeconomy: the circular economy, the creation of biodegradable products, short supply chains and the importance of locality, adaptation to climate change in agricultural production and the associated problems (extreme weather conditions, the emergence of new diseases and pests), awareness of the

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interdependence of all links in the food chain and the need for greater cooperation. They also pointed out the growing need for digitalization, automation, and process optimization. Among the challenges of agricultural biotechnology in general, participants emphasized the development of healthier, more efficient crops and animals to feed the population. The participants consider particularly important that biotechnological methods are used that are adapted to local conditions, complement existing farming systems and traditional crops, and are accepted by the public. The resulting products should maintain or increase biodiversity and have no harmful short as well as long-term effects on the environment. The participants also pointed out the problem of globalization and the reduced competitiveness of Slovenian companies due to limited research funds and a limited market. Automation, optimization, and control of biotechnological processes in production are also challenges.

In addition to good basic knowledge of biotechnology, recent graduates must be able to take a holistic view of processes, be curious and innovative, know where and how to find relevant information, be responsible, rational, and persistent in the work process, think critically and be able to work in (interdisciplinary) teams. Communication skills in the native language and good foreign language skills (English and in some cases German) as well as computer skills are becoming increasingly important. Industry representatives also emphasize the willingness for continuous learning and training.

According to industry representatives, the biggest problem for young people entering the labor market is the lack of practical skills. For example, even handling laboratory equipment, calibrating a device such as a pH meter and not knowing the importance of hygiene in the laboratory can be a problem for some young people. Sometimes, even with an otherwise good basic knowledge of biotechnology, employers are surprised to find that graduates lack some fragments of knowledge, such as calculating concentrations, for example.

Closer cooperation between universities and industry is very important from many aspects. Stable and productive cooperation may influence that university graduates acquire the right and necessary skills and mindsets required on the job market, as well as it is necessary for their own personal development. Development of closer links between university and business can encourage the exchange and sharing of knowledge, have significant and unreplaceable role in creation of long-term partnerships and opportunities and definitely drive innovation, entrepreneurship and creativity.

When asked how the identified problems can be overcome and what role the university plays in this, the participants named the constant updating of curricula and more modern teaching methods as the most important. As progress in biotechnology is extremely rapid, curricula can often become outdated. Against

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this in mind, industry representatives would like to see greater collaboration with universities in updating curricula. It would also be necessary to change the teaching methods at universities more efficiently to modern, student-oriented approaches. In this context, participants mentioned the need to include more project- and problem-based learning, more student's teamwork and more practical training including internships in companies. Students should be more involved in research and project work and participate in scientific and professional symposia and other professional events. In view of the public higher education system in Slovenia, in which the funding of study programs increasingly depends solely on the number of students enrolled, and the fact that the younger generations are becoming smaller in number, industry representatives warn against a general lowering of the criteria for the knowledge acquired by students. Furthermore, the education system often ignores the needs of gifted students or those who perform highly in areas of their interest and learn faster than their peers. Therefore, teachers need to be empowered to differentiate instruction by providing a variety of learning pathways within the same classroom that differ in content, focus, activities, or outcome.

The workshop participants see considerable untapped potential in the role of future employers to enable young graduates to make a smoother transition from academia to industry. This includes the involvement of industry in the regular updating of curricula and the fact that industry is an excellent training ground for internships for students, where they are confronted with problem solving in real industry. Projects with industry are also mentioned as particularly important. These include projects that involve students in solving challenges in the regional business sector (the former Creative Path to Knowledge program, which was co-financed by the European Social Fund, and the current Student challenges of the University of Maribor program, which is financed by the university itself). According to an industry representative, these projects are among the most important and efficient transfers of knowledge into practice, as the students involved develop innovative solutions to the challenges of the business sector in the local and regional environment under the guidance of pedagogical mentors and experts from the industry. The projects are short, lasting 3 to 5 months, but the students (4 to 10 of them) work in interdisciplinary groups and develop general and discipline-specific competencies, practical knowledge, and experiences useful for the transition to professional life. Temporary student work is also a good way for an employer to find and train a suitable candidate for a future position. Student work in Slovenia is arranged via the e-Student Service – an employment agency that mediates temporary and part-time work for students.

