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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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LINKAGES BETWEEN BIODIVERSITY, FOOD AND NUTRITION

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I. Introduction

1. The 3rd session of the Intergovernmental Technical Working Group on Plant Genetic Resources for Food and Agriculture, Rome, 26-28 October 2005, considered the document *Support for countries to generate, compile and disseminate cultivar-specific nutrient composition data, and the relative* priority *of obtaining cultivar-specific dietary consumption data,* and the associated information document, *FAO activities in nutrition and biodiversity*. The urgent need for these data was presented in the context of better informing nutrition policies and programmes.

2. The Working Group noted FAO's long-standing activities in food composition and consumption in relation to agriculture, health, environment and trade and presented recommendations for action. Since that time, many activities have been initiated, successfully linking biodiversity, food and nutrition.

3. It is now more widely recognized that food biodiversity can provide some sustainable solutions for combating food insecurity and malnutrition, through the programmes on Biodiversity for Food and Nutrition, the Sustainable Diets Initiative, and many national, regional and international programmes and policies. Nevertheless, due to its importance, the linkages between biodiversity, food and nutrition should be more widely studied, researched and publicised, and more efforts should be made to mainstream the concept into food, agriculture, health, trade and nutrition sector policies and programmes.

II. IMPORTANCE OF BIODIVERSITY FOR AGRICULTURE AND NUTRITION

Biodiversity and agriculture

4. In 2010-12, around 870 million people, mostly living in the developing countries were undernourished (see reference 4 in Appendix II). At the same time, about 2 billion people are overweight and obese, and the number is increasing steadily (see reference 5 in Appendix II). Globalization, industrialized agriculture, population growth and urbanization have changed the patterns of food production and consumption that has profoundly affected the ecosystems and human diets. Drastic changes in food habits happened in many countries around the world, where locally available nutritionally-rich foods have been gradually replaced by a few foods that originated abroad, which are energy-dense and nutritionally-poor. Such dietary simplification neglects traditional nutritious foods and is also associated with micronutrient deficiencies and diet-related chronic diseases (see references 6, 7 in Appendix II). Biofortification (e.g. golden rice) has been considered as a strategy to combat micronutrient deficiencies; however, micronutrient deficiencies generally involve more than one micronutrient. Furthermore, biofortification as a strategy that focuses on increasing a subset of nutrients in a few staple foods risks further simplification of diets (see reference 8). Biodiversity, agriculture, food and nutrition are all interrelated and all contribute to promote health. Plants, animals, aquatic organisms, micro-organisms and invertebrates together form the ecosystems that contribute to the biodiversity that agriculture and food production rely upon (see reference 9). Sustainable agriculture integrated with biodiversity supplies a wide range of foods rich in essential nutrients to maintain human health. In turn, the co-existence of a wide range of species and varieties of plants and animals will promote a biodiversity-rich environment.

5. The Cross-cutting Initiative on Biodiversity for Food and Nutrition[1] identified the contribution of agricultural biodiversity as a priority for improving nutrition and health of the rural and urban poor.[2] It promoted the use of local biodiversity, including traditional and local

[1] COP 8 Decision VIII/23
[2] Nutrition Stakeholders Meeting Rome, Italy 16-17 February 2006.

foods with their many sources of nutritionally-rich species and varieties, as accessible and sustainable sources of nutrition (reference 10). At the Rio+20 Summit (ref. 11), world leaders reconfirmed that for poverty eradication, migrating towards sustainable food production and proper protection of the natural resources are the key points to sustainable development. Accomplishing these objectives is important to achieve food and nutrition security. Although some successes have been seen in poverty reduction coupled with environmental sustainability, more co-ordinated agricultural policies and programs need to be put in place (ref. 4). Furthermore, more efforts should be generated to mainstream biodiversity into agricultural policies and nutrition-related programmes.

6. Accelerating the progress towards hunger reduction and nutrition improvement is less about the development of innovations and technologies, but more about focusing on what is already known and in practice, with enduring efforts to conserve and use biodiversity. As year 2015 is approaching, to achieve Millennium Development Goal 1, we must improve the whole food system, starting from agriculture through the food supply chain to consumption.

7. The paper presents a scientific review on the linkages between biodiversity, food and nutrition, and the gaps and opportunities for implication and improvement.

