

*This report is a draft version. Work is still on progress.
The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.*



**Directorate General for
Agriculture and Rural
Development**

**Preparatory action on
EU plant and animal genetic resources
(AGRI-2013-EVAL-7)**

WORKSHOP REPORT

Exploring the need for a pan-European network and infrastructure for the conservation and sustainable use of MiGRs in Food and Agriculture

23-24 November 2015, The Netherlands

Exploring the need for a pan-European network and infrastructure for the conservation and sustainable use of MiGRs in Food and Agriculture

WORKSHOP REPORT

23-24 November 2015, The Netherlands

The Workshop is one of seven that cover the four different domains under scrutiny: animal (AnGR), plant (PGR), forestry (FGR), and microbial genetic resources (MiGR). This workshop took place in the context of the study launched by DG AGRI of the European Commission called " *Preparatory action on EU plant and animal genetic resources*" which is being conducted by a Consortium of experts and consultants. It started in July 2014 for duration of 2 years.

More information on the objectives of the study can be found on the study website: <http://www.geneticresources.eu>.

The Workshop is the third of the series and covered the MiGR domain.

CONTENTS

1	Introduction	1
1.1	Background	1
1.2	General challenges for improving collaboration and co-ordination among stakeholders on conservation and use of MiGR	3
2	Agenda of the Workshop.....	4
3	Summary of the discussions on the presentations during the two plenary sessions (<i>setting the scene</i>)	6
4	Conclusions and Specific Actions.....	15
	ANNEX 1: List of participants	17
	ANNEX 2: Presentations.....	18

Exploring the need for a pan-European network and infrastructure for the conservation and sustainable use of MiGRs in Food and Agriculture

1 Introduction

The third workshop on “*Exploring the need for a pan-European network and infrastructure for the conservation and sustainable use of MiGRs in Food and Agriculture*” was held in The Netherlands on November 23-24, 2015. It was prepared by:

- **Marizeth Groenewald** (CBS-KNAW, the Netherlands); and
- **David Smith** (CABI, UK)

The following additional experts provided significant input towards the success of the workshop in their capacity as moderators, rapporteurs or presenters:

- **Gerard Verkley** (CBS-KNAW-NL)
- **Loredana Canfora** (CREA RPS-IT)
- **John Morris** (Assymptote -UK)
- **Anton Sonnenberg** (University of Wageningen-NL)
- **Giancarlo Perrone** (ITEM-IT)
- **Vincent Robert** (CBS-KNAW-NL)

The focus of Workshop 3 was to explore additional possibilities to expand collaboration between national microbial collections and the food and agricultural stakeholders in order to improve the conservation and sustainable use of the available MiGR in the EU

1.1 Background

The micro-organisms that are currently known represent a significant percentage of the existing organisms on earth and the estimated number of microbes exceeds that of insects, and makes them the largest group of living organisms on earth. Microbial diversity includes bacteria, yeasts, filamentous fungi and microalgae amongst others. To date it is still unclear what the full potential of these organisms is but it is clear that a coordinated approach on conservation and sustainable usage of them will accelerate innovation and discovery. Microorganisms of agricultural interest play a key role in sustainable food production such as dairy products e.g. cheese, also wine, beer, oil, etc., additionally in the production of food related products. They can also have positive impact on soil fertility and crop nutrition; be used for bio-control of pests and diseases and as bio-fertilisers. However, they can also have a negative effect through secretion of toxins, they can be pathogenic to crops or be present as contaminants in the processing of food products. The collection of microorganisms is quite unlike that of plants and animals as they are generally unseen and most often gathered in environmental samples requiring subsequent steps to isolate them as pure cultures.

Bacteria are usually one-celled that can be found everywhere on earth and are one of the smallest microscopic living organisms found. In 1676, Anton Van Leeuwenhoek first observed bacteria through a microscope. The first observed bacteria were shaped like

rods, but bacteria can be spiral or spherical in shape. They have been used for thousands of years in the preparation of fermented foods, such as cheese, pickles, soy sauce, sauerkraut, vinegar, wine and yogurt. Specific bacteria are also used as biological pest control that is environmentally friendly, with little or no effect on humans, wildlife, pollinators and most other beneficial insects.

Yeasts are fungi and in the general sense are also microscopic single-celled organisms, but they are bigger than bacteria (often in the order of 80 times the volume); they ordinarily reproduce by fission or budding with the daughter cells often remaining attached. Many yeasts ferment sugars to form alcohol and carbon dioxide and that is also why many types of yeasts are used in the production of different foods and food related products such as bread, beer, wine and also in non-alcoholic products such as non-alcoholic beer, production of probiotics and use as flavouring compound in food.

