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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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MICROORGANISMS USED IN FOOD PROCESSING AND AGRO-INDUSTRIAL PROCESSES

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I. INTRODUCTION

1. The Commission on Genetic Resources for Food and Agriculture (Commission), at its Seventeenth Regular Session, adopted its Work Plan for the Sustainable Use and Conservation of Micro-organism and Invertebrate Genetic Resources for Food and Agriculture (Work Plan).[1] The Work Plan addresses microorganisms and invertebrates as functional groups[2] and foresees that the two functional groups to be considered by the Commission at its Twentieth Regular Session will be (i) edible fungi and invertebrates used as dietary components of food/feed and (ii) microorganisms used in food processing and agro-industrial processes.[3]

2. The Work Plan foresees that each functional group will be addressed on the basis of:

(a) a summary of the status and trends of conservation, use, and access and benefit-sharing, based on previous work of the Commission, existing literature and, as appropriate, an open survey that may also compile best practices with respect to their sustainable use and conservation;
(b) a mapping of regional and international organizations and other institutions most relevant for the functional group and the identification of strategic areas of possible collaboration; and
(c) an analysis of the gaps and needs, and possibilities for the Commission and its Members to address them.[4]

3. In response to the Work Plan, FAO commissioned the preparation of a study on the sustainable use and conservation of microorganisms used in food processing and agro-industrial processes. As some agro-industrial processes, notably those related to nutrient cycling, biological control and biostimulation, have been addressed in other background study papers recently prepared under the Work Plan, the current study focuses on the use of microorganisms in food processing and in the processing of agro-industrial materials into non-food value-added products.

4. The Intergovernmental Technical Working Group on Microorganism and Invertebrate Genetic Resources for Food and Agriculture (Working Group), at its First Session, took note of the draft study and provided feedback in writing. The revised draft study is contained in the document *Draft study on the sustainable use and conservation of fermentation associated microorganisms within the agrifood system*.[5]

5. The present document draws on the findings of the draft study to provide an overview of the conservation and sustainable use of this functional group.[6] It further presents the conclusions of the Working Group on the future work of the Commission and its Members on the functional group, and seeks the Commission's guidance in this regard.

II. KEY FINDINGS

Roles of microorganisms in food processing and agro-industrial processes

6. The use of microorganisms in food processing and non-food agro-industrial processes is an important component of agrifood systems. Traditional fermentation processes have long been vital to the food security and livelihoods of many people around the world. More recent and ongoing developments in these fields are creating new options that potentially have major significance for efforts to improve food security while also addressing the climate and biodiversity crises.

7. Where food processing is concerned, applications involving the use of microorganisms can broadly be grouped into the following categories: the production of fermented foods (FFs) through traditional fermentation processes; the production of fermentation-derived foods (FDFs) using biomass; and the production of FDFs using precision fermentation.

8. Key advantages of FF and FDF production include the following: shorter timelines because of the speed at which microorganisms grow; reduced land and water use; potential to valorize agricultural

[1] CGRFA-17/19/Report, *Appendix E*.
[2] CGRFA-17/19/Report, *Appendix E*, paragraphs 8–14.
[3] CGRFA-17/19/Report, *Appendix E*, paragraph 14
[4] CGRFA-17/19/Report, *Appendix E*, paragraph 16.
[5] CGRFA-20/25/8.3/Inf.1.
[6] A more extensive version of this overview can be found in document CGRFA/WG-MIGR-1/24/3 Rev.1.

by-products and food waste; stability in supply; and flexibility in the site of production because of its reduced dependence on climatic/weather conditions.

9. Production of FFs currently takes place at several scales, ranging from the household level, where fermentation serves as a low-cost technique for preserving raw materials such as milk, to large industrial operations designed to meet increasing consumer demand. To enable the standardization of products, increase control over the microbial community and lower the risk of contamination, extensive efforts are being put into the design of starter cultures, including through the identification of key strains in natural communities, the use of non-conventional strains and the assembly of semi-synthetic communities containing genetically engineered or evolved organisms.

10. The more than 5 000 different varieties of fermented foods produced across the world reflect the diverse range of microorganisms (bacteria, and yeasts and other fungal species) utilized in traditional fermentation. The genetic resources of these microorganisms are a product of traditional knowledge, as the composition and structure of a fermentation-associated microbial community are linked to the chosen substrate and the design of the fermentation process, which selects for the microbial strains that define the qualities of the final food product.

