BREED & FEED

CREDIT Vibes

Deliverable 2.3 - Technology Roadmap NutriCrops for NutriFΘΘD

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Abstract of deliverable:	This roadmap will explore all the desired outcomes of the CREDIT Vibes project and the NutriCrops for NutriFΘΘd (N4N) initiative for MRI, the institutional and economic landscape, end consumers, the general public, and all stakeholders, along with steps and actions that will be taken to ensure said nutriproducts become a reality. It will build a welcoming environment for adopting healthy fΘΘd, with all the necessary arrangements for its development and distribution in various markets.

Table of contents

Technology Roadmap NutriCrops for NutriFΘΘD

Executive summary

CREDIT (Creativity, Research, Education, Development, Innovation, and Transformation) Vibes project has put developing nutribreeding technology at the forefront. This involves identifying crops (colored maize and soybean) with nutritional and bioactive properties and then operating in stringent laboratory conditions to isolate a working collection of nutricrops, which can then be used to create novel product prototypes with enhanced nutritional/sensory qualities and proven safety. These novel product prototypes, or nutricrops, will lay the groundwork for introducing healthy and nutrient-rich food to every sphere of life, from farms to day-to-day meals, and for protecting *fθθd* safety and nutrition in the long term.

The baseline for spreading the technology and knowledge to all targeted groups will be the Nutribreeding Hub, whose goal is to enable cutting-edge networking and sharing that leads to the adoption of the green method of nutrifood production on farms nationwide and beyond.

All in all, the CREDIT Vibes project has a large number of goals and desired outcomes of how the nutribreeding technology development will positively impact the economic landscape, along with clear directions to reach them. In this roadmap, we will explore directions and goals in-depth while unambiguously laying out the impact of the CREDIT Vibes project on MRI, other institutions, farmers, end-consumers/citizens, EU policies and plans, the economy as a whole, and more. Next, we will inspect the technical and market barriers in reaching the goals and outcomes. Finally, we will set forth a roadmap achievement approach for quality protein maize (QPM) and colored seed hybrids that demonstrates a plan for overcoming said barriers and setting the stage for achieving the desired outcomes.

Quality protein maize (QPM) contains the opaque-2 gene along with numerous modifiers for kernel hardness. Therefore, QPM is maize with high nutritive value of endosperm protein with substantially higher content of two essential amino acids - lysine and tryptophan, and with good agronomical performances. Although QPM was developed primarily for utilisation in the regions where, because of poverty, maize is the main staple food, it has many advantages for production and consumption in other parts of the world, too. QPM can be used for production of conventional and new animal feed, as well as for human nurture. As the rate of animal weight gain is

doubled with QPM and portion viability is better, a part of normal maize production could be available for other purposes, such as, for example, ethanol production. Thus, breeding QPM is set as a challenge to produce high quality protein maize with high yield and other important agronomical traits, especially with today's food and feed demands and significance of energy crisis. (see: http://rik.mrizp.rs/handle/123456789/215). QPM's target markets are co-operatives, family-owned, small, medium-sized, or even large broiler farmers, and producers of feed for broiler and piglet fattening.

Market data shows that broiler farming incurs most of its cost from its operating input, mainly feed (Mallick et al., 2020). Broiler farming is mostly financially profitable but has a high unit cost of production and low unit price selling. Production challenges lie in improving energy efficiency and the feed conversion ratio (especially with the increased prices for feed ingredients like maize, soybean, etc).

For now, there is no information that products made from blue corn can be found on our market. There are mainly biscuits on the market based on white wheat flour, which is very poor in bioactive substances, i.e. phenolic compounds with high antioxidant capacity. Wheat flour, as well as yellow corn flour, does not contain anthocyanins. Among the special products with a functional effect, you can find a biscuit with the addition of dried berries containing anthocyanins, but these products have a low percentage of berries and a high price. Target markets for colored seed products are consumers with special diet needs.

One of the key points of the road map is to position the Maize Research Institute (MRI) as an essential seed supplier for feed companies that already have good market/end customer access, developed distribution channels and even point-of-sale operations.