A doctoral student who attended the workshop believes that students themselves are largely responsible for overcoming the problems of young graduates that were pointed out in the session. Students have chosen to study themselves and if they are to complete their studies, they must also have sufficient self-

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motivation and initiative to build their own knowledge and skills profile and personal development. Student mentioned participation in Erasmus+ mobility programs for traineeship as an excellent opportunity to gain practical experience. At the University of Maribor, sufficient funds are available to enable anyone who shows interest to spend time abroad at the desired institution. In addition to acquiring specific practical skills, a traineeship abroad under Erasmus+ or Ceepus programs enables students not only to improve their communication, language, and intercultural skills, but also to strengthen their soft skills, which are highly valued by future employers, as well as their entrepreneurial thinking and acting. All workshop participants agreed with the student's opinion.

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TÜRKİYE

Participants discussed innovations in biotechnology in relation to environmental problems, food, energy, global warming, and nanotechnology. They emphasized the search for solutions to fundamental issues such as environmental pollution, water usage techniques, disease and pest control. These innovations are also addressed in the European Framework Programs. Examples of such innovations include approaches that reduce the use of chemical fertilizers in plant production, enhance water and photosynthesis efficiency in plants, develop new biotechnological methods to reduce carbon emissions in animal production, and explore alternative energy sources.

In the field of nanotechnology, it was mentioned that the efficiency of silicon technology used in batteries, for instance, is low despite its high cost. It was noted that nanotechnology plays a significant role in addressing this problem, particularly in materials used for photovoltaic technology and environmental applications. The ability of polymer materials to absorb and remove heavy metals, making them suitable for water purification, was highlighted. Nanotechnology was also emphasized for its applications in defense, textile, food packaging, and its potential to reduce energy consumption. It was further stated that nanotechnology finds utility in drug delivery, medical applications, and functional coatings. The widespread use of nano fibers and nano particles in cosmetics, masks, and other fields was underscored. These technologies were recognized for their economic, environmental, and multi-sectoral benefits.

As an example of innovations in the food sector, chocolate was highlighted. The focus in this field is on producing functional foods. For instance, efforts are being made to develop easily digestible chocolate for individuals with milk allergies who are unable to consume regular chocolate available in the market. Additionally, the production of chocolate with functional food properties, such as sugar-free and high-protein chocolate using vegetable proteins, was emphasized. Studies are also being conducted to meet special requirements like gluten-free chocolate. Consequently, it is now understood that the demand for

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food is shifting towards functional and protein-enriched foods, and the integration of plant-derived proteins into the food sector is deemed important. Moreover, participants mentioned the potential of recycling biological wastes as food, citing colostrum as an example of waste material being utilized in a dairy farm.

The challenges in the field of biotechnology were described by the participants as follows: Apart from difficulties related to the qualifications and salaries of new graduates entering the biotechnology field, participants identified issues such as intellectual property rights and ethical regulations as additional obstacles.

Regarding the employment of new graduates, it was stated that creating added value is crucial for the private sector. The hiring of new graduates at minimum wage was seen as demotivating. The relevance and value of certificates and practical experience gained during studies and the quality of laboratory facilities at the graduates' respective schools were emphasized. Solutions to these problems need to be identified and incorporated into biotechnology education.

New regulations on intellectual property rights and ethical issues were also mentioned. The importance of economic and intellectual property rights was emphasized, along with the need to consider ethical aspects. It was suggested that individuals entering the sector should receive education in intellectual property rights and ethics, and that the social dimensions of ethics should be evaluated alongside legal ethical issues in various sectors. The challenges arising from differences in legal and social ethical values between different countries were addressed. It was emphasized that ethics, both in the sector and in education, should be evaluated at both the international and national levels.

