Scoping study to determine the data sources on biodiversity in diet and food intake

Final Report

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This study is a collaboration with Ghent University and Bioversity International

Authors: Smith, K.W., Bronselaer, A., De Baets B., De Tre, G., Van Camp, J., Van Damme, P., Vanhove, W., Lachat, C.

Correspondence to: Carl.lachat@ugent.be PhD, Department of Food Safety and Food Quality, Faculty of Bioscience Engineering | Coupure links 653, 9000 Gent-Belgium | +32 9 264 9377

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BACKGROUND

Biodiversity in diet data is defined as any data on dietary intake which classifies food items consumed using botanical nomenclature specified below subspecies level (ie. variety/breed/cultivar).

[Definition follows that of the Expert Consultation for Nutrition Indicators for Biodiversity, FAO, 2010]

The increasing homogeny of the global food supply, combined with sweeps of perceptible climate change have alerted scientists and policy makers to our planet's rapid decline in biodiversity and its implications for the future of food security (CBD, 2010). Furthermore, the concrete implications of declining biodiversity towards human health and livelihood are not well documented, or understood (Fanzo, 2012). The critical need to understand how these systems interact has inspired research initiatives bridging biodiversity and food security. These have, in

turn, sparked collaborative research from the historically divergent fields of botany, environmental science, and public health nutrition. This novel topic, exploring the influence of biodiversity on human nutrition, nutritional sustainability, livelihood, and economic stability, and vice versa, is in rapid expansion. However, heterogeneous, disperse data, lacking agreement of quality standards, indicators, and a central point of collection, is an impedance to carry out research at scale (Hardisty, 2012). The need for standardization of data, and subsequent creation of larger datasets comprising a variety of geographies, geologies and cultures are needed to model, monitor, and report time-based trends in biodiversity and public health nutrition (Cardindale, 2010).

Governments, institutions and prominent researchers have recognized the importance of reconciling the biodiversity and public health nutrition research. The need for specific metrics that allow assessment of how diet drives biodiversity, and how biodiversity influences diet quality, have been endorsed in the form of open calls for consortia, i.e. the formulation of the Aichi Targets[1], the Millennium Development Goals, BIHorizons of the H2020, the UN Environmental Program and the Biodiversity Indicators Partnership, Convention on Biological Diversity, FAO-Bioversity's call for biodiversity indicators and in diet data.

At present, agricultural production, market availability and consumption surveys are proxies for quantification of panoptic biodiversity in foods, modeling and monitoring of time-based trends. This approach however, doesn't take into account post-harvest losses, whether or not foods were actually consumed, wild/foraged/non-cultivated edibles, or seasonality(Hawkesworth, 2010). Data from individual dietary intake studies provide a more accurate assessment, as they estimate directly what is consumed by individuals.

Furthermore, specific data on the contribution of biodiversity to diets, where seldom collected, is patchy, fragmented and inaccessible for re-purposing in new analyses. Available reviews indicate only a minority of these studies employ proper botanical identification methods to investigate how biodiversity is related to dietary intake in humans (Penafiel, 2011). New approaches and new instruments are needed to gather and harmonize small data collections so that research can accurately quantify food diversity according to botanical standards.

Various new approaches for information management offer promising solutions to make sense of heterogeneous data. Data scratching and web 3.0 applications are increasingly used in biosciences to locate, link and integrate data from various sources into composite results. The semi-automatic and automatic nature of data mining applications could by-pass the need for manual updates, facilitating the markup of taxonomic descriptions (Hardisty, 2012). Through innovations in database management larger databases can be created from fuzzy, or incomplete, heterogeneous smaller datasets, which when harmonized, are available for flexible queries. Re-purposing data in this way brings cost-efficiency to research efforts, as well as increased value for datasets. After the localization and characterization of available data, the second step, and perhaps greatest hurtle, will be to access and streamline this data into a usable and searchable database. However, this challenge is surmountable, and is already being realized in the domain of biodiversity informatics, and initiatives for similar projects on the side of agriculture and nutrition have been proposed. (see Annex I)

[1] http://www.cbd.int/sp/targets/, accessed 05/05/2014

OBJECTIVES

Our aim is to explore the use of these new technologies to integrate biodiversity and diet data a variety of sources into an interoperable and, eventually, open-access web resource.