8. FAO estimates that of a total of 300,000 plant species, 10,000 plant species have been used for human consumption since the origin of agriculture (12). Nowadays, we rely on only around 30 crops to feed the whole world's vast population and they provide us with up to 95% of dietary energy or protein supply (12). In the animal domain, only five animal species, namely cattle, sheep, chickens, goats, and pigs supply a majority of animal-derived foods that provide macro- and micro-nutrients (13). Therefore, agricultural diversity within major plant/animal food sources should be promoted and managed effectively to ensure global food security and nutrition. However, commonly consumed species and varieties are not necessarily the ones richest in nutrient contents; thus, appropriate selection of species and varieties or breeds with high nutrient contents will help optimise nutrition-sensitive agricultural practice. For example, potato is a predominant staple in some countries. Over 5000 varieties of potatoes are found and the variation in nutrient contents is significant among varieties (14). Iron content of different varieties of potatoes ranges from 0.14 to10.4 mg/100 g edible portion. Such a wide variation in iron content would result in a significant difference in iron nutritional status of consumers (14).

9. Modern agriculture cannot rely solely on conventional species of plants and animals to alleviate hunger and malnutrition. Neglected and underutilized or wild species have important roles as food resources. For instance, minor dairy animals are important sources of protein and micronutrients for poor rural communities where these species and breeds exist (15). Despite the fact that some underutilized and wild species are promising nutritious foods, they are not as widely used today as they could be, particularly as smallholders are the backbone of global food security (16). Employing biodiversity in agriculture, in particular traditional and indigenous varieties, would improve the livelihood of small holders, maintain food cultures, and improve nutritional intakes (6,17). In contrast, modern large-scale agriculture practices reduce diversity in the food systems (18) by the widespread replacement of genetically diverse traditional or farmers' varieties by homogeneous modern varieties (13,14). Moreover, diversified agricultural systems have the ability to buffer variations in yield, and safeguard against climatic and pestilent changes and disasters that may threaten one or more species in the ecosystem (1,18).

Biodiversity and nutrition

10. Healthy diets for populations depend on both the availability and accessibility to a wide variety of foods to maintain health and daily activities. Ready-to-use therapeutic foods, supplements or fortificants, including biofortificants, have been proposed as a means to combat micronutrient deficiency; however, these approaches may only provide short-term solutions but not be effective in the long-term (19). Moreover, there is growing evidence that these supplementation and fortification programmes have contributed to the neglect of the consumption

of diverse foods within local culture (8). The more sustainable and efficient way to improve nutrient contents of diets is to improve diet diversity, i.e., consuming a variety of foods that are naturally high in micronutrients and locally available, such as fruits and vegetables. Research has demonstrated a strong association between diet diversity and diet quality, with improved nutritional status of children (20,21). Dietary diversity is also associated with micronutrient density of the diet, especially for young children (22). Thus, a food-based approach which promotes dietary diversity is a more sustainable solution to reduce hunger and malnutrition (23).

11. Food biodiversity, encouraging the use of local and traditional foods could potentially resolve malnutrition among rural people living in vulnerable areas, particularly in areas where there is a wide range of plant and animal species. Studies that investigate the relationship between the intake of diverse traditional food and dietary quality often show that traditional foods provided better nutrition, an example being the Awajún people in Peruvian Amazon (24) (See appendix 1 for more examples). In many studies, traditional diets provide a higher food diversity thereby a better supply of essential nutrients in the diet such as protein, iron, thiamin, riboflavin, vitamin A and dietary fibre (24). However, a rich and diverse environment does not necessarily lead to food and nutrition security without proper recognition and utilization. For instance, plant biodiversity in DR Congo is abundant, however, the wild edible plants are rarely consumed and thus have not contributed substantially to the local diets (25). Consumers of wild edible plant were found to have higher intakes of vitamin A, vitamin C, vitamin B-6 and calcium than non-consumers.

Table 1. Examples of the evidence linking biodiversity to nutrition

Country/Region	**Targeted group**	**Findings**	**Reference**
Andhra Pradesh, India	Dalit mothers with young children	Traditional food consumption had protective effects against chronic energy-deficiency. Low consumption of traditional foods was suspected to be associated with higher risk of clinical vitamin A deficiency.	(39)
Arctic Canada	Adults in Yukon First Nations, Dene/Metis, and Inuit communities	10-36% of energy was derived from Traditional Foods. Higher intakes of protein and more micronutrients were associated with meals containing traditional foods.	(40)
Cameroon, Uganda, Hawaii, Philippines, Cambodia	171 different genotypes of bananas and plantains (Musa spp.)	100 g of pulp from the cultivars with high pro-vitamin A can provide up to 95% of the vitamin A requirement for children and 47% for adults.	(41)
Mekong Delta and the Central Highlands in Vietnam	Women	21% and 14% of folate intake for women were from wild vegetables, in Mekong Delta and Central Highlands respectively.	(42)
Cambodia	16 common Cambodian fish species, and cooked fish dishes and soups	A serving of a sour soup prepared with *E. longimanus* (a species of fish that is high in iron) has the potential to cover 45% of the daily iron requirement for women of childbearing age.	(43)