For instance, it was mentioned that genetic modifications in cancer cases are ethically acceptable when viewed from a life-saving perspective. However, it was stressed that the naming of such modifications should be handled carefully. The example of genetic changes in SMA (Spinal Muscular Atrophy) patients was provided, suggesting that alternative naming might be more effective. The misconception that herbal products are solely for consumption as food was corrected, stating that they are also used in clothing and other industries. The use of herbal products in the pharmaceutical industry and the fact that all biologically derived clothing materials are agricultural products were highlighted. Agricultural solutions were noted for their positive effects on reducing carbon footprint and regulating carbon dioxide levels, although negative effects of some solutions were also discussed. For instance, the environmental pollution and

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health problems associated with the use of lithium were mentioned. The negative externalities of smoking on the economy and the healthcare sector were referred to, and the need to evaluate such damages was emphasized.

Additionally, it was suggested that an ethical approach to organic solutions involving genetic modifications should be taken in relation to microbiological agents. For instance, organic solutions in pesticide use could be achieved through genetic modifications of microbiological agents, offering environmental advantages. The potential positive outcomes of recombinant approaches in nitrogen production were also highlighted.

Apart from challenges faced in the private sector, the issue of colostrum, which has commercial value but presents sterilization problems, was brought up and the need for a solution was emphasized.

The importance of knowledge and skills such as creating organized tables, summarizing data, and interpreting results using Excel and other programs was highlighted in the biotechnology industry. The ability to quickly create tables to meet daily and periodic reporting requirements was mentioned. Additionally, specific skills related to biotechnology, such as monitoring antibiotic resistance, reporting findings, and determining treatment methods, were deemed necessary. Participants emphasized the importance of technical knowledge and interpretative competence, suggesting that pursuing a master's degree would be preferable for specialization. It was recognized that opportunities for working in the field at the undergraduate level are limited, and alternative course options and practical experiences in different fields should be offered.

Despite the emphasis on molecular biology, it was acknowledged that graduates entering the biotechnology industry need to adapt to diverse fields. Addressing the lack of knowledge in areas such as animal science was identified as an area for improvement, and offering alternative education and resources to gain a wide range of knowledge and skills was recommended.

The utilization of knowledge and skills acquired in molecular biology laboratories was highlighted. Graduates should be able to access additional information by referring to laboratory notes and effectively communicating with professors, in addition to their theoretical knowledge. Furthermore, it was emphasized that closer collaboration between industry and academia is necessary to support technological advancements. The integration of basic scientists into various industrial fields, highlighting their role in finding solutions to applied and industrial problems, was emphasized. It was stated that basic

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scientists are not limited to academic or teaching roles but can make significant contributions to industry as well. Universities were urged to provide students with information on the sectors in which they can work and the knowledge they will need before graduation. Developing students' laboratory experiences and industry connections was seen as crucial. The discrepancy between reports prepared by undergraduate students in practical courses and those expected in the industry was discussed, and the need for undergraduate programs that facilitate interaction with the private sector was underscored.

Participants mentioned that one of the challenges in transitioning from university to industry is data analysis, which plays a critical role in problem-solving. It was emphasized that finding the root cause of a problem is vital in the private sector to avoid misleading superiors. They gave an example of not questioning the quality of milk by sampling spoiled milk during university courses. The difficulties faced in identifying the root cause of a problem highlighted the necessity for a problem-oriented education. Learning data analysis and problem-solving skills solely through personal experience was seen as challenging, emphasizing the need for such skills to be incorporated into training programs. The importance of fostering a culture of learning and questioning was also emphasized.

To address these challenges, participants suggested the following actions for universities, industry, and students:

Universities should establish mentoring systems and address problems related to idea generation and creative work. Staying updated on new developments, trends, and the direction of the industrial industry was seen as important to identify students' field-related problems and deficiencies.

From an industry perspective, it was acknowledged that the training process required for new recruits, particularly in small companies, can burden the companies, leading to the avoidance of such training programs. Participants emphasized the need to resolve problems related to this issue.

Regarding students, it was noted that they struggle with developing project ideas and understanding the expectations within the scope of project calls. Creativity was identified as a lacking aspect in their ideas. Moreover, students were deemed insufficient in conducting research, accessing resources, and having comprehensive knowledge of various programs, often requiring re-teaching by the company during internships.

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