This study will specifically

(i) Search the Internet for sources of information on biodiversity and diet i.e. ethnobotanical, food composition, food consumption. Both availability and type of formats will be assessed in this regard,
(ii) Map the information flow (sources and types of data),
(iii) Identify information gaps, and
(iv) Draw conclusions on the feasibility of developing tools to source and analyze existing data on biodiversity and diets, i.e. web based applications and web 3.0 ontologies.

METHODS

STAGE 1: LITERATURE REVIEW, RESOURCE SEARCH

1) Review and cataloging of literature and Internet resources on pertinent topics such as biodiversity, biodiversity informatics, nutrition metrics, dietary diversity, ethnobotany, food composition, and food consumption was carried out.

2) Current and ongoing projects linked to biodiversity informatics, nutrition metrics, or biodiversity and nutrition were searched through Internet and via personal contacts and members of their management were contacted.

   By identifying a broad range of current and ongoing projects and programs and contacting them these projects/programs were able to share methods, experience, and information about the data they have stored or collected so that we may assess the feasibility of the proposed application. (see Annex V)

STAGE 2: CREATION OF AN OPEN LETTER TO PARTICIPANTS AND STAKEHOLDERS, AND TEMPLATE QUESTIONNAIRE

An open letter was written to introduce potential participants and stakeholders to the scoping project, with the aim of creating some awareness about the project, but also to accrue contacts who have data on biodiversity and diet. Botanical museums, organizations, and individuals involved in data curation, informatics and management. (Annex II)

In interviews with team members and other network contacts, who are closely involved in the fields of informatics, ethnobotany, biodiversity and nutrition, information about current and ongoing projects, programs and potential database sources were collected. This report can be found in Annex V and VI and will serve as a template to identify potential participants and collaborators should the project receive funding.

The template (Annex IV) consists of a series of categories to form metadata, eventually to classify data source, type, and availability based on information that data custodians may input. All

features of data will be described, the variables, format of data, completeness, and project or study outputs. Original template design was based on templates used by Swedish LifeWatch, as well as a the Global Burden of Metabolitic Risk Factors of Chronic Diseases Working Group put together by Imperial College, UK, and the FAO Food Composition Database for Biodiversity (http://www.fao.org/docrep/019/i3560e/i3560e.pdf).

STAGE 3: INTERVIEWS

Contacts identified from literature review and Internet sources were contacted either by phone or email to determine if these organizations, institutes and individuals may contribute either data or expertise. Two versions of the open letter were made, one for those with expertise, and the second for those who might be able to contribute information about their data. Interview questions from the template were administered via phone, email, Skype, or in person, to determine details on the availability and exact format of data. Conversational interview was also held with those having expertise, or interest in related topics. This information was fruitful towards understanding the feasibility of such a project.

The open letter used for introduction can be found in Annex II , as well as a data template questionnaire (Annex IV). The data template outlines important variables collected during biodiversity and diet research. This template can be used to form metadata:

i) **Structural categorization of complex variables, metadata for geographic and geological information,**

ii) Suggestions for automated determination of data source quality

STAGE 4: TEAM WORK

Meeting with IT team members (Guy de Tre, Bernard de Baets, Antoon Bronselaer) to discuss:

Data quality and completeness was considered for effective harmonization of data across collections.

Interoperability Analysis – Comparison of the technical basis of biodiversity in nutrition data integration, including data similarities and differences

1) Technical scenario for interoperability,
2) Tools and options for interoperability
3) consideration given to data standards and quality

STAGE 5: WRITING OF FINAL REPORT

Roughly broken into 3 categories:

1. Summary report that includes availability of data sources, format of data and summary of findings from Stages 1 -4

2. Conclusions on feasibility of development of a web based approach to search and house data on biodiversity in diets obtained from the internet, or locally stored

3. Suggestions and recommendations for avenues of development for software or web-based applications to encourage and facilitate data interoperability

RESULTS

SOURCES OF INFORMATION

Contacted individuals ranged from ethnobotanists, some with over 20 years' experience in the field, to informatics and taxonomic specialists of Botanical museums in London, and Belgium and the USA. A total of 35 email requests were sent resulting in 17 phone interviews. The majority of respondents were those involved in fields of informatics, data management, curation and biodiversity/botany, those with actual data on biodiversity and diet were however more difficult to reach for phone interview. Many people holding data have 1 -2 papers published on the topic, but have since shifted research focus.

