



COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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EDIBLE FUNGI AND INVERTEBRATES USED AS FOOD/FEED

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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 Microorganism and Invertebrate Genetic Resources for Food and Agriculture (Work Plan).¹ The Work Plan addresses microorganisms and invertebrates as functional groups² and foresees that the two functional groups 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:
 - (i) 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;
 - (ii) 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
 - (iii) 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 edible fungi and invertebrates used as dietary components of food/feed. The study does not cover aquatic invertebrates, as they are covered under the Commission's work on aquatic genetic resources for food and agriculture (AqGR). The study does, however, touch on aquatic insects, a group that shares characteristics with its terrestrial counterparts and that has rarely been addressed in AqGR-related work.
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 edible fungi and invertebrates used as dietary components of food/feed*.⁵
5. The present document draws on the findings of the draft study to present an overview of the sustainable use and conservation of this functional group. 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

Use of edible fungi

6. The term "edible fungi" is used here to refer to a group of larger species of macrofungi, typically having a stem and a cap with gills or pores but also including those with other forms, for example truffles. There are over 2 300 recorded species of edible fungi, of which a small group of 100 to 200 species are regularly consumed worldwide by humans.
7. Edible fungi have long been harvested from the wild, and an overwhelming majority of these wild-harvested species cannot be cultivated because of their complex growth requirements. However, some species have been successfully domesticated. There are also some species that undergo semi-cultivation in their natural environments (e.g. the tending of trees artificially inoculated with truffles).

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-20/25/8.2/Inf.1.

8. A small number of cultivated species dominate a well-established commercial market and a vigorous international trade.

9. Edible fungi are rarely fed to animals.

10. The extent to which genetic improvement techniques are used in the breeding of edible fungi is difficult to estimate because of commercial secrecy. Likewise, little information is available on breeding goals in commercial production.

Use of edible invertebrates

11. Insects are the group of terrestrial invertebrates most important in human diets, with over 2 100 species consumed. Snails are the next most significant group. A number of terrestrial species from other invertebrate taxonomic groups also contribute, including spiders and scorpions (arachnids) and woodlice (crustaceans).

12. Wild-harvested terrestrial invertebrates have traditionally been important components of many people's diets in many parts of the world, especially in tropical countries, and this remains the case today. A range of different terrestrial invertebrates have also traditionally been harvested from the wild to feed to poultry.

13. Insect farming has expanded rapidly in recent decades, especially in tropical countries. Until recently, domestication of terrestrial insects was restricted to honey bees and silkworms. However, some species used for feed or food are now undergoing domestication. Some producers have begun to practice selective breeding and have been able to develop populations that provide higher yields.

14. Growing interest in insect farming is being driven both by increased demand for traditional local foods and by the potential of insects as relatively environmentally friendly sources of protein for feeding humans, livestock and fish.

15. With the exception of snails in parts of Europe, the consumption of terrestrial invertebrates is limited in the Global North. Converting insects into powders that can be incorporated into food products such as baked goods might be a way of expanding their use in the face of cultural aversions.

Status, trends and threats

16. For both edible fungi and edible terrestrial invertebrates, overharvesting – the extraction of unsustainable volumes of individuals of a species – is the threat most often reported by countries, scientists and conservationists, as well as by local harvesters facing influxes of poorly informed commercial collectors. The scientific evidence does not always support fears about the effects of excessive extraction, particularly in the case of the wild harvesting of edible fungi.

17. Besides overharvesting, other threats to edible fungi and terrestrial invertebrates include inappropriate and harmful harvesting practices, climate change, habitat loss and degradation (caused by urbanization, deforestation, pollution, etc.), and the loss of traditional knowledge of how to manage and harvest wild species.

18. Interest in the conservation status of macrofungi in general has greatly increased over the last three decades or so. National-level monitoring began in the 1980s, and there are now more than 40 national red lists. These are most common in Europe, North America and South America. Edible fungi are included in these monitoring efforts, although there are as yet no specific attempts to prioritize the monitoring of species that are of high value to people or for which there are concerns about overexploitation.

19. The International Union for Conservation of Nature (IUCN) established a Global Fungal Red List in 2013. A few edible species have been assessed for inclusion, and several others are in the process of being assessed. While the sample of assessed species is not large, some are assigned to the categories Endangered, Vulnerable or Near Threatened globally.

20. There are major concerns globally about the risk status of insects and other terrestrial invertebrates, although species-level monitoring is limited outside developed regions. Edible species are assumed to face threats similar to those that affect their non-edible counterparts, and they may face the additional threat of overharvesting or overexploitation. The latter threat is likely to be greater for

species that are in demand as sources of food/feed but are not farmed. Conversely, a few edible species, for example agricultural pests such as grasshoppers and locusts, may be so abundant that wild harvesting is unlikely to be a significant threat.