1 Introduction

Malnourishment is a severe problem affecting not only Serbia and Europe but also the entire world. According to the United Nations Decade of Action on Nutrition 2016-2025, 821 million people remain chronically undernourished, 149 million children under five years of age are stunted, over two billion people suffer from micronutrient deficiencies, and there are two billion overweight people (almost a third of the entire population), among which 678 million are obese. According to the World Health Organization (WHO 2020), developed countries follow the same obesity patterns due to excessive consumption of energy-rich foods in saturated fats, trans fats, sugars, and salt (WHO, 2024). In contrast, underdeveloped countries face malnutrition or 'hidden hunger' due to the consumption of nutrient-poor foods (WHO, 2024a).

Therefore, the need for developing new types of *feed* (food and feed) that are healthy and nutrient-rich has never been more prominent. One of the best ways to satisfy this need in a sustainable and proficient manner is through the use of a new *feed* enrichment approach in modern agriculture called biofortification. It is a process that increases the bioavailability and nutrient density of food crops through conventional plant breeding and recombinant DNA technology without compromising and sacrificing any of the characteristics that are a priority to farmers and end consumers.

Nutribreeding, the new research avenue intended to enhance and enrich human and animal health by ensuring the development of *feed* with high nutritional value and satisfactory sensory characteristics, is based on the biofortification concept. The essential element for getting from biofortification to micronutrient-enhanced *feed* is the initial grain, which hides the genetic potential necessary for enhancing and reimagining how we eat and feed our animals.

However, developing the nutribreeding technology is just the beginning of the desired impact of the CREDIT Vibes project. It will also aid the structural transformation of the Maize Research Institute (MRI) by improving its management, adaptation, and long-term sustainability. Moreover, spearheading this project will raise the MRI research profile and enable access to genetic wealth, such as crops, for enhanced nutritional composition and human health. The CREDIT Vibes MRI project will have many other positive effects, as explained in the following sections, but such effects will go far beyond this institution. The attraction and generation of high-quality researchers to MRI will not only mean more projects for them but also the ability to train and equip other institutions and organizations in Serbia to take on more international projects. The agro-knowledge and agro-technologies transfer will increase by 15-20%, empowering the entire economy to take advantage of the nutricrops development.

By establishing a Technology Transfer Office (TTO) and a Project Management Office (PMO) at MRI, the positive effects of more projects and technology transfer to the economy will extend beyond nutribreeding technology to all future projects these offices will help manage. The NutriCrops for NutriFƟƟD (N4N) initiative will inspire several micro-transformations, which, when combined, will lead to excellence for MRI and the whole Serbian institutional landscape.

Furthermore, the CREDIT Vibes project will benefit Serbian, EU, and other citizens because it is rooted in an eco-friendly system that enables everyone to access healthy food, regardless of socio-economic standing. In addition, the project's developed Dissemination, Communication, and Exploitation Plan ensures all stakeholders, including the end-consumer, are always kept in the loop, knowing the benefits and how to attain them. The project also aims to empower young people in the agro-*feed* industry and women in organic farming to boost farm productivity by 20-30%

2 Information about nutribreeding & industry

Maize has low nutritional quality due to poor content of essential amino acids lysine and tryptophan in the dominant seed storage protein fraction, zeins. However, Quality Protein Maize (QPM), a variety of opaque maize but with good agronomic traits, can have 60% to 100% higher content of lysine than standard maize. Monogastric animals (pigs, poultry, fish), like humans, cannot synthesize lysine and tryptophan de novo and thus these amino acids must be supplied through diets. QPM was primarily developed for human consumption to overcome malnutrition in countries where maize is staple food. Thus, QPM is of tropical origin and its adaptation to temperate regions is frequently hampered by the retained exotic germplasm.

Development of adapted QPM hybrids is mainly aimed for feed industry. It has been shown that substituting standard maize with QPM in feed diets could be profitable due to improved weight gain, feed conversion ratio and decreasing of dietary lysine supplementation.

MRI at Zemun Polje has a program on converting elite inbred lines through marker assisted breeding into their QPM counterparts and developing commercial QPM hybrids. Up to now, two inbred lines have been converted, while eight lines have passed through three or four generations of backcrossing and one generation of selfing. Tryptophan content in the converted selfed plants was in the range from 0.080 to 0.093 (*http://rik.mrizp.rs/handle/123456789/969*).

Besides developing QPM counterparts of commercial hybrids, one QPM hybrid - ***ZPQPM13*** obtained by crossing a converted elite inbred line and an adapted tropical inbred line was developed and tested over different locations and in different years.