From interviews we have been able to identify sources of biodiversity and diet data, as well as harvest viable ideas for research tools (particularly web-based applications). Sources of actual data were found widely dispersed throughout the world, although some institutions take particular interest in research bridging biodiversity and nutrition. These are Bioversity International, Ghent University, Belgium, The Center for Indigenous Peoples Nutrition and Environment (CINE), and Universities of South Africa (Witswatersrand, Stellenbosch, Cape Town University and the Medical Research Council, MRC), likely FAO INFOODS and HarvestPlus could be used as sources, although they were not available for interview. Summary of these institutions, their function and output can be found in **Annex III.** A concrete list of publications and research output can be found in **Annex V**. A list of persons interviewed and their contact information can be found in **Annex VI.**

TYPE, FORMAT AND ACCESSIBILITY OF DATA

Most data is kept on personal or institutional hard drives, found in the form of excel files. Data on biodiversity and nutrition that we retrieved was not stored in a designated data repository, which means data is not accessible through metadata searches via internet, thus for these datasets, data retrieval/reuse cannot be automated. A data collection initiative by FAO INFOODS on biodiversity and nutrition is a cataloguing of current and past research initiatives, rather than a collection of actual datasets.

Food intake data is generally gathered by a trained nutritionist or ethnobotanist according to accepted standards per that discipline. Botanical data is most often collected by a botanist from a local herbarium or museum, and less often by a consultant brought in from outside that locality. Most projects make efforts to engage local institutions as experts in botanical fieldwork. Research leaders generally have separate files for dietary intake data, botanical data and other data (economic, agricultural, anthropometric), with codes or names as the common denominator linking files.

Intake data variables differ according to the needs of the study, whereas botanical data is relatively standardized. Botanical data caries taxonomic data up to cultivar/variety level, Dietary intake studies are generally based in 24h recall or FFQ, and have additional variables such as DDS, HDDS, FVS, Wild or Cultivated, Local or Not-local, traditional and non-traditional, method of procurement, and food security metrics. Many studies document consumption pertaining to certain groups of foods, such as wild edibles, non-cultivated foraged foods, forest foods, leafy greens, specific species of fish, fruit, this can go down to use of one particular food such as rice or bananas. This data, although it does not represent the complete picture of biodiversity of diet, it is the most useful proxy indicator for answering questions related to consumption of biodiversity we have at this time. We found no study that had documented all food consumed by individuals by botanical name. The task of documenting botanical sources for all foods consumed proves difficult especially when moving towards more urban societies with processed and store-bought food. Mieke Faber has a study in the pipeline to examine the food environment through seasons, including biodiversity and commercial intake over a period of 2 years, with a total of 8 different time points for intake survey in both rural and urban zones. This may be the most comprehensive example of a biodiversity and diet survey yet proposed, categories of commercial and non-commercial foods may be rather subjective, and loosely connected to biodiversity, but it is a solution until advancements in technology are made which can easily track the origins of commercial food products.

All data found is subject to terms of use set forth by original authors and funding agencies, permissions associated with publication of datasets, and data clearance policies from relevant ethics committees. Therefore the interoperability of data is difficult to estimate as each dataset comes with its own set of barriers. Open access data is becoming recognized as a means to generate value for datasets and these barriers may lift in the near future. For the moment, none of the datasets found were completely open-access.