The filamentous **Fungi** include a tremendous variety of organisms. These unique multicellular eukaryotes include thousands of examples and their impact on our world as decomposers is absolutely crucial to every ecosystem. They have also other properties that can be used in the production of food products. Some sausages, such as salami, incorporate starter cultures of moulds to improve flavour and reduce bacterial spoilage during curing. A range of fungi are used to make soybean paste and soy sauce, various cheeses including Brie and Blue cheese, microbial rennet for making vegetarian and other cheeses, sake, other distilled spirits and many other products.

Micro-organisms that have been preserved in culture collections for many decades are now being utilised for novel purposes. Diversity of characteristics within a species can be observed and this emphasises the importance of preserving multiple, diverse strains within species in a proper manner to allow future innovative uses. Microbial genetic resource (MiGR) centres have an extremely important role underpinning the conservation of microbial biodiversity and their *ex situ* preservation. This includes the responsibility to assemble, preserve, and authenticate reference and additional biological materials and its associated information for distribution to academia and industry. This allows future studies and uses of these genetic resources to facilitate further developments in agriculture, food, biotechnology and education. Two clusters of MiGR centres exist: the well-established generalist collections and smaller collections that are more specialised and very often interested in specific characteristics of the microbes and even focus on microbes that inhabit specific niches.

Unfortunately these groups are just beginning to get organised in the form of a European Research Infrastructure, bringing together this distributed community. Currently there is not a collaborative focus on the conservation and sustainable use of the MiGR specifically for Genetic Resources for Food and Agriculture. It is difficult to assess the total cover and numbers of MiGR that are kept in public culture collections and that are accessible for future use for these purposes. It is expected that much higher numbers are incorporated in private collections, collections involved in small

scale production, those that focus on the needs of the people of the specific geographical region or collections that are retained for specific uses in the food industry. Most of these MiGR are not available nor is the information and data linked to them sufficiently accessible.

Currently microbial culture collections preserve a broad range of microbial diversity, and deliver well-identified, authentic and high-quality materials to the users. They play a key role in the conservation and sustainable use of authentic reference material for research and development. The general principle is that *ex situ* collection approaches should be complementary to promote conservation and sustainable use. In contrast to the genetic resources of plants (PGR), animals (AnGR) and forestry (FGR), *in situ* conservation of MiGR is not generally carried out and monitored; often it is assumed that the microorganisms will look after themselves consequently information on this is very limited. Several EU projects have been launched in the past few years that focussed on aspects linked to collections of living microorganisms and how to harmonise microbial conservation within the EU. However, there still remains the need to specifically address the conservation and sustainable use of MiGR; culture collections and stakeholders in the food and agriculture field should come together to assess the what needs to be done to improve the current situation.

In MIRRI, an ESFRI research infrastructure currently preparing itself for an ERIC status, an effort has already been made to improve many of these aspects and the focus should be to collaborate with MIRRI to bring together the hidden resources and deliver a comprehensive and coordinated coverage with the relevant data to make them useful in the field of Genetic Resources for Food and Agriculture. The question to be addressed is how possible future networking, collaboration approaches and co-ordination can contribute to a more effective and efficient strategy for conservation and sustainable use of MiGR in food and agriculture in Europe without duplicating what already is done in MIRRI; the focus should be on filling the gaps.

The key objective of the MiGR Workshop is to explore additional possibilities to expand collaboration between national microbial collections and the food and agricultural stakeholders in order to improve the conservation and sustainable use of the available MiGR in the EU.

1.2 General challenges for improving collaboration and co-ordination among stakeholders on conservation and use of MiGR

One of the main problems for co-ordination of conservation and use of MiGR of relevance to food and agriculture in Europe is the huge variation in the type of organisms, their current usage and potential. Collections keeping these types of MiGRs vary from public service collections with a primary taxonomic focus, to collections with a more specialised focus on application areas for specific sectors such as plant pathology, food, environmental, and non-public collections of patented organisms or private collections. They also vary considerably in size, form and function as they include culturable organisms from bacteria, fungi to yeasts, their replicable parts such as genomes, plasmids and cDNAs, viable but not yet culturable organisms, cell and

tissues, databases containing molecular, physiological and structural information relevant to these MiGRs and allied bioinformatics. Some key issues are:

- Microbial *ex situ* collections lack the level of co-ordination and collaboration with stakeholders in the food and agriculture groups, as is seen among the PGR, AGR and FGR collections, also represented in this consortium.
- How can the microbial Biological Resource Centres (mBRCs) collaborate with stakeholders maintaining additional very important Genetic Resources for Food and Agriculture in order to ensure the conservation of the huge amount of microbial biodiversity that already exists?
- How can better communication and collaboration be established between culture collections, researchers, partners from the food and agricultural industries and stakeholders involved in small scale production of regional products to improve the conservation and sustainable use of as much as possible MiGR important in food and agriculture in Europe.
- mBRCs also maintain extensive databases providing access to information on cultures, their characteristics, literature, DNA sequences etc. How can the Genetic Resources for Food and Agriculture community be stimulated to make more use of these data and to add new data generated by this community ?.