This hybrid is currently used in feeding experiments with the objective to test effects of replacing standard maize with QPM in diets on broiler performances. Hybrid ZPQPM13 showed favorable traits for growing in these regions, and its grain yield was at the level of one of the leading ZP hybrids - ZP 606. However, grain moisture of this hybrid was 3% higher than that of ZP 606, pointing out to the tropical origin of its parental inbred lines (*http://rik.mrizp.rs/handle/123456789/1124*).

As a gluten-free cereal, corn is one of the most suitable raw materials for the production of food for people, as well as people who are intolerant to gluten and suffering from celiac disease, and together with rice, it is the most cultivated cereal in the world. Among cereals, colored corn is the most important and richest source of anthocyanins. Simple or acylated, anthocyanins are mainly found in the aleurone layer of the maize endosperm or pericarp and affect the color and antioxidant capacity of the grain.

3 Direction and goals

The CREDIT Vibes project starts with developing nutribreeding technology and using it to create healthy, eco-friendly, and nutrient-rich *feed*. However, that is only a small part of the project's overall goal, as its activities will also ensure that *feed* is available to farmers and the general public, along with the dissemination of information that demonstrates how important it is to enhance and improve the way we eat.

Moreover, the CREDIT Vibes project will serve as the long-needed incentive to structurally transform Maize Research Institute (MRI), enhance its operations and position, boost the number of projects it can take on, and ensure a raised level of highly skilled researchers and non-research staff. The project will also help MRI build sufficient competence to compete for Horizon Europe project funds in a coordinator role, raise the capabilities of MRI to compete for EU funding, and significantly improve the number of published journals, improving its long-term sustainability.

To develop nutribreeding technology and elevate the nutritional power and health of human food and animal feed, a certain number of pre-defined steps will be taken:

1. To identify potential genetic diversity for nutricrops suited to organic production systems. Crops (colored maize and soybean) with nutritional and bioactive properties will be identified, including hybrids/varieties presently popular in conventional production. The information will be gathered and stored by a set of standard descriptors and will encompass information from original databases and links to the genebank holder website/s.
2. To multiply the seed material and run rigorous tests until a working collection of nutricrops is isolated. The core driver for producing said nutricrops is a know-how concept and turnkey system that will start from the highly nutritious genotypes

and provide organic agro-technology, which will be based on intercropping and cover-and-trap crops.

3. Finally, there will be an evaluation of applied crop cultivation technologies in order to obtain maize and soybean genotypes of high yield and grain quality, which will then be used to produce a new type of crop dubbed 'nutricrops' and lead to novel nutriproduct prototypes that will revolutionize the health and nutrition power of feed. The last step is determining the market and obstacles to achieving a certain benefit by selling products in the domestic and foreign markets here and the next 3-5 years.

Moreover, the research deliverables in CREDIT Vibes will support Sustainable Development Goals (SDGs), in particular, SDG 2 'Zero hunger', SDG 3 'Good health and well-being', SDG 12 'Responsible consumption and production', SDG 13 'Climate action' and SDG 15 'Life on land'. At the same time, strategic transformation deliverables as well as harmonization of the R&I system with high-ranking institutions in the EU in CREDIT Vibes, will support Sustainable Development Goals (SDGs), in particular SDG 4 'Quality education', SDG 5 'Gender equality', SDG 9 'Industry, innovation and infrastructure', SDG 10 'Reduced inequalities', SDG 16 'Peace, justice and strong institutions' and SDG 17 'Partnerships for the goals'. Furthermore, CREDIT Vibes activities are in line with the EU approach to Food Security, the European Innovation Partnership 'Agricultural Productivity and Sustainability' and the EU Biodiversity Strategy as well as the Smart Specialisation Strategy of the Republic of Serbia (4S) and will fall under the scope of the EU regulation implementing the Nagoya Protocol on Access and Benefit Sharing.

4 Role of administration within MRI

Creating a **Technology Transfer Office (TTO) and a Project Management Office (PMO)** will play a crucial role in both harnessing the benefits of the CREDIT Vibes project inside and outside the scientific community and the institutional landscape. The PMO at the Maize Research Institute will provide all the necessary support that ensures researchers can vastly improve their number of manageable projects by assisting with preparing project proposals (technical and financial), helping with the applications process, and monitoring if the projects' deliverables and milestones are reached with sufficient quality.