Conservation measures

21. Given that, as noted above, edible fungi and terrestrial invertebrates are affected by many of the threats faced by biodiversity, it is reasonable to assume that broadly speaking they are likely to benefit from general biodiversity conservation measures, whether these measures involve establishment of protected areas, restoration or creation of habitat, reduction of pollution, control of invasive species or introduction of more biodiversity-friendly agricultural practices.

22. With regard to potential threats posed by overharvesting, various schemes have been put in place to train harvesters in good practices and link this to the issuing of permits. This can have positive impacts, but concrete evidence for its effectiveness is limited. Various countries have introduced bans and restrictions on particular practices that are regarded as unsustainable. Enforcement is, however, sometimes weak.

23. Traditional knowledge on good harvesting practices can contribute to the planning of conservation measures. More could be done to document such knowledge. Moreover, where wild harvesting is a traditional practice, local people often have unwritten rules that regulate the use of potentially threatened species, although these may break down in the face of rising demand.

24. A number of edible fungi species are maintained in culture collections around the world. However, opportunities to conserve wild edible fungi *ex situ* are constrained by the fact that the majority of species are difficult to culture.

Policy and institutional frameworks

25. While many individual universities and research institutes conduct research on edible fungi and terrestrial invertebrates, there are few coordinating bodies that promote research, information exchange or policy discussion on these groups of organisms.

26. When the use of edible fungi and terrestrial invertebrates for food or feed transitions from being a traditional, small-scale practice undertaken for subsistence purposes or to meet demand in local markets into a larger-scale commercial activity, a range of regulatory issues become more prominent.

27. As noted above, as demand increases, wild populations may come under increasing pressure, and regulation of wild harvesting may be needed. However, the development of effective regulatory frameworks depends on the availability of good information as to what particular activities are causing significant harm to which wild populations and on how harvesting practices are evolving. There are, unfortunately, many knowledge gaps related to edible fungi and terrestrial invertebrates and their use. In many cases, national regulations appear to be patchy in their coverage, insufficiently well designed or ineffectively implemented.

28. As with other types of food and feed products, there is a need to ensure that the use of edible fungi and terrestrial invertebrates does not pose a threat to food and feed safety. Approaches currently vary considerably around the world, and it is again unclear whether appropriate solutions have been implemented.

29. As international trade expands, there will be a growing need for international standardization of regulations to ensure safety and facilitate access to markets. Codex Alimentarius currently provides little guidance on food- and feed-safety issues in the edible terrestrial invertebrate sector or about the potential risks associated with poisonous mushrooms.

30. Again, as with other types of agricultural products, growth in the edible fungi and invertebrate sectors, and in particular the growth of trade, brings a range of other regulatory issues increasingly into play, including sanitary regulations (invertebrate and fungal health), environmental regulations and (for invertebrates) animal welfare regulations. In many cases, regulations in these fields are again relatively undeveloped.

31. The genetic resources of edible fungi and invertebrates, like other components of biodiversity, fall under national and international access and benefit-sharing (ABS) regulations. It is unclear whether there are specific provisions for these groups in any national ABS laws or policies, or whether any problems with access to their genetic resources or with inadequate sharing of benefits derived from their use have arisen.

Gaps, needs and possible actions

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

Status, trends and threats

(i) Monitoring of the status and trends of macrofungi and terrestrial invertebrates needs to be strengthened, with more priority given to edible species.

(ii) Understanding the impacts that different threats have on edible fungi and terrestrial invertebrates is a major challenge, and more research is required.

Farming and cultivation

(i) Information on the development of techniques for farming edible mushrooms is difficult to obtain because of commercial confidentiality, making it difficult to identify approaches to promote the sustainable development of the sector.

(ii) The feasibility of using semi-cultivation techniques at scale for edible fungal species other than truffles needs to be clarified.

(iii) Techniques for large-scale farming of invertebrates for food and feed are improving rapidly (especially insects for feed), but numerous knowledge gaps remain.

(iv) Greater sharing of available data on best practices in the breeding and genetic improvement of farmed edible fungi and terrestrial invertebrates could drive production gains, while respecting the need for commercial confidentiality.

(v) Appropriate technology for the cultivation of edible fungi on small farms requires further research.

Wild harvesting

(i) The impacts of commercializing the wild harvesting of edible mushrooms and invertebrates are not fully understood, and there is a lack of consensus regarding what sustainable harvesting means.

(ii) Commercial harvesting is a threat for species of edible invertebrates where local knowledge is disregarded, highlighting the need to better document and share this knowledge.

(iii) Better evidence concerning the impacts of wild harvesting of edible fungi is needed, as well as wider awareness of existing studies, most of which show little or no negative environmental impact from intensive harvesting. In this context, there is also a need to distinguish the impacts of harvesting intensity from those of adverse harvesting practices.

(iv) There is a need to improve knowledge of the physical and ecological conditions that favour production of wild edible fungi, particularly in areas beyond the forests in Europe and North America.

(v) Research into markets, harvesting practices, and the nutritional contributions made by edible fungi and terrestrial invertebrates is needed.

(vi) Best practices in the farming of edible fungi and terrestrial invertebrates should be shared through the educational system and government extension.