SOURCES OF INFORMATION TOWARDS WEB PORTALS AND RESEARCH TOOLS

WEB PORTALS

Challenges to consider in creation of a biodiversity and diet data web page/ web repository/ web-based application:

- Names disambiguation and nomenclature standards
- Standardization of research methodology
- Identification of priority research questions and indicators
- Analysis of data quality (redundancy, fuzzy data, co-references)
- The original intention of the study
- Citations for datasets, confidentiality, terms of use for datasets
- Whether a data repository or a data portal alone will be used

STANDARDS – NAMES DISAMBIGUATION

Examination of the history of the problem of web portals in biology at large is necessary when considering available options and opportunities for biodiversity and diet data web portal design. In a comprehensive paper by bioinformatics computer scientist, Dr. Alex Hardisty, Cardiff University, the problem of establishing e-infrastructures for biodiversity data (as well as any other kind of related science) is clearly put forth(Hardisty, 2012). The world of biodiversity informatics hopes to, in the near future, do what genetics and biomedical sciences have done to standardize and unify data completely through web-based applications. However, such an old science with records previously based in paper, rife with a long history of nomenclature disputes (now termed 'taxonomical impediments') cannot hope to move with the same ease into the digital age as biomedical science. In biodiversity and diet data collection and integration we intend to use taxonomical names for dietary intake surveys, thus we inherit the problem of names disambiguation and species identification.

This 'taxonomic impediment' described by Hardisty is not exclusive to botanical sciences, for interoperable data in biodiversity and diet to be achieved a system of reliable identification for plant and animal species is required as well as ontologies which link vernacular names to species names, tools for names disambiguation, and validity checks. A solution exists which is currently being used by most web services providing biodiversity data (LifeWatch, SEPASAL, BioFresh, BioVel), called the TDWG Darwin Core standards promoted by GBIF. These standards for taxonomy have been established in consortiums involving large organizations such as MOBOT (Missouri Botanical Gardens), GBIF and the Convention on Biological Diversity(CBD). These large organizations, along with many partners have come together through the years to establish TDWG DarwinCore standards. DarwinCore standards are a "vocabulary of terms to facilitate the discovery, retrieval, and integration of information about organisms, and their spatiotemporal occurrence" (http://rs.tdwg.org/dwc/). These are tools to automate names disambiguation using machine to machine language (web services), these are the Integrated Publishing Toolkit from GBIF, and PESI from the EU-NOMEN project (http://www.eu-nomen.eu/portal/webservices.php). Dietary intake data, although lacking rigorous standards when it comes to a fixed selection of variables for assessment, will be less of a calamity in that methodologies, indicators and recording methods are fairly well established. Those ambiguities that do exist need systematic creation of ontologies; a task which the ENPADASI project may hope to resolve (http://www.healthydietforhealthylife.eu/index.php/enpadasi). Furthermore, as the topic is relatively young, creation of data standards and data integration tools will enable interoperablility of data into the future.

VALIDITY AND QUALITY

A web portal which provides access to biodiversity and diet data should ensure that the data is reliable and quality, perhaps including a rating system for data, and a label (metadata) which considers the intention of the study (whether the study was meant to look at agriculture – nutrition linkages, or nutrition status of a population and can be used to inform the user about relevance, trustworthiness and importance of the data. A rating system of validation steps in the form of 'check constraints' can be used to verify that the data are of the correct data type and lie within certain pre- set boundaries.

CITATIONS

Each dataset contained or referenced by the web portal should be assigned a DOI or barcode, so that authors may receive appropriate recognition in the case of data reuse. The system of citation recommended by the World Agroforestry Centre's Gateway is a good example: http://thedata.org/citation, another system for generation of DOI's : http://www.datacite.org/services .

PUSHING OR PULLING? STORING OR SCRATCHING?

The way that data is sourced and stored should be considered carefully, as there are pros and cons associated with both data portals and data repositories (storage options), as well as systems of pushing or pulling (source options).

Push, or server push, describes a style of Internet-based communication where the request for a given transaction is initiated by the publisher or central server. It is contrasted with pull, where the request for the transmission of information is initiated by the receiver or client. A web crawler can be considered as a pull mechanism to bring information to a single page, applying metadata elements which are periodically harvested from specific locations. For instance, a search engine capable of crawling the web for sources of biodiversity and diet data and cataloging them will be a pull mechanism, to pull in references, articles, news bites, or even images. It is possible to generate databases (of interoperable data) using the pull mechanism, but in most cases large datasets are generated by a push mechanism**.** BioFresh uses a push mechanism called the Integrated Publishing Toolkit, open source software from GBIF, to publish datasets as a data paper, or Excel spreadsheets or text files in DarwinCore format are pushed through the IPT to their webpage. Swedish Lifewatch uses a push and pull system, external data providers are requested to provide data through web services created specifically for Lifewatch, based on the SOAP technique(a simple XML standard for communicating data), and are pushed to the LifeWatch server using https to protect data transfer. This is particularly useful for systems like LifeWatch which rely on many small batches of data, sometimes single species observations from citizen scientists. The system however is not totally automated, 2 staffed scientists are charged in verification and quality of incoming data.