III. INFORMATION REQUIRED TO PROMOTE THE USE OF BIODIVERSITY FOR FOOD AND NUTRITION

12. Consumption of different varieties/breeds may have significant impacts on nutrition and health outcomes. The information on food composition and consumption from various varieties/cultivars/breeds and their dietary contribution to nutrition and human health has been increasing as awareness grows. However, most farmers and consumers are not aware of the high nutrient content of certain varieties compared with others, thus do not grow or consume them. Therefore, acquiring data on the composition and consumption of food biodiversity is essential to understand the impacts of biodiversity on food and nutrition security and human health. The importance of continuing the collection of these data in future food composition databases and food consumption surveys is thus of paramount importance.

Food composition

13. Food composition data provides an important link between nutrition and food biodiversity. Accurate and adequate food composition data forms the basis of dietary assessments that evaluate food security and nutrition adequacy. Different varieties/cultivars/breeds can contribute to significant variations in nutrient contents (1,14). In fact, macronutrients from different varieties of the same species could vary by 10-fold, and micronutrients by up to 1000-fold (26) by virtue of the genetic resource itself. Table 1 shows the range and average amount of nutrient in varieties of rice and potatoes. Thiamin content of different varieties of rice can vary by more than 10-fold (0.117-1.74 mg/100g). Similarly, the range of calcium content of different varieties of potatoes varies by more than 20 times (1.3-27.8 mg/100g). Average or mean values for these nutrients mask the difference, which are not just statistically significant, but also nutritionally significant. Therefore, reporting compositional information at the taxonomic level below species is essential to the understanding of genetic variation of nutrient content in a food species. In the past, nutrient data were rarely available for varieties; however, through initiatives spearheaded by FAO/INFOODS, there has been an increasing emphasis on food biodiversity among the food composition community of data generators (laboratories), compilers and users. Nevertheless more awareness raising, and more capacity development is needed.

14. **Table 2.** The range and average nutrient contents among various varieties of rice and potatoes (whole) (100g edible portion, raw) Source (14,27)

	Rice		**Potatoes**	
Nutrient	Range	Average	Range	Average
Protein (g)	5.55-14.58	8.55	0.8-4.2	2.1
Starch (g)	-	-	9.1-22.6	16.1
Iron (mg)	0.70-6.35	2.28	0.7-10.4	1.4
Calcium (mg)	1.0-65.0	26	1.3-27.8	10.6
Thiamin (mg)	0.117-1.74	0.475	-	-
Niacin (mg)	1.97-9.22	5.32	-	-
Vitamin C (mg)	-	-	4.6-40	17.1

15. Food composition data for biodiversity also offers additional information to improve conservation and management of biodiversity (28). Nutrient data on existing biodiversity has become one of the primary criteria for some variety/cultivar promotion programmes (29). These data are also being used to screen genetic material for plant improvement programmes, to breed improved yield and disease-resistance into within-species varieties with higher nutrient contents, thus negating the need to use genetic material from outside the species (28, 30). An example of the recognition of the importance of composition and consumption data for the varieties of rice was provided in Box 1.

Box 1 Recommendations of the International Rice Commission (31)

The International Rice Commission, at its 20th Session and 21st Session recommended:

- Existing biodiversity of rice varieties and their nutritional composition need to be explored before developing transgenic varieties of rice.
- Nutrient content needs to be among the criteria in cultivar promotion.
- Cultivar-specific nutrient analysis and data dissemination should be systematically undertaken.
- The evaluation of the composition and consumption of rice cultivars should continue for the development of biodiversity indicators to guide agro-biodiversity conservation and human nutrition.

16. Furthermore, food composition data also has important economic value. Comprehensive food composition data can help expand trade and improve safety of food intake as many countries request accurate labelling information on nutrient contents. Furthermore, this information is not only important for food labelling, but also for devising serving size, risk assessment and dietary assessment.

Food consumption

17. Besides food composition data, food consumption data are required to understand the impacts of food biodiversity on the quality of diets and nutritional status of consumers. Food consumption data are records of food intake at individual or population level in a specified period of time. To capture food consumption data for biodiversity, precise identification of species and varieties is needed (32). Apart from what is consumed, information on how much food is consumed, as well as nutritional status of the consumers are also required (32).