The expectation of the workshop was that the different stakeholders present would raise a variety of considerations and possibilities for networking, co-ordination and collaboration that could lead to the improvement of different aspects concerning the conservation and sustainable use of MiGR of relevance to food and agriculture in European for the future

2 Agenda of the Workshop

The agenda presented below was developed to facilitate discussions of the identified challenges.

On the first day a plenary session was organised where three speakers introduced important aspects that set the scene for discussing the need for a pan-European network and infrastructure to ensure better communication and acceleration of the exchange of best practices in order to improve the conservation and sustainable use of the MiGR of relevance to food and agriculture. Afterwards different issues were discussed in the framework of the first four themes and the results were highlighted at the same time.

- Theme 1: Improvement of the communication between Member States concerning best practice and the harmonisation of efforts in the conservation and sustainable use of genetic resources
- Theme 2: Enhancing networking among key stakeholders and end-users in view of exploring marketing (and other cooperation) opportunities, such as provided by quality schemes and short supply chains

- Theme 3: Improvement of the exchange of knowledge and research on genetic diversity in agricultural systems

On the second day the plenary session, also included three speakers who set the scene for a discussion on the methods to maintain ecosystem services of associated biodiversity – initiatives and collaboration between microbial collections and industrial partners by looking at joint efforts between microbial collections, industrial partners and small scale producers of regional products. Additionally, in the discussion session, issues of relevance to the framework of the last three themes and the results were discussed.

- Theme 4: Adaptation of breeding methods and legislation to the need of conservation and sustainable use of genetic diversity
- Theme 5: Contribution to the successful implementation of rural (urban/countryside) development measures concerning genetic diversity in agriculture
- Theme 6: Explore bottlenecks and enabling conditions for the sustainable use of genetic resources in agriculture
- Theme 7: Reduction of unnecessary administrative burden so as to provide better access to actions

The final session brought together the important gaps and actions needed for improvement in coordinated access to data and resources.

23 rd November 2015		
13.00 - 13.30	<ul style="list-style-type: none"> • Welcome of participants • Reminder of the objectives of the study • Objectives of the workshop 	Sirpa Karjalainen David Smith
13.30 - 15.00	Setting-up the scene :	
	- Networking networks to access materials and data: the MIRRI perspective	Gerard Verkley
	- Guidelines for the conservation and exploitation of the agricultural Biodiversity (GIBA)	Loredana Canfora
	- Development in preservation technologies and their application	John Morris
15.30 – 15.50	Coffee break	
15.50-17.00	<ul style="list-style-type: none"> • General Discussion - Specific discussion regarding presentations - Focus discussion on first four themes of project 	Moderator and rapporteur: David Smith

24 th November 2015		
9.00 - 10.30	Setting-up the scene :	
	- Fungal collections, relevance for mushroom breeding and biobased economy	Anton Sonnenberg
	- BioGenRes and CNR/ITEM collection: Microbial resources for improving quality and safety of Mediterranean products	Giancarlo Perrone
	- Integrated databases: potential usage and	Vincent Robert

	perspectives	
10.30 – 10.50	Coffee break	
10.50-12.00	<ul style="list-style-type: none"> • General Discussion <ul style="list-style-type: none"> - Specific discussion regarding presentations - Focus discussion on last three themes of project 	Moderator and rapporteur: Marizeth Groenewald
12.00-12.15	Conclusions and next steps	

3 Summary of the discussions on the presentations during the two plenary sessions (*setting the scene*)

The programme was built around six presentations with time for supportive and follow up discussion on the main themes of the preparatory action.

The six presentations are included in the Annex to this report. The issues raised during the presentations and the conclusions drawn for each of the seven themes of this project are presented below.

Networking network to access materials and data: the MIRRI perspective

Issues arising during the presentation:

- Several networks of microbial resources exist already at national, regional and global levels, but more input from stakeholders is needed to guide resource holders to produce the required information, products and services in order to supply a complete package for optimum conservation and sustainable use of MiGR for agriculture.
- There are gaps in the range of the type of organisms of relevance to food and agriculture that are available and the amount and quality of the associated data. Here the Genetic Resources for Food and Agriculture stakeholders should play an important role, giving advice on what the priorities should be and how the gaps should be filled.
- There is a lack in specialised expert clusters that can give sector specific information. A more focused approach is needed considering the huge variation in the type of organisms and the ways in which these are used.
- Partnerships and better communication are needed between users, resource holders, industries and funders to address the key issues of the Genetic Resources for Food and Agriculture community.