On the other hand, the TTO will analyse the market situation, identify companies interested in using the products and technologies developed by the Maize Research Institute of Serbia, and sign collaboration agreements with them, thereby ensuring the benefits of nutribreeding technology and all future projects managed by the TTO reach the private sector and all members of the public. The TTO and PMO will sign at least six collaboration agreements with companies interested in using the products

and technologies developed by the Maize Research Institute of Serbia over a three-year period.

The Institute is planning to adopt the internal **IP regulation** in the first year after adoption of this IP Strategy. The internal regulation shall cover the scope of application, definition of job-related innovations with specific emphasis on agriculture, guidelines to determine ownership and inventorship (including the rights of collaborating partners), tools to keep intellectual property confidential (as long as needed), information on the research record keeping practices, safeguards that protection for the IP is in place before the results are published, disclosure process and forms, establishment of the internal evaluation committee, evaluation process, recommendations by the committee to the director, remuneration to the inventors/innovators, which department is responsible for IP protection or termination thereof, IP portfolio data base, and other relevant provisions. Suggestion is to appoint a three-party committee (one person from TTO, one from Commercial Affairs and one from SC) that evaluates each disclosed research result and recommends a business decision to the Director. Project Results Project Implementation Project Proposal PMO - proposal - partnering - grant agreement TTO - background & foreground knowledge - material transfer agreements - monitoring project results TTO - IP disclosure & evaluation - IP protection - commercialization - PMO - project management - WPs & deliverables - financial monitoring PMO - project reporting - data protection - financial record keeping CREDIT Vibes, no. 101059942 13 | P a g e Department for Legal Affairs and HR shall prepare the first draft of internal IP regulation and put it in to public consultation for review and amendments. After public consultation, the second draft is consulted with the members of the SC and the management of the Institute. The final version of the document is approved by the director and implemented by the Research and Development.

Initially, the CREDIT Vibes project will raise the demand for highly skilled researchers and non-research staff, which will lead to better training capabilities, improvement of learning tools, and opening the jobs of the future. However, said jobs of the future will translate into the economy, thereby opening new job possibilities across the board. Strategic networking and staff exchange will, in combination with all the above, support R&I collaboration and increase staff mobility, which inevitably leads to innovative initiatives. In order to ensure that the right profile of researchers is available for the rising scale and complexity of projects, MRI's newly **developed HR office** will elevate the level of training and activities. These HR best practices will go beyond MRI and affect the entire institutional landscape that will be brought on to aid in the accomplishment of newly acquired projects. Networking and collaboration will not only stay within Serbian borders but will also spread across the region and the EU.

5 Technology uptake by industry

5.1 Target markets

Positioning our product as QPM hybrid with value-added traits or as feed for broiler chicks, we aim to improve the efficiency of operating input (seed or feed) and help farmers improve their financial gain through reduced costs and improved feed conversion ratio.

Our ideal customers are small to mid-sized broiler farmers or small food mixture manufacturers. The Serbian broiler farmers market is financially demanding but growing, especially with high export potential. Our product will offer significant benefits such as lower financial inputs of feed mixtures, better farm output, and improved financial outputs in profit margins.

There are no products from colored maize seed on the Serbian market, making our blue grain maize biscuit unique (Figure 1).

Figure 1: Biscuit made from blue grain maize with a high content of polyphenolic antioxidants

From a market point of view, attractive and stable color is an important sensory characteristic of food. In the last few years, the food industry has increasingly used various natural pigment compounds of plant origin, which at the same time have a strong antioxidant potential. In contrast to artificial additives, natural dyes attract great interest due to their presumed safety and potential health effects. However, incorporating natural pigment compounds into food systems represents a certain challenge due to their low stability, i.e., sensitivity to production factors such as light, oxygen, temperature, and pH value.

On the other hand, the TTO will analyse the market situation, identify companies interested in using the products and technologies developed by MRI, and sign collaboration agreements with them, thereby ensuring the benefits of nutribreeding technology and all future projects managed by the TTO reach the private sector and all members of the public. The TTO and PMO will sign at least six collaboration agreements with companies interested in using the products and technologies developed by MRI over three years.

5.2 Advantages and main benefits of MRI products

The main advantage of MRI products is that there are no competitors for QPM aimed at animal feeding programs in Serbia or Europe.