11. Although information on the status of this biodiversity is limited, the loss of traditional practices means the loss of the associated microbial communities. Globalization and industrialization are accompanied by the increasing use of starter cultures composed of one to three well-characterized domesticated microbial strains rather than the complex microbial communities that emerge from traditional practices. Characterization of the latter microbial communities allows the identification of microbial species with attractive properties that can be used in the design of other bioprocesses.

12. Where non-food processes are concerned, there are also some well-established uses of fermentation within agrifood systems, for example in silage making. Precision fermentation is now creating new opportunities to utilize a variety of materials derived from agrifood systems, often by-products or materials otherwise regarded as wastes, as a basis for alternatives to petrochemical-based systems for the supply of a range of different products.

13. Despite the potential significance of FFs in efforts to promote food security, they currently receive limited policy attention. Constraining factors include a lack of knowledge of their health benefits and of how food safety and the standardization of products can be achieved in artisanal set-ups. Where FDFs are concerned, technical barriers to expansion include the pressing need for an increase in global fermentation capacity, especially in resource-limited regions.

State of conservation

14. The conservation of microbial diversity is vital to the future development of food-processing and non-food agro-industrial microbial applications and hence to the development of a sustainable bioeconomy. Culture collections are a key resource in this regard, as they allow the long-term storage of microorganisms, whether isolated from nature or engineered. These collections can be large public repositories accessible in accordance with international agreements, research collections in academic institutions or industrial research laboratories.

15. Numerous culture collections have been established around the world: the Culture Collections Information Worldwide repository records 859 culture collections, based in 80 countries, storing more than 4 million microorganisms. A number of global and regional research and industrial networks relevant to FFs, FDFs and conservation of related microorganisms are emerging worldwide. However, in many parts of the world shortages of funding (especially for meeting high, long-term operating costs), infrastructure and expertise restrict opportunities to identify, characterize and store isolates relevant to fermentation applications. Technical challenges surrounding the preservation of microbial communities as a whole are another major constraint.

Policy and institutional frameworks

16. Given that the genetic resources of fermentation-associated microorganisms are products of traditional knowledge that have great potential for commercialization, arrangements for facilitating access to them and the fair and equitable sharing of benefits arising from their use for research and development are a significant policy issue.

17. As with other components of biodiversity, the global legal framework for this is provided by the Convention on Biological Diversity and the Nagoya Protocol. However, as with several of the other functional groups of microorganisms and invertebrates addressed by the Commission over recent years, unintended consequences of the application of these instruments include constraints to the expansion of culture collections and microbial biological resource centres (mBRCs) because of the complex bureaucratic bilateral negotiations required for sampling and collaborative characterization efforts. This has an impact on both academic researchers and biotechnological companies, potentially hampering the use of promising microbial strains.

Gaps, needs and possible actions

18. Based on the findings of the draft study, the following gaps, needs and possible actions to address them can be identified:

(a) There is a need to establish frameworks for the provision of long-term financial support for culture collections and mBRCs. One avenue could be to promote the involvement of private industry in the maintenance and funding of culture collections and mBRCs. Another would be funding via international organizations for centralized collections, with clear and simple paths for access to resources in line with relevant international agreements.

(b) In parts of the world where such capacity is currently weak or non-existent, there is a need to build the infrastructure and skills needed to preserve and characterize the microbial communities behind local FFs – as well as microbial strains from various environmental niches that may have potential for use in the production of platform chemicals and high-value compounds from non-food agro-industrial materials – and enable the development of starter cultures.

(c) Better documenting traditional knowledge related to FFs would help to promote food security, the preservation of cultural heritage and the identification of novel microbial strains with industrial potential. Where traditional practices are in decline, opportunities to revitalize them need to be explored and, where relevant, supported.

(d) There is a need to establish legal and policy frameworks that (a) safeguard the rights of Indigenous Peoples and local communities over the microbial genetic resources associated with the food-processing techniques they have developed, (b) facilitate fair and equitable international research collaborations, and (c) minimize constraints to access caused by unclear guidelines and lengthy bureaucratic procedures. Multilateral solutions could be explored. Especially in light of developments in engineering biology applications, there is need to determine how to deal with digital sequence information related to fermentation-associated microorganisms.

(e) Constraints to the expansion of commercial fermentation capacity to meet forecasted demand for the production of FDFs need to be overcome.

(f) Harmonization of definitions related to fermentation technologies, such as precision fermentation, could be an initial step towards harmonizing policies governing their use, including with regard to labelling, which has a substantial impact on consumer understanding of novel food products.