Guidelines for the conservation and exploitation of the agricultural Biodiversity (GIBA)

Summary:

Microbial diversity in agriculture is a special example of interaction between environmental conditions, microbes and human activity. Microbial communities involved in food farming are strictly related and are influenced by many genomic interactions and food competitions throughout the entire farm and food supply chain.

For all these reasons it is necessary to safeguard the soil microbial genetic resource not ignoring, in addition, the soil-microorganisms plant system. Microbial genetic resources for food and agriculture, form complex and dynamic associations with plants and play key roles in soil quality, host productivity, host health.

The *Italian National Plan for Biodiversity* has strongly emphasised the importance of microbial biodiversity in general and in the agricultural context, leading to the introduction of a specific sub-group on Microbial Biodiversity within the Italian Working Group for Biodiversity of Agricultural Interest asked to prepare the “Guidelines for Biodiversity”. The main objective of this work is to provide guidelines for the conservation of biodiversity for animal genetic resources. This text has been designed to meet the operational needs of technical stakeholders involved in the implementation of measures for the conservation of animal genetic resources and has been written thanks to the contribution of experts and the consultation of numerous articles and scientific papers. The document emphasises the intrinsic value of native Italian breeds as irreplaceable and unrepeatable national heritage. It also highlights the need for further work on the current and future economic assessment of the domestic breeds, and the scientific, cultural and environmental services they can provide to society.

This evaluation is a prerequisite to advance and evolve the overall strategies and individual activities for the conservation of biodiversity in agriculture - and breeds in particular put in place up to now. Strategies and activities that, in many cases, helped to avoid or slow down the extinction of native breeds, but in other instances proved ineffective in halting the genetic erosion process that began with the establishment of intensive breeding systems, currently more and more unsustainable from an economic or environmental point of view.

The document provides concepts, tools and operating protocols for the conservation of animal genetic resources through an innovative approach that takes into account the multifunctional role of local breeds; it also lists some examples of application of the suggested protocols. The text is divided into 2 parts: the first describes the general concepts of biodiversity and animal genetic resources, provides some data on the loss of biodiversity and the genetic erosion in the world and in Italy, as well as legislation and breeds conservation initiatives put in place at global and local level. In the second part, after the chapters dedicated to the nomenclature, the definition of species and breed, and the use of morphological and molecular markers for characterisation of the breeds, the study proposes tools and operating protocols for the protection and enhancement of native breeds threatened by genetic erosion or at risk of extinction.

In addition to the conservation strategy currently implemented in countries of the European Union, the guidelines propose an innovative approach that provides the concept of “priority” of a certain breed to achieve a specific conservation objective. Finally, the report includes some case studies that help to understand the concepts and protocols described in the text, as well as a glossary of terms and extensive scientific literature.

- There has been some effort in the past to create guidelines for some of the subsectors in the Genetic Resources for Food and Agriculture sector but at the moment no practical implementation strategies are in place. Such an example is the one from Italy; this needs to be discussed at the European level to ensure it's applicability at the regional level. Case studies on specific priorities are necessary to demonstrate their utility.
- The development and implementation of new technologies, including isolation and preservation methods and methods for accurate characterisation of the microbes such as Next Generation Sequencing, are needed to improve our understanding of microbial diversity and function and provide information to address key issues such as soil fertility.
- There are mechanisms needed in order to manage the risk of genetic erosion and the associated loss of microbial biodiversity in natural environments. It is important to find means to preserve the microbial-soil interactions for *in situ* conservation of the MiGR in natural environments. This is also relevant for microbial interactions in other environments.

Development of preservation technologies and their application

Issues arising during the presentation:

- Technologies for preservation are advancing but there is still a need to address important issues such as; keeping all organisms that are present in environmental mixed samples alive and active. This includes processes such as spontaneous fermentations that are used in the wine industry that may be based on several organisms which need to be preserved in a mixed culture for future reproducibility and sustainability of the wine making processes. Many individual species cannot yet be grown in culture and if traditional ex situ conservation methods i.e. isolation, purification and storage were used for long-term preservation then key organisms in the process could be lost.