The main features of the QPM are reducing costs in the feed industry and bringing a new, affordable, high-quality product to the market. QPM is intended for broiler producers to improve the efficiency and quality of broiler raising. This would be the first such product in Serbia, with a high potential to compete in the world market. It would also stimulate breeding for different adapted QPM hybrids to widen the offer to the feed industry and, in this way, produce new competitive maize hybrids.

List of the three key commercial benefits or advantages of the QPM hybrids are:

1. Financial gain through reduced costs for feed producers
2. Financial gain for broiler producers due to improved feed conversion ratio
3. Financial gain for MRI through launching a new product - Institute product innovation

Regarding the project/research value chain, the team could position itself as the seed provider for feed-producing companies that already have good access to market/end customers, developed distribution channels, and even point-of-sale operations. This gives the team a better position to focus on undeveloped R&D activities with producing companies, offering the potential to license or partner for future ventures. The team already has connections with Agro-mil and Hrana produkt, which are animal feed producers in Serbia.

By introducing biscuits made from blue grain maize with additional nutritional values and classified as a functional food with potential health effect into the production and sale it is possible to achieve a higher price on the market compared to standard food products, which at the same time achieves a greater financial profit. For now, there is no information that similar products can be found on our market, i.e. blue grain maize biscuits. Maize is mainly used as a raw material in animal feed production, the price of which cannot be compared with the cost of human food. By using the product, it is possible to achieve extra profit by converting a cheap raw material (maize), with which the market is saturated, into a finished product with a high price.

In addition to the financial effect, the use of maize biscuits and flour would have an effect on preserving and improving the general health of the population, that is, the users of this food product. Primarily, this refers to the youngest population that uses sweets in their daily diet. The various biological activities of phenolic compounds, which are rich in biscuits, enable their use in the prevention of many diseases, such as cancer, cardiovascular diseases, neuro-degenerative diseases, diabetes, and obesity (Pojer et al., 2013). The health effects of blue maize biscuits can be compared to the possible health effects of berries. In addition, by consuming one hundred grams of blue maize biscuits, the content of phenolic compounds with a high antioxidant capacity that we introduce into the body would amount to an average of 300 mg GAE (Žilić et al., 2016).

In comparison, by consuming 100 grams of blackberries and chokeberry, the content of phenolic compounds introduced into the body amounts to about 280 mg GAE, i.e., 1070 mg GAE (Jakobek et al., 2007). Unlike phenolic compounds originating from berries, which are found in a free soluble form, phenolic compounds originating from maize kernels in biscuits are found in an insoluble form bound to dietary fibers (Žilić, 2016). Fiber-bound phenolic compounds stay longer in the gastrointestinal tract, collecting harmful free radicals that constantly form in the intestinal tract (Adam et al., 2002). In this way, the phenolic compounds of biscuits can be involved in the prevention of colon cancer, which is one of the most important functions of phenolic compounds originating from cereals.

Basic advantages of ZP flour by MRI:

- Integral (from the whole grain of maize - coat, endosperm, and germ)
- Naturally gluten-free (does not contain allergenic proteins)
- Non-GMO
- Produced from specific, specially selected ZP maize hybrids with white, yellow, red, and blue grain colors (high nutritional and functional values)
- Controlled production of raw materials (it is grown in the fields of the Institute, and the entire production process is under the constant supervision of technologists)
- The traditional way of grinding (on a millstone, which ensures complete preservation of all natural ingredients of the maize grain)
- ZIP closure on flexible packaging (enables multiple opening and closing of the bag while preserving the freshness, durability, smell, and taste of the flour)

First, the population's needs for nutrients and bioactive molecules essential for improving human and animal health and nutrition were extensively analysed, with results showing the necessity of introducing widely available nutrient-rich and healthy food. The new crop genotypes created during the project will be organically and sustainably produced with improved nutritional value and bioactive properties.

Additionally, the CREDIT Vibes methodology is designed to do no significant harm (DNSH principle) to any of the six environmental objectives detailed under the EU Taxonomy Regulation.

Figure 2: ZP integral maize flour, blue and white grain

5.3 Technical and market barriers

Two main barrier groups can endanger the attainment of the CREDIT Vibes goals. The first, the technical group, pertains to obstacles in developing the nutribreeding technology, which would endanger many other non-technical activities and benefits discussed in the previous section. The second, market group, pertains to the barriers in the institutional and economic landscape that can stop or slow down the translation of the scientific benefits from MRI to other institutions, companies, end consumers, and other stakeholders. Market barriers affect the translation of nutribreeding technology into the economy and all subsequent projects handled by the TTO and PMO offices. In this section, we will cover every potential barrier inside the two groups, along with ways to mitigate their effects, and put the CREDIT Vibes project on course to its established goals. Let us start with the technical barriers.