18. Many dietary assessment methods can capture food consumption. Tools commonly used include food recalls, dietary records, food frequency questionnaires and others. Of these methods, recalls and records can be easily adapted to surveys aimed to capture consumption data on food biodiversity (32). It has been suggested that well designed and integrated dietary surveys can accurately assess the usage and consumption of foods linked to food biodiversity (32).

19. Food consumption data for biodiversity can help recognise the importance of biodiversity in achieving food and nutrition security in rural area (7). For example, in rice-based aquatic ecosystems, aquatic production in addition to rice (e.g., fish, frogs, shrimp) is an important resource for rural livelihoods in developing countries. It was demonstrated that a total of 200 species of organisms were found in aquatic rice-based ecosystems (32). In Northeast Thailand and southern Cambodia, aquatic animals from rice field contributed to more than 50% of all aquatic animals consumed (32). In Laos, rice fields are the source of about 2/3 of all aquatic organisms consumed by rural households (32).

20. There is a concern that rural households would not be able to recognize the variety/cultivar when conducting dietary surveys focusing on food biodiversity. However, a field study concluded that over 80% of households were able to identify rice by cultivar (33). Thus, measuring food consumption in great detail at household level is essential to understand and advance biodiversity in nutrition-sensitive agricultural practice. Furthermore, such information is also needed in order to investigate and promote local nutritious varieties.

21. Few national or regional consumption surveys have reported food intakes at the cultivar/variety/breed level. It is anticipated that recording variety-specific consumption data will be a challenging task. Reliable methods to evaluate the contribution of biodiversity to healthy diet need to be developed.

IV. MECHANISMS FOR THE COLLECTION AND DISTRIBUTION OF DATA AND THE AVAILABILITY OF DATA

Mechanisms

22. FAO, in collaboration with other parties, is currently promoting food biodiversity and collection of data for foods that are related to biodiversity. To establish a basis for the recognized linkages between biodiversity, food and nutrition, and facilitate the need to enhance sustainable use of biodiversity, nutrition indicators for food biodiversity on food composition and food consumption (the indicators) have been developed (10,34).

- The indicator on food composition is the count of foods with sufficient description to address species, subspecies and below, or wild or underutilized foods, with one or more values for nutrients or other bioactive components, as found in published or unpublished records or databases (34).
- The indicator on food consumption is the number of foods reported in a dietary or food intake survey with detailed information variety/cultivar/breed or underutilized or wild foods (32).

23. The FAO/INFOODS Food Composition Database for Biodiversity has been developed and launched to specifically address the importance of composition data for biodiversity and publish the available data of high quality (34). It is the first international database to support countries on the generation, compilation and dissemination of cultivar-specific nutrient composition data. Data have been collected from peer-reviewed articles, reports, books and also unpublished results. Users can easily access the database and integrate data into their regional or national databases. Furthermore, study guides, tools and guidelines, such as Guidelines for Food Matching, have been established for inspection, compilation, calculation and use of food composition and consumption data, which are specific for or can be used for data on food biodiversity.

Availability and quality of data for biodiversity

24. Since the development of the indicators, food composition data for over 12800 foods have been reported; and food consumption data for over 4900 foods have been reported (35). Most data on food composition were found from Asia, followed by America, Africa, Europe and Oceania; while most of food consumption data were found in Oceania, followed by Asia , Africa, America and Europe (35). In 2011, the majority represented wild and underutilized foods (90%), and the rest of the foods were taxonomically below species (10%) for both food composition and food consumption. Furthermore, a significantly large volume of data were available for plant foods compared to animal foods (26,35).

25. In the future, data and nutrient coverage for biodiversity will need to increase, and the quality of the available data needs to be improved.

V. GAPS

Lack of food composition and consumption data for biodiversity

26. Food composition data are rarely collected for the purpose of food biodiversity, and these data are not often found in databases. Similarly, few surveys have collected food intakes for biodiversity. Generating more nutrient composition data for biodiversity is important for the development of dietary assessment instruments that could capture and analyse food intakes at the species and variety/breed level, and thus promote or give credit to specific nutrient-rich varieties/breeds. More composition data would also enable food labels that encourage the awareness of the unique composition of those often neglected nutrient-rich foods.

27. The available data gathered so far are of variable quality and collections of data derived from different sources, namely scientific articles, theses and technical reports; however, there is a need to develop ways to integrate these data into the large sharable systems. In addition, concerning the available data, there is often a lack of accurate and detailed information on food items, variations in analytical methodologies and reliability of the data.