Fungal collections, relevance for mushroom breeding and biobased economy

Summary:

Wit-rot fungi are the only organisms that can degrade lignin in lignocellulosic materials. Some of these fungi are selective, which means that they degrade lignin while hardly degrading cellulose. In this way, cellulose becomes available for enzymatic degradation to generate sugars for the production of bioenergy or raw materials for the production of bioplastics. In this way, second generation biofuels can be produced avoiding competition with food as is done now by using starch crops. The fungal treatment increases also the digestibility of lignocellulose for ruminants and in this way a whole new source of crop residues can be made available as animal feed. Some of the white-rot fungi also produce edible mushrooms (grey oyster mushrooms, shiitake, king oyster mushrooms etc.). The selective degradation of lignin during vegetative growth makes cellulose and hemicellulose available for mushroom production. Research on improving the extent and selectivity of lignin degradation in lignocellulosic

materials benefit thus both the mushroom production and the use of fungi to valorise lignocellulose.

Until now, not much research has been done to improve the performance of fungi using the genetic variation within each species. Plant Breeding Wageningen UR has an extended collection of fungi and preliminary research has shown that the variation within each species is high with respect to selective lignin degradation. This means that collecting, preserving and evaluation of genetic variation for fungi that can be used to improve the produce edible mushrooms and to improve valorisation lignocellulose by selecting better strains and also by breeding strains for this particular purpose. So far, hardly any evaluation has been done for European countries what the genetic variation is in natural populations. There is thus a need to initiate such an evaluation soon also because some natural environments where these species grow are changing rapidly.

Issues arising during the presentation:

- There is a need for a survey of Edible Mushroom providers in Europe. It is a US\$2 billion industry. Preliminary sampling has shown that there is a large genetic variation of natural populations of white rot fungi and fungi that produce edible mushrooms in Europe. Exploitation of wild varieties of mushrooms has thus a lot of potential but little is being done to explore this at the moment and this gap has to be filled.
- There is a demonstrated potential in mushrooms, not only as food products but also in the light of bio-based economy where they can play a role in e.g. valorisation of the most abundant biomass on earth, i.e. lignocellulose.
- Many indigenous species are endangered and although there are collections in EU, there is limited collaboration among them. There is a large potential for collaboration between MiGR holders and the mushroom industry using wild relatives having more genetic variation in their mushrooms for example through breeding; means for collaboration should be investigated further.

BioGenRes and CNR/ITEM collection: Microbial resources for improving quality and safety of Mediterranean products

Summary:

In recent years a rising common concern is looking at biodiversity concept with a new sight, attempting to evaluate its economical value, as ground step for supporting measures proposed by national governments and international committees. The Department of Bio-Agrifood Sciences (DiSBA) of National Research Council (CNR) among its targets includes defense, knowledge and exploitation of genetic resources of plants, animals and microorganisms involved in various Agrifood sectors. The DiSBA Institutes hold important collections of biological material belonging to these three main sections. Totally, they are more than 100,000 accessions and they were recently included in Italian network BioGenRes (www.biogenres.cnr.it/). These data related to genetic resources available in the DiSBA could be used to foster collaboration not only

among researchers, but also citizens, stake-holders, public and private institutions, allowing understanding the mechanisms that shape biodiversity, both for their effective exploitation in improvement programs for a sustainable food production. The section "Microorganism" in BioGenRes includes the Agro Food Microbial Culture Collection "ITEM", with more than 11,000 strains (<http://server.ispa.cnr.it/ITEM/Collection/>). ITEM is member of European Culture Collection Organization (ECCO) and of World Federation Culture Collection (WFCC), it take part as associated partner of the European Project on Microbial Resource Research Infrastructure – MIRRI (www.mirri.org/). All the strains are stored in duplicate: cryo-preserved at – 150 °C and as fresh cultures at 4 °C. These are mainly isolated from the Mediterranean agro-food systems, including various microorganisms (fungi, yeasts and bacteria) of noteworthy pathological, toxicological and agro-food importance, such as *Aspergillus*, *Alternaria*, *Beauveria*, *Fusarium*, *Penicillium*, *Trichoderma*, *Saccharomyces*, *Hanseniaspora*, *Lactobacillus*, *Oenococcus*. Some of them are involved in plant and animal diseases, other are responsible for mycotoxins contamination of crop and food products, as well as for production of various secondary metabolites with different biological activities (i.e. antibiotics, entomo-, phyto- and zoo-toxins). Autochthonous yeast and bacteria (including probiotics) have been preserved and characterised for their application in food/beverage industrial sectors (i.e. functional foods, typical Apulian wines, table olives and dairy products). In general, the microorganisms preserved are of agro-food and agro-industry interest, they may represent a new frontier for discovering novel and safe metabolites with specific biological activities, environmentally friendly agrochemicals, as well as new and typical starters for the food industry.