Data repositories tend to be less automated; typically data is merged manually and is integrated as it is uploaded to the server. Data can be requested in a specific format through user templates, to ease the process of data integration, or a software product which automates the process can be used (such as SMART Documents, a piece of software under development at UGent).

All of these services provide an entry point for data discovery, by making metadata on datasets open access, but protecting data through access rights (users must make requests to see data, ie. World Agroforestry Research Gateway). Data in these repositories is subject to validation and curation, and users are able to search for and download data relevant to their topic using filters, or a google search.

POSSIBLE RESEARCH QUESTIONS AND GAPS

NEEDS

> **"The literature exploring connections between human health and ecological alteration includes multiple studies scattered across a variety of disciplines that leave many of the most important relationships incompletely characterized." – Myers et al., 2013**

A web portal for biodiversity and diet data does not yet exist, although data is still scarce at this stage, now is the most important time to give it a place on the World Wide Web. Internet visibility will aid in building capacity, providing researchers access to resources, as well as a community atmosphere, encouraging community responsiveness. A service which supports research can also promote cost-effective research (data reuse policies, trainings), create effective tools for research (intake software, food composition tables, research mapping, visualization), and establish communication pathways to enhance collaboration (consortia, seminars).

Ideally a web application/portal should enable flexible and intelligent queries, while keeping up with evolving knowledge and providing reliable and rapid access to data. The promotion of open access data is widespread by now throughout the research community, but action must follow word. Building Internet repositories which safely house or safely stream data are needed in order for the institutions to follow through on these open access data promises and commitments.

FOOD COMPOSITION DATA

For biodiversity and diet data to become more prevalent, in addition to creation of standards, indicators, and a commitment to building community and capacity, more food composition data is needed. The encouragement by FAO INFOODS has done much to promote analysis of wild and underutilized foods, however, for a fully comprehensive system we need composition data on ALL foods. The availability of food composition data for regions should be close at hand and easy to locate, currently INFOODS links out to various websites rather than keeping food composition tables in one location. EUROFIR has started to compile a thorough food composition database from 26 compiler organizations around the world. It contains common descriptions of foods, common component definitions, the analytical methodology, and bibliographic reference along with taxonomic name and information relating to use.

NEW TECHNOLOGIES

The difficulty and detail of dietary intake surveys is well recognized, simplified metrics are used occasionally to reduce the burden (eg. DDS). However, biodiversity and diet surveys are yet more detailed than an average intake survey by involving species-level plant/animal identification. The burden introduced by new need for detail will be reduced in the future by face-recognition software to identify plant species, open access information to nutritional composition of these species, apps which automate names disambiguation perhaps compiling food composition lists for use in the field. Services already exist to easily construct ontologies and metadata tags for incoming data, free data publishing repositories promoting open-access policy (OpenAIRE, Scratchpads), technologies for plant/animal identification such as questionnaires (WAC), and digital taxonomic backbones that can be added to websites for names disambiguation (KEW).

Comprehensive food composition tables, available research tools and support will enable us to answer these larger, looming research questions.

QUESTIONS

What are the health-related differences between food varieties?

How do varying levels of biodiversity affect human consumption patterns/nutrition status?

How does human consumption influence presence/absence of biodiversity?

What defines edible biodiversity? How can we quantify it? Can a standardized indicator be used?

What is the interplay between climate (even seasonality), biodiversity, and nutrition status?