Food and feed safety

(i) Efforts are needed to determine and regulate which species of fungi can be safely sold. Standardized methods are needed for assessing the quality and reliability of evidence on edibility and for resolving inconsistent reports on safety.

(ii) There is a need to improve labelling and to develop procedures that guarantee the safety of food and feed containing terrestrial invertebrates, including to address potential threats from allergies and contaminants.

(iii) As trade increases, so does the need for international standardization of food- and feed-safety regulations for products containing edible fungi and terrestrial invertebrates.

(iv) Consideration could be given to introducing a classification scheme for assessing case reports and establishing a common protocol on the edible properties of fungi and terrestrial invertebrates under the Codex Alimentarius.

Conservation

(i) Evidence as to the effectiveness of introducing permits and policing harvesters as a means of conserving edible fungi and terrestrial invertebrates is currently limited and needs to be monitored.

(ii) Reviews of the evidence base for bans on wild harvesting and what lessons can be learned for future conservation measures could be conducted in selected countries.

(iii) More information is needed on the impacts of regulating wild harvesting. The concerns of local communities that rely on wild harvesting for food/feed and income need to be taken into account in the development of conservation measures.

(iv) Information about local collectors, their harvesting practices and their knowledge of wild-edible fungi and terrestrial invertebrates is limited. Understanding these factors is vital to the development of effective conservation measures.

(v) Evidence on the impact of education campaigns on the conservation of edible species of fungi or terrestrial invertebrates remains limited, and this could be further studied.

(vi) Approaches to expanding the implementation of forest-management approaches that have been shown experimentally to benefit wild edible fungi need to be better investigated.

(vii) There is a need to promote the inclusion of wild edible fungi in wider policies on forest management, especially in the Global South.

(viii) The development of regulations needs to anticipate potential threats to species of wild edible fungi and terrestrial invertebrates as they begin to be commercialized.

(ix) Lessons learned from the formulation and implementation of regulations related to the wild harvesting of edible fungi and terrestrial invertebrates – as well as those related to other aspects of their conservation – should be widely shared, including internationally. There may be opportunities to learn lessons from approaches that have been successfully applied to regulate hunting or fishing.

(x) Efforts to establish protected areas that benefit wild edible fungi and terrestrial invertebrates need to be stepped up.

(xi) Developing new techniques for growing edible mushrooms *in vivo* (cultures) could support *ex situ* conservation.

Collaboration

(i) Wider collaboration among relevant interest groups would help to improve the continuity of efforts to improve the sustainable use and conservation of edible species and strengthen research capacity in this field.

(ii) Strengthening and expanding existing networks related to edible fungi and terrestrial invertebrates would help improve links between researchers, policymakers and producers, foster wider

sharing of knowledge and techniques, and encourage better awareness of relevant social and environmental issues.

III. CONSIDERATIONS FOR FUTURE WORK

33. The Working Group, at its First Session, considered the potential future work of the Commission and its Members on edible fungi and invertebrates. In this regard, the Working Group:⁶

(i) noted the importance of ensuring that the monitoring of wild species of edible fungi and invertebrates is aligned with the IUCN Red List of Threatened Species and the work under the Convention on Biological Diversity (CBD);

(ii) noted the importance of monitoring genetic diversity within species within these functional groups;

(iii) noted the importance of identifying and monitoring all kinds of threats affecting these functional groups;

(iv) stressed that the priority for conservation should be reducing ecosystem degradation but that there is also a need to develop new techniques for *ex situ* conservation of edible fungi and invertebrate genetic diversity;

(v) noted the need for the topic of edible fungi and invertebrates to be included in university-level curricula in order to support the development of capacity needed to scale up production;

(vi) noted the key role that national governments have to play in the promotion of edible fungi and invertebrates, including by ensuring that they are addressed in national strategies and frameworks for genetic resources; and

(vii) noted the potential role of online knowledge portals for edible fungi and invertebrates in providing access to national policy frameworks, programmes and best practices.

34. No recommendations specifically related to potential actions that might be taken by the Commission itself to promote the sustainable use and conservation of edible fungi or invertebrates have emerged. Cross-cutting issues relevant to a range of invertebrate and microorganism functional groups, potentially including edible fungi and invertebrates, are discussed in the document *Follow-up on other functional groups of microorganism and invertebrate genetic resources*.⁷

IV. GUIDANCE SOUGHT

35. The Commission may wish to:

(i) recommend that the draft study be finalized, published as a background study paper, widely publicized and brought to the attention of the Global Soil Partnership, and the relevant bodies of IUCN and the CBD, through their respective secretariats; and

(ii) invite countries to promote the sustainable use and conservation of edible fungi and invertebrates, including by ensuring that they are addressed in national strategies and frameworks for genetic resources and by promoting their inclusion in university-level curricula.

⁶ CGRFA-20/25/8.1, paragraphs 18, 19, 20 and 21.

⁷ CGRFA-20/25/8.4.