Issues arising during the presentation:

- There are still only a few projects that focus on the development and improvement of regional products. This is mainly due to the lack of financial support for the development of specific products from MiGR.
- Better marketing is needed to promote the use of MiGR in different products e.g. spontaneous fermenters in wine, cheese, olive oil; probiotics and biological control agents.
- A crucial problem is that particular activities often involve complex interactions among the microflora that exist in a specific habitat; thus improvement is needed in preservation technologies and regeneration of these preserved materials.
- It is unfortunately very difficult to control such traditional spontaneous fermentations and create stable optimal conditions in order for the microflora to behave in a reproducible manner.
- Better partnerships and a mutual understanding is needed to bridge the gap between resource holders and the small enterprises and farmers in the specific fields.

Integrated databases: potential usage and perspectives

Issues arising during the presentation:

- There is a need to address information at the strain level to ensure their best possible use of the GR. The full potential of the microorganisms in terms of key or favoured properties is not always present in all strains of the same species. Production quality and yield are often dependent on the strain. It is therefore important that data is generated and coordinated at this level.
- The aim should be to have a minimum number of portals in order to link existing data for MiGR present on the web all together that will ease the search of relevant information on available MiGR. This can be done as an online *strain book* that will interlink data and also facilitate exchange of data and information from different users where necessary. There are already some examples such as the online Qbank database that was created for plant protection issues.

Discussions and conclusions made on specific issues concerning the seven themes

Theme 1: Improvement of the communication between Member States concerning best practice and the harmonisation of efforts in the conservation and sustainable use of genetic resources

- There is a need to explore and understand microorganisms that can play a role in food and agriculture and their potential uses much better. A major concern and focus point is the lack of knowledge on (mixed) environmental samples that are difficult to culture and difficult to preserve as mixtures of organisms. Often the component species need different treatments where they are known; most are unknown organisms with unknown requirements.
- There is insufficient information and knowledge on the functionality of many microorganisms found in agricultural niches.
- There is a need in the field of Microbial Genetic Resources for Food and Agriculture for more structured multidisciplinary interactions. Researchers, farmers, collection holders and industry have different knowledge that is required for the successful conservation and sustainable use of the MiGRs in food and agriculture.
- At the moment it is not clear to the industrial partner how they can benefit from collaboration with collection holders. Industry (e.g. wine, mushroom and Cider) requires a focused response to their needs but for the moment many strains that may have beneficial properties are lacking such information.
- It is important to focus on improvement of existing and already established guidelines and network infrastructures and not reinvent the wheel.

Theme 2: Enhancing networking among key stakeholders and end-users in view of exploring marketing (and other cooperation) opportunities, such as provided by quality schemes and short supply chains

- The focus should be to advertise and promote the possible use and importance of MiGR and include more specific information on the genetic resources to make them usable and attractive to end-users such as industrial partners.
- One major stakeholder group is bioindustry which have the need to keep information confidential and two-way exchange of information is often difficult (or needs to be under non-disclosure agreements). This problem can be resolved by specific mutually beneficial business models. Exchange of information and close collaboration between bioindustry and MiGR holders is currently working on a bilateral basis, but it is much more difficult to achieve successful collaboration where multiple partners are involved e.g. between companies and consortia of resource holders.
- Strategies for conservation of endangered organism communities should be executed by collaborating partners representing activities in all ecosystems where micro-organisms are living in a closed symbiotic environment.
- (End-)users need to feel involved and be better informed on specific problems they might have and how they can benefit from outsourcing and collaboration with MiGR holders. It is important to involve stakeholders as advisors to connect the different sectors, research/(biotech) industry/MiGR holders/farmers, with each other; it is also important that collection holders provide up to date detailed information on the MiGR that are available. Combined workshops covering each of the relevant sectors should be organised that should first focus on basic information to introduce the different aspects of importance for each sector and then become more focused in designing strategy and actions to improve innovation and discovery.

Theme 3: Improvement of the exchange of knowledge and research on genetic diversity in agricultural systems

- There are already quite a lot of success stories demonstrating collaboration between research collections, mBRCs, small focused collections, farmers and (biotech) industry. It is important that these successful collaborations are publicised and promoted in order to trigger the interest from all sectors of Microbial Genetic Resources for Food and Agriculture. This can be done with research projects that involved genetic resources and led to specific products or collaborative platforms e.g. the collaboration of microbial domain Biological Resource Centres with the Quarantine organisms Barcode Of Life (QBOL).
- It is also important to transfer technology and knowledge to lesser resourced countries within EU and include them in established networks and involve them in the decision making.
- Coordination is needed in order to integrate whole genome sequence data with known functional data. It is important to use existing examples and data resources to better understand and incorporate this type of mega data to strain information (using the strain book model – see presentation by Vincent Robert).