CONCLUSIONS - REMARKS

FEASIBILITY OF INTEROPERABLE DATA

Internet searches of literature and conversations with scientists affirmed what we already suspected; that there is relatively little data on the topic for the moment. However research into biodiversity and nutrition, which links important topics like sustainable agriculture, ecosystems, livelihoods, food security and population health, is on the global research agenda (Aichi targets, Horizons2020, Daniel and Nina Carasso, Gates Foundation, Eurobon). This type of research will continue to be encouraged and funded into the future, and so we can expect an increase in data on the topic. As in many topics which bridge disciplines data collection requires collaboration and understanding between those involved, in a fast-paced world this joining of forces is sometimes difficult. Furthermore, biodiversity and diet research, as a cross-disciplinary field lacks place in the literary world, research is subsequently published in diverse journals such as Economic Botany, Public Health Nutrition, Food Composition and Analysis, Journals of Clinical Nutrition, and Ethnopharmacology. Therefore, data and research from this field is scattered among journals and institutions, and is not always adapted for reuse as they emerge sometimes as small datasets, from different scientific domains, for specific purposes. Hence, the need for a set of standards which can allow aggregate data to be comprehensive and complete, and interoperable.

> **"Lack of empirical evidence of agricultural impacts on nutrition outcomes may say more about variations in study design and methods than about lack of initiative."**
>
> – Webb, 2013 Impact Pathways from Agricultural Research to Improved Nutrition and Health: Literature Analysis and Research Priorities

The suggestion by this report is that a consortium or seminar be held either online or face to face, with interested and engaged members of the scientific community. A gathering, virtual or physical, can also help to spread awareness of the existence of a serious agenda to make biodiversity and nutrition data interoperable, as well as to discuss how this can happen (i.e. Legal/ethical aspects, authorship rights and permissions). A discussion live among experts would additionally help to prioritize research questions and consolidate agendas, identify gaps and mobilize expertise.

After data has been standardized information lifecycle management in biodiversity and diet data may require much human intervention, limiting automated data processing and ingestion. In all cases, some level of pre-processing is needed to make the dataset suitable for sharing and for publication. Those wishing to contribute data to the system will need to follow a set of guidelines to prepare, license and adhere consent and access rights to their dataset. A support system will be needed for users contributing data as well as users wishing to extract data. If data is stored in the system the digital repository itself will have requirements for upkeep, data management will need to be confidential, and effective documentation of the history of the repository will need to be kept. Metadata standards will enable identification of datasets, and templates can provide examples of dataset structure without being too prescriptive. Publications will also start to exist in a semantically structured form, enabling machine-readability. Data papers work now much in the same way, and these sorts of publications will eventually become the norm and semi-automated data scratching tools will be able to search more freely, finding sources of data or research more easily.

FEASIBILITY OF WEB PORTAL/ WEB APPLICATION

Feasibility will depend on the complexity of the web page/ web-based application, the decisions as to whether the portal itself is a repository, or a wrapper and whether the function of the portal is to pull information in, or to have users push information/data to the website. Outlined below are ideas for web portal features drawn from the experiences of interviewees, as well as design and function concepts gleaned from various project websites. The following recommendations are based on options which seem technically realizable in the near future and are cost-efficient.

WEBSITE

A general website for user interaction, publications, news, search engine/repository and hosting is provided free of charge from the Belgian Biodiversity Platform (BELSPO), a group working closely with GBIF to integrate taxonomic and species occurrence data from Belgium into GBIF. This group also has expertise in setting up the internal databases that can be used to cross-check taxonomical names against DarwinCore standards, as well as perhaps integrating some elements of the GBIF catalogue into a personal webpage using the Integrated Publishing Toolkit (IPT). Although, because the data we are using is not species occurrence data, using GBIF IPT may not be an option to push data to the server, depending on how the IPT works. However it is perhaps still possible to cross-check taxonomical names against GBIF standards, without IPT. This remains to be further investigated. Additionally, BioFresh, a Belgian fresh water biodiversity group partially located at UGent, has experience with IPT and with cross-checking data against GBIF standards.

Similarly, the Natural History Museum of London has developed a system called Scratchpads, a Drupal-based virtual research environment (VRE) meant for use in biology, particularly in biodiversity, as there are modules which integrate taxonomical backbones, species occurrence maps into their web-interface. The internal system is flexible in that Drupal modules can be added to Scratchpads to customize functionality. One of the unique features is that in addition to publishing data or research online, authors have varying levels of permission to access and alter, upload and download data, therefore, many people are able to contribute to the site easily. There are auxiliary modules to personalize webpages which build google maps using geocoordinates, and which build up taxonomies.