(g) Fermentation needs to be integrated into agricultural practices as a means of *in situ* valorizing by-products and waste, promoting circularity in production systems and addressing concerns over how FDF production may impact food sovereignty. Exploring opportunities and frameworks for partnerships between agricultural and FF/FDF producers could further support these objectives.

(h) Research on the role of FFs as part of healthy diets needs to be strengthened, as do science communication and awareness raising on fermentation technologies and FF and FDF products. Accompanied by appropriate quality-control and certification procedures, better understanding of the components of FFs that confer health benefits can ensure that consumers are well informed about the health and nutritional value of the wide array of products entering the market. New evidence emerging from microbiome science may provide the basis for

further refinement of food-based dietary guidelines to include the consumption of a range of FFs.

(i) To effectively realize the potential of non-food products biomanufacturing from agro-industrial materials, especially as an alternative to petrochemical-based production, concerted efforts need to be made to direct resources, including both public and private investments, towards the compounds that hold the greatest potential for economically feasible and sustainable production. This requires effective communication between industry and academia. Improving technology transfer terms at universities and public institutions could also help to lower barriers to commercialization.

III. CONSIDERATIONS FOR FUTURE WORK

19. The Working Group, at its First Session, considered the future work of the Commission and its Members on this functional group. In this regard, the Working Group:

(a) stressed the need to strengthen the technical and human capacity needed to characterize and improve the use of the microbial communities behind local fermented food products and other microorganisms with potential for application in food processing or in non-food agro-industrial processes in the context of circular economy, including characterization at within-species level;[7]

(b) recommended that countries document or improve documentation of, as appropriate, traditional knowledge associated with FFs and address shortages in fermentation capacity to meet demand for fermentation-derived foods;[8]

(c) recommended that countries, through appropriate regulatory instruments and other measures, improve the integration of fermentation processes into agrifood systems;[9]

(d) noted the need to ensure adequate funding for the long-term storage and accessibility of microorganisms and their associated data of potential relevance to food processing and non-food agro-industrial processes in culture collections;[10]

(e) highlighted the need to improve the infrastructure for *ex situ* conservation and the coordination of activities in this field at national and international levels;[11]

(f) noted the need to facilitate access to microorganism genetic resources relevant to food processing and non-food agro-industrial processes and to ensure fair and equitable sharing of benefits arising from their use and associated traditional knowledge, including from digital sequence information on microorganisms and invertebrate genetic resources (MIGR);[12]

(g) recommended harmonizing terminology related to the use of microorganisms in food processing and non-food agro-industrial processes in the context of circular economy;[13]

(h) stressed the need to strengthen capacity and improve collaborative research, awareness-raising and scientific communication related to the use of microorganisms in food processing and non-food agro-industrial processes and overcome barriers to the commercialization of beneficial food processing and non-food agro-industrial technologies involving the use of microorganisms;[14]

[7] CGRFA-20/25/8.1, paragraph 9.
[8] CGRFA-20/25/8.1, paragraph 10.
[9] CGRFA-20/25/8.1, paragraph 11.
[10] CGRFA-20/25/8.1, paragraph 11.
[11] CGRFA-20/25/8.1, paragraph 11.
[12] CGRFA-20/25/8.1, paragraph 12.
[13] CGRFA-20/25/8.1, paragraph 12.
[14] CGRFA-20/25/8.1, paragraph 13.

(i) noted the need to ensure transparency in the use of microorganisms in commercial food products through the development of standards for providing microorganism names on the labels of fermented food products;[15] and

(j) highlighted the need to promote research on the roles of FFs as parts of healthy, safe and nutritious diets.[16]

20. It can be noted that, while the Commission could, in principle, contribute to action in most or all of the fields referred to by the Working Group, whether by overseeing the development of tools and guidance to support activities at country level or by developing global policy responses, no concrete proposals for action by the Commission on this functional group specifically have, thus far, emerged. Some of the above-listed observations – including those related to access and benefit-sharing and *ex situ* conservation – are relevant to several MIGR functional groups and could potentially be addressed as cross-cutting issues.

IV. GUIDANCE SOUGHT

21. The Commission may wish to:

(i) recommend that the draft study be finalized, published as a background study paper and widely publicized; and

(ii) invite countries to (a) strengthen the documentation of traditional knowledge associated with fermented foods, (b) take supportive actions to address shortages in fermentation capacity to meet demand for fermentation-derived foods, and (c) improve the integration of fermentation processes into agrifood systems through appropriate regulatory instruments and other measures.

[15] CGRFA-20/25/8.1, paragraph 13.
[16] CGRFA-20/25/8.1, paragraph 14.