Theme 4: Adaptation of breeding methods and legislation to the need of conservation and sustainable use of genetic diversity

- In the future, genes from the yet to be cultured microbes that were acquired from metagenomic programmes will be introduced in suitable/appropriate hosts. It is therefore important to acquire better information on legislative requirements. Suitable Material Transfer Agreements (MTAs) are essential to have available that allow for the implications of breeding rights and to have legal certainty when using such products, in particular access and benefit sharing requirements.
- There is a lack of coordinated projects that focus on microbes associated with specific plants (saprobes and obligates).

Theme 5: Contribution to the successful implementation of rural (urban/countryside) development measures concerning genetic diversity in agriculture

- It was demonstrated that retaining microbial genetic variability is important particularly for use in the cheese, wine and meat industries represented. This is necessary in order to have a food product that is diverse in its taste, texture and even colour.
- Improving nutritional value of food has become a relevant topic and for this it would be interesting to look at the genetic variability in the microorganisms that are currently used to improve the nutritional value of products.
- *In situ* and *ex situ* conservation programmes need to link more strongly with an emphasis to protect endangered species. Conservation programmes need additional tools in order to measure the impact on the microbial populations in specific areas and habitats and not only stop at the indicator species of plants and animals that are observed.
- There are many novel resources and knowledge that have not yet been used or explored and it is important to find ways to access, use and incorporate these diverse resources and information into the existing and future rural developments.

Theme 6: Explore bottlenecks and enabling conditions for the sustainable use of genetic resources in agriculture

- Access and Benefit Sharing mechanisms introduced by the implementation of the Nagoya Protocol could be a bottleneck. MIRRI and its partners are looking at simplified practices to ensure compliance but importantly, to reduce the burden that comes with it.
- The scope and depth of information is currently not enough to identify potential uses of available microorganisms.
- Long-term sustainability of databases is currently a problem. After the end of a project, funding runs out and databases are not maintained anymore and they become unavailable or outdated.

- Collaboration between researchers, collection holders and farmers is sometimes very difficult. The specialities of the different groups differ and therefore use must be made of extension workers i.e. intermediaries that can understand the different ideas and problems that are faced by all parties and who are able to understand both sides of the interaction.
- Promotion and visibility of mBRCs and the smaller specialist resource collections needs to be addressed. Quick and clear routes of access to all information are needed by practitioners and end-users of the collections. Currently, potential users of MiGR are unaware of what is available and what the potential is of many of the available sources.

Theme 7: Reduction of unnecessary administrative burden so as to provide better access to actions

- Again the issue of ABS, in particular the implementation of the Nagoya Protocol was raised as a big issue. Infrastructures such as MIRRI can play a role in simplifying daily practices and reduce possible unnecessary administrative burden. At this respect. Also MIRRI national node could be of great help in reducing administrative burden
- Grant applications are burdensome, requiring a lot of work only to be faced with a high percentage of rejection. A two stage process is preferred where the detail of the project delivery is produced in the second phase of the application.

Conclusions

The key conclusions were that the network of MiGR to support the Preparatory action on EU plant and animal genetic resources was in place through MIRRI and other national and regional initiatives. However, a coordinated and focussed programme to better understand the role of microorganisms in Food and Agriculture was missing. Collections containing MiGR should be better promoted and new ways should be found to communicate and work together with end users, resource holders, researchers and farmers/environmentalists. Business plans are needed for the successful collaboration among partners in the areas of importance outlined above and to promote the usage of MiGR in such projects. It is important that all parties are well informed and advised and therefore advisors are essential for successful collaboration between all parties involved.

Recommendations

The participants of the workshop agreed that there is a need for an infrastructure to drive the provision of solutions of specific problems and limitations and explore the specific needs for EU plant and animal genetic resources for Food and Agriculture is required. However, this should be built around existing research and resource infrastructures and previous efforts that were made should not be duplicated in the future. There is need for improvements to specifically address the conservation and sustainable use of microbial genetic resources for the future but negotiations with

MIRRI and establishment of expert clusters could address this and similarly other sector needs..