5.3.1 Technical barriers presentation and mitigation

As mentioned, most technical barriers are connected with the challenges of successfully developing nutribreeding technology. Hence, one of the barriers is the existence of poor germination in the working collection of crops. The best way to minimize the appearance of such a barrier is to increase the size of the working collection of each species in order to accommodate for poor germination and poor seed vigor. Another technical issue could be potential problems with seed

multiplication, meaning that there would be a lack of working material. To tackle this problem before it has a chance to appear, the list of genotypes in the working collection will be increased by at least 10% compared to what the initial plan dictates.

While the organic environment in which the technology development will take place is a considerable advantage for the quality of the end product, it can also cause certain problems. The most prominent of these problems are widespread pest and disease outbreaks arising from production in an organic environment. However, as long as all organic treatments are considered and exploited, these outbreaks should be contained. An additional beneficial factor, which is climate, can also have a negative side. Extreme climatic events may cause crop failure and hence endanger the exploitation of well-crafted nutricrops products. To avoid such incidents that seem beyond control, cultivation will be planned on multiple sites, thus differentiating the risk and significantly improving the chances of having enough exploitable products regardless of climatic conditions.

Moving on to the human factor contributing to technical barriers, it would be remiss if we did not mention the possibility of experiencing a server crash or a hacker attack in this day and age. However, the Data Management Plan lays out detailed and easily applicable preventative measures for both possibilities. Naturally, all the strategies and activities introduced so far are novel and require the staff to keep up with the pace and improve as the project progresses to keep execution at a satisfactory level. Hence, the current staff may be unable to handle these advanced challenges. However, a tactical approach to reskilling, upskilling, and hiring new staff will be more than enough to mitigate this barrier. Temporary staff might also be needed to mitigate unavoidable staff-related events, such as illnesses, maternity leave, etc. Finally, monetary and other incentives might be needed to elevate the staff's interest in participating in learning and promotion events.

The biggest burden of successfully mitigating all of the staff-related barriers falls on the HR office. Hence, if the HR office is not reformed as planned and modern, effective policies are not enforced, all the above problems get a whole new perspective. However, since the plan for revolutionising the way the HR office functions is in place, such a scenario should not happen. This also implies that things like the lack of project management and administrative skills will be mitigated with the proper training and improvement measures.

5.3.2 Market barriers presentation and mitigation

The first and foremost market barrier is the potential elevation of the economic crisis. The global economy is still recovering from the effects of the pandemic and the ensuing isolation measures, while the war in Ukraine and problems in Gaza remain unresolved. At the moment, the economy has not yet been put to a halt but was

merely slowed despite the war-disrupted energy and food markets combined with some of the most stringent monetary restrictions in history. According to the International Monetary Fund (https://www.weforum.org/agenda/2024/02/imf-economic-growth-eurozone-recession-5-february/) the baseline forecast is for global growth to slow to 2.9 percent in 2024 (1.4 percent in advanced economies. All this implies that the economy is unstable, which has been considered when making all financial projections and activity decisions.

Amidst the potential economic crisis, the cost of organic nutrifood keeps increasing. High prices are not only a research barrier but also contribute to creating a gap between the willingness of end consumers to consume and buy healthy *feed* and their potential to actually do so, given finance-related issues. The higher the price premiums, the more challenging it becomes to incentivize people to consume highly nutritious healthy food. The CREDIT Vibes project will aid such development efforts and promote the benefits of organic nutrifood to ensure the general public grasps the importance of including them in daily consumption routines.

Another concern can be the political situation in Europe and its neighboring regions. If it becomes unstable, which is not entirely ruled out, funding and priorities may change, thereby affecting the project's feasibility. However, the CREDIT Vibes project outlines numerous ways of communicating the importance of the work and its dissemination, which should not be ignored by any relevant policymakers. Moreover, the activities for obtaining public support ensure another layer of safety from eventual game-changing events.