Lack of comprehensive and simultaneous evidence demonstrating the linkages between food biodiversity and nutrition

28. There is insufficient empirical scientific knowledge/evidence that demonstrates a direct relationship between biodiversity and nutrition . The understanding and promotion of biodiversity for food and nutrition is largely based on studies in specific disciplines rather than studying biodiversity, sustainable development, agriculture, nutrition and health, and economy as a whole (6). Thus, the actual interrelationship among different disciplines is not yet fully understood. Furthermore, the existing evidence comes from regions that are rich in terms of diversity.

29. Research that provides additional evidence to develop agro-ecological models for guiding actions on the sustainable use of biodiversity for food and nutrition in urban and more developed areas is urgently needed (16).

30. The promotion of food biodiversity must take safety, environmental impacts, perceived risks and benefits into account to manage risks. However, absence of standards and combined methodologies makes it difficult to study the links in a broad concept.

VI. POLICY IMPLICATIONS AND POSSIBLE ACTIONS

31. In the past, there was little focus on the role of ecosystems in providing essential nutrients for the human diets. Yet. nutrient contents of foods from the same species could differ significantly. A better understanding of which foods (at species level or below) provide specific nutrients, as well as ecological functions is necessary for a sustainable application of biodiversity in food and nutrition. Therefore, investigation and documentation of food biodiversity, local and traditional foods need to be improved (7). Baseline information including local and scientific names, selected primary characteristics (e.g. availability, season, and nutrients), amount consumed and frequency of consumption should be reported as part of the food composition and consumption data. In addition, data should be provided in a simple, systematic and concise way to enhance accessibility and utilization also at policy level.

32. Prioritizing biodiversity for agriculture and nutrition policies(7). Policy makers and general public should all be educated on the importance of biodiversity for food and nutrition security (36). Food biodiversity should be mainstreamed into nutritional and agricultural policies and programmes, to promote the awareness of local nutritious variety/cultivar/breed as well underutilized and wild foods. At the same time, agricultural industry also has to take biodiversity into account in food production, such as breeding, selection and improvement.

33. Promoting small holders production, processing and marketing to use food biodiversity. Promoting biodiversity could contribute to improved household income among rural farmers, as well as enhancing the market value for traditional and underutilized foods. Appropriate food production systems, combining traditional knowledge and skills with modern concepts can perform better than agro-industrial ones (around 180%) to provide food to people in developing countries (37). External interventions must respect local insights, cultures, and commitment. Strategic approaches must be tailor-made, which address specific concerns in specific regions. The activities and programmes need to include community/local members and investigate the local consumption patterns that are sustainable regarding local biodiversity (38). Moreover, approaches should encourage/support other potential contributing partners (e.g. education, women/youth groups, and business sector) and improve communication among all stake-holders (38). For flexible and productive smallholder systems, policies should highlight agro-ecological capacity building, including eco-efficient, environmental friendly techniques and facilities (17).

VII. CONCLUSIONS

34. Biodiversity, food and nutrition are interrelated, a better understanding of the relationship can provide significant contributions to promote food and nutrition security, and to prevent micro-nutrient deficiencies and diet-related chronic diseases. Biodiversity provides a wide range of nutritious foods, which leads to dietary diversity that helps to improve the quality of the diet and human health. Therefore, food biodiversity needs to be mainstreamed into nutrition-sensitive agriculture practice and to all nutrition-related policies and programmes.

35. Nutrient contents in foods depend on species as well as variety/cultivar/breed. Therefore, composition and consumption data for biodiversity are needed for a thorough understanding and proper utilization of food biodiversity. Thus, robust generation, compilation and dissemination of variety/cultivar/breed specific food composition and consumption data need to be promoted.

APPENDIX I

GLOSSARY

Food biodiversity: Food biodiversity is the diversity of foods that covers the ecosystem, the species in the ecosystem, and the genetic resources within them (e.g. subspecies, varieties, cultivars, and breeds) (1).

Nutrition-sensitive agriculture: Agriculture that effectively and explicitly incorporates nutrition objectives, concerns and considerations to achieve food and nutrition security.

Malnutrition: The term "malnutrition" is used in a general sense. It includes undernutrition that covers inadequate consumption, poor absorption or excessive losses of nutrients and calories, as well as overnutrition indicated by excessive consumption of energy and nutrients (2).

Biofortification: It is the development of micronutrient-dense crops through breeding (3). This can be done either through conventional selective breeding or through genetic engineering.

Dietary diversity: A measure of the variety of food from different food groups consumed over a reference period

Food Composition: Food composition covers detailed analytical information on nutritional, non-nutritional and bioactive constituents of foods.

Food Consumption: Food consumption records food intake at a specified period of time at individual or population level.

APPENDIX II

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