4 Conclusions and Specific Actions

- Mechanisms are needed for stakeholders to guide the resource holders to produce and make available the essential information regarding the resources, the required resources and services they need. It is clear that industry that specialise in e.g. wine, mushroom, cheese, bakery products, dry cured meat, cider etc. require a focused response to their specific needs.
- New initiatives will have to determine what sector specific data are needed for the different sectors in the Genetic Resources for Food and Agriculture cluster. In such a way the full potential of microorganisms can be identified and this advanced knowledge can be added to existing data and most importantly made available in a sustainable way for utilisation.
- Specific case studies are needed to address the big challenges that exist in areas that are still not well explored such as soil fertility and mitigation for climate change. The outcome of these studies can provide structured approaches to implement new technologies and metagenomics in such studies in order to get a better understanding on how such data and information can be used to develop the necessary tools.
- Partnerships are needed between users, resource holders, industry and funders to address the diverse key issues of the Genetic Resources for Food and Agriculture community. This should also be done through more structured multidisciplinary interactions.
- Mutually beneficial business models between companies and consortia of resource holders will make collaboration more attractive for bioindustry partners.
- Multi-disciplinary (environmental, plant, animal etc.) strategies for the conservation of endangered organism communities are needed as micro-organisms are involved in complex interactions in their natural surroundings.
- There is a need to promote success stories. This can be done through outreach from projects that involved genetic resources and led to the production of specific products; or collaborative platforms for example the collaboration of the microbial domain Biological Resource Centres with the Quarantine organisms Barcode Of Life (QBOL).
- There is still a big gap in the amount of knowledge on novel techniques and the usage of state of the art technologies between some of the EU member states. It is important to look at ways to transfer new technology and knowledge to lesser resourced countries and include them in decision making strategies.
- There is still a lack in the type and amount of information available on legislative requirements and suitable MTAs. Important information should be made more easily available and better explained, for example information concerning the

implications there are for breeders of mushrooms and the legal certainty in the usage of the products i.e. ABS and benefit sharing requirements.

- Partnerships between resource holders, the scientists and the farmers in the field should be strengthened and a mutual understanding is needed and can be achieved by involving expert advisors in the specific sectors that can connect the different partners.
- Find ways to improve the availability and safekeeping of important MiGR for the user community e.g. by making the deposition of important strains mandatory in mBRCs and aiming to improve current culturing and preservation techniques for difficult organisms or for organism consortia (mixtures).
- Look into ways to ensure the self-sustainability of small specialised collections that focus on specific niches and products and make them more available for the user community.
- Find ways to improve the collaboration amongst the different kinds of collections (mBRCs, private, research and restricted).
- Improving legal clarity on aspects of Biosecurity and ABS for all stakeholders may open possibilities for more and stronger collaboration and interaction between the different sectors, which now are still quite reluctant to collaborate with each other. Improvement on these aspects will also have a positive effect in the future for development and marketing of novel products, and working together in making a difference in the EU food and agriculture sector.

All in all, the conclusions made have highlighted numerous needs in all areas dedicated to the conservation and use of MiGR. There is a clear underpinning structure being put together but it is clear that there are still significant improvements to be made with regards to the needs of the food and agriculture sector to encourage sustainable use of this genetic resource.

ANNEX 1: List of participants

Name	Organisation/Expertise	Country
B. Brugmans	Limgroup (Mushroom industry)	NL
L. Butinar	Wine Research Centre Slovenia (wine making)	SI
N. Cadez	Culture collection Slovenia	SI
L. Canfora	Research Centre for the Soil-Plant System	IT
P. De Vos	Univeristy of Gent	BE
G. Gandini	Università degli Studi di Milano	IT
M. Groenewald	CBS-KNAW (collection)	NL
J. Houbraken	CBS-KNAW	NL
S. Karjalainen	EU commission	
M.S. Lemut	Wine Research Centre Slovenia (wine making)	SI
R. Luiten	DSM (Food industry)	NL
M. Moracci	Institute of Biosciences and BioResources (CNR)	IT
J. Morris	Asymptote (Preservation)	UK
G. Perrone	Institute of Sciences of Food Production (CNR – Bari)	IT
E. Ricca	Federico II University of Naples	IT
V. Robert	CBS-KNAW	BE
J.P. Sampaio	PYCC Portuguese Yeast Culture Collection	PT
D. Smith	CABI	UK
A. Sonnenberg	Wageningen UR	NL
D. Traon	ARCADIA	FR
B. Turchetti	DBVPG Industrial Yeasts Collection	IT
G. Verkleij	CBS-KNAW/MIRRI	NL

ANNEX 2: Presentations

1. Networking networks to access materials and data: the MIRRI perspective

Gerard Verkley

PDF available

2. Guidelines for the conservation and exploitation of the agricultural Biodiversity (GIBA)

Loredana Canfora

PDF available

3. Development in preservation technologies and their application

John Morris

PDF not available

4. Fungal collections, relevance for mushroom breeding and biobased economy

Anton Sonnenberg

PDF available

5. BioGenRes and CNR/ITEM collection: Microbial resources for improving quality and safety of Mediterranean products

Giancarlo Perrone

PDF available

6. Integrated databases: potential usage and perspectives

Vincent Robert

PDF not available