Tradition, habits, and overall resistance to change represent yet another potential market barrier. In traditional societies, any change, no matter how beneficial, is met with doubt, and initiators must go above and beyond to prove its value to the individual and the society as a whole. Engrained eating habits also represent a significant challenge because changing them is more complex than wanting and needing, especially given their interwovenness with traditions. This is where the importance of a well-rounded communication plan comes in, with both short-term messaging intended to soften current resistance and working on changing the long-term understanding and views regarding nutrition being instrumental in mitigating said barrier.

Finally, we should not rule out the possibility of yet another pandemic and all the consequences it brings, affecting people and economies worldwide. Travelling, education, and enhancement of human resources are the most potentially affected factors. To minimize the consequences of such a turn of events on the project and its translation to the economy, all measures for ensuring online work and long-distance education in as many aspects of the project as possible will be taken.

6 Future development plans

This section will explore all the desired outcomes of the CREDIT Vibes project and the NutriCrops for NutriFeed (N4N) initiative for MRI, the institutional and economic landscape, end consumers, the general public, and all stakeholders, along with steps and actions that will be taken to ensure said outcomes become reality. First, the CREDIT Vibes project will build a welcoming environment for adopting healthy *feed*, with all the necessary arrangements for its development and distribution. The groundwork for developing nutribreeding technology and introducing novel products with higher nutritional power and amplified health benefits has already been laid, as discussed in the Direction and goals section.

Production of the ZPQPM13 hybrid will be conducted in 2024 to obtain quantities necessary for further testing and marketing purposes. The seeds from this production will be chemically analysed for biochemical components necessary for precise feed formulations. Also, experiments on the meat quality of broilers fed with ZPQPM13 will be performed. According to the literature, broilers fed with QPM hybrids can increase breast muscle yield and reduce abdominal fat (Panda et al., 2014). If this proves true, ZPQPM13 can be presented as a hybrid with additional values for broiler producers. After the experiments, an application for patent protection will be submitted.

The invented technology will become more ready for commercialisation. Further analysis of the target markets and their needs will allow us to modify, redesign, and prepare the technology for commercial use accordingly. Therefore, increasing the invention's commercialisation potential will be the main aim of the further program. It would allow us to improve the technology readiness level (TRL) through the additional testing setup required for the technology in collaboration with industrial partners (and external experts).

Existing regulations in Serbia do not include registration procedures for QPM maize with improved protein content. The MRI proposes to the Ministry of Agriculture that two-year tests be required according to the same principle as for maize of normal quality (VCU-Yield, moisture, laying, and DUS test for parents and hybrid).

As a gluten-free grain, maize is one of the most suitable raw materials for food production for people with gluten intolerance and celiac disease (de la Hera et al., 2013). Together with rice, it is the most cultivated grain in the world. Among cereals, colored maize is the most important and richest source of anthocyanins. Simple or acylated anthocyanins are mainly found in the aleurone layer of the maize endosperm or pericarp and affect the color and antioxidant capacity of the grain.

Furthermore, the project's initiatives and work packages are constructed to create fruitful collaboration in the region and the European Research Area regarding

projects, staff exchange, and more. Raising the excellence of MRI will inspire positive scientific, economic, and societal effects of raising, such as opening new science pathways, elevating the skills of researchers, incentivizing other not-directly-related projects, empowering other institutions to make improvements, establishing a dialogue and cooperation with the private sector and the general public, and more. Finally, the aforementioned transfer of agro-technology and agro-knowledge improved by around 20% will be a major economic growth propeller. The increased efforts in developing novel nutribreeding technology will boost scientific excellence all around, aid the development of new research avenues and know-how technologies in sustainable, eco-friendly farming, which will then lead to new projects with other institutions and companies, initiate a knowledge transfer, and strengthen the economy as a whole. All this will ultimately also help close the research gap within Europe.

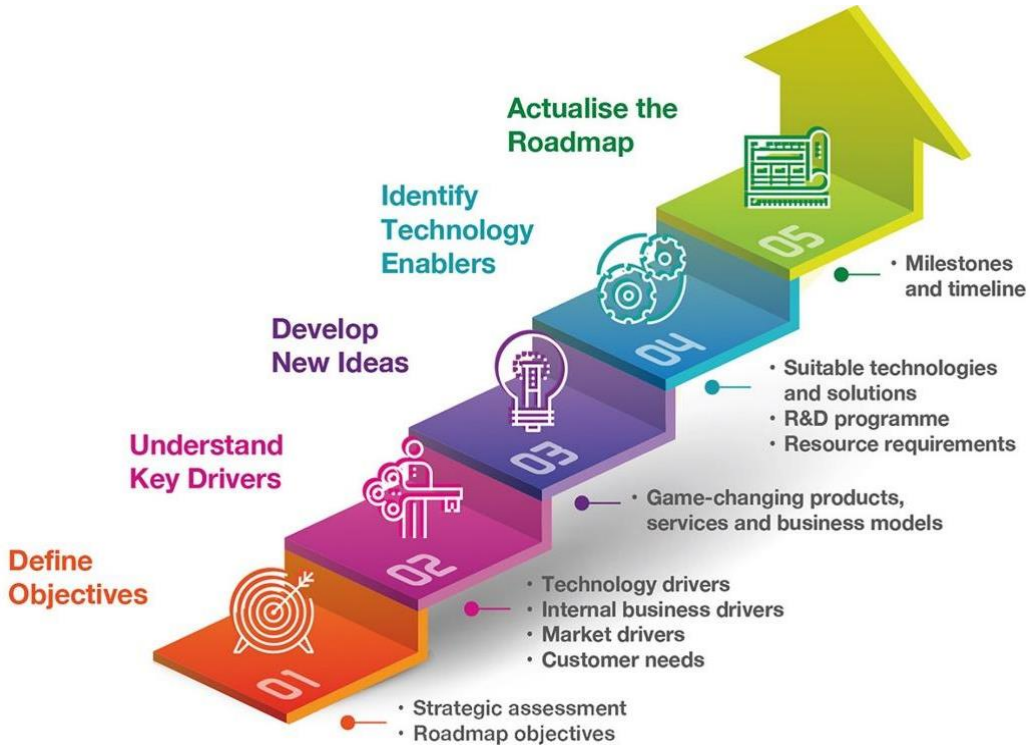

*Figure 3: Steps of practical N4N roadmap (*https://www.usme.org.sg/how-we-help/operation-and-technology-roadmap)

Establishing TTO and PMO, for which the steps have already been taken and outlined in this document, will vastly improve and aid the translation of said scientific excellence and ideas into projects, resulting in concrete benefits for the entire economy. The TTO will strengthen transfer technology management capacities, bridge the innovation gap, and open new markets within Europe. The PPO will strengthen research management capacities, bridge the knowledge gap in project management, and rapidly acquire know-how accumulated in Slovenia and Greece,

thus enabling the establishment of a system that will facilitate the preparation of project proposals and access to funding opportunities in the EU Framework programmes and beyond as well as broader participation of the coordinating institution in the Horizon Europe programme. And the last step is to determine the market and obstacles for achieving a certain benefit by selling products on the domestic and foreign markets here and in the next 3-5 years.

7 Conclusion

In the age of undernourishment, obesity, micronutrient deficiencies, and many other negative effects of the large percentage of the world's population eating nutrient-poor food, the development of nutribreeding technology initiated by the CREDIT Vibes project is not only a major scientific breakthrough but a must for introducing novel feed/food consumption patterns into farms and households in order to save our planet and our health. Therefore, the project was developed in a way that both facilitates the creation of novel nutrient-rich food products and ensures they are available to everyone while taking action to raise the awareness of every institution, company, and individual in our modern society.

The revolution starts from stringent laboratories where the technology will be developed, moves across the structural transformation of MRI, which ensures its staff is better equipped and able to handle more projects with challenging goals and compete for EU funding, and then transfers to other institutions working with MRI, the private sector, farms, and eventually individual households. The economic benefits go beyond creating jobs for the future, creating new standard job posts, and boosting the organic nutricrops market. Heightening and boosting the transfer of agro-knowledge and agro-technologies will enable the entire economy to take advantage of the nutricrops development.

Finally, this document laid out specific steps the TTO and PMO offices will take to empower both the creation and fulfillment of potentially ground-breaking projects and their translation into concrete benefits for the economy and society. When the nutribreeding technology is successfully developed and integrated into the economy, the procedures and guidelines developed in the process will form a strong foundation for doing the same with the multitude of future projects CREDIT Vibes will inspire and enable.

The need for an alternative type of fөөd that also has an improved nutritional composition will ensure the opening of new and expansion of existing domestic and foreign markets in the next 3-5 years.

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