GEOREFERENCE TOOL

Georeferencing software is a common addition to many sites, and provides a visual experience for users. Examples such as Canadensys (http://www.canadensys.net/) and Swedish Lifewatch, provide options to filter results of a map search, making it easier for users to locate projects, resources or publications. Maps which have filters allow users to select what visual they would like, for example, research being done on a particular species, or a map of locations of projects of a certain institution or individual can be useful when building a network of expertise, conducting a literature search, or searching for research gaps. Systems like Canadensys and the Scratchpads maps function use standards to encode geographic points called GeoJSON.

TAXONOMY

Disambiguation of taxonomical names is one of the major functions of most botanical museums, leading museums addressing this issue are, MOBOT and KEW, both were interviewed for this study. KEW has begun development of a software program called Medicinal Plant Names Services, with a grant from the Welcome Trust, enabling researchers to search and discover pharmaceutical plants by various elemental characteristics (ie. plant part, effect, means of consumption or use, common or scientific name). The service also includes cleaning of datasets through suggested spelling corrections, removal of duplications, co-ordination with KEW's plant authentication services, and is working on building an API interface which would allow machine to machine communication. It was mentioned during the interview that a similar tool could be envisioned for those working to collect botanical information on edible plants, potentially app-based with face recognition software. This would make it easier for nutritionists and ethnobotanists to identify what plant species may have been consumed during survey. Such a tool then opens access to existing knowledge of nutritional properties of species and perhaps cultivars. This could be very useful in a development context during field work.

The database Tropicos created at MOBOT contains a list of over 1.2 million scientific names, easily searchable, it provides information on plant species by either common or scientific name, providing links to references, publications and images. MOBOT has also developed the Taxonomic Name Resolution Service (TNRS, http://tnrs.iplantcollaborative.org/about.html) which is a computer-assisted automated service for standardization of scientific names, avoiding manual correction. The website claims that some large collaborative databases (like GBIF) can contain errors, such as synonymous or unmatched names. When building a food list for use in the field a service providing automatic checks to food lists would be a boon to researchers, facilitating the standardization of intake data by starting fieldwork with correct botanical names.

DIETARY INTAKE

Online food intake software such as Lucille, developed by UGENT, or EUROFIR, from the European Commission, are useful tools which can also help to standardize and create interoperable food intake data. EUROFIR is backed up by a database containing detailed information about edible foods including scientific names, preparation and edible parts, it's export data will be similarly structured. Lucille has the advantage of not having an internal database, users create the food composition tables they themselves will use and upload it, independent of what an internal database may or may not contain. The only disadvantage of Lucille is that uploaded data can be subject to error, as there are no internal validity checks, in the case of adding information related to plant taxonomy this can become tricky. Eventually it can be envisioned that a cross-check is made as food composition tables are uploaded to Lucille, which flags items containing errors, and helps users with botanical names disambiguation, duplicates and synonyms in a user-friendly semi-automated way, similar to the way that TNRS works.

ONLINE DATA INTEGRATION

Most data systems do not integrate separate datasets from separate studies, unless the data are rigorously standardized (i.e. species observation, genetic information), likely due to the complexity of doing so. However, there is a need for larger datasets in order to answer questions about worldwide trends in nutrition and biodiversity, and there's no other way to start to compile data other than to do it through an online medium. Species observation data is becoming interoperable through projects such as LifeWatch, whereby users upload data in a using a form and this is then integrated into the larger repository dataset (https://www.artportalen.se/LogOn?ReturnUrl=%2fSubmitSighting%2fReport)

In the event that separate datasets, projects or publications are uploaded from various locations and stored on the internal server, metadata can be generated semi-automatically for each dataset, publication or project so that information on the website is easily searchable by external search engines. Imagining biodiversity and nutrition data are as rigorously standardized as species observation data, it may even be possible to automatically integrate data online. Formulas for upload, like questionnaires, could be used to ensure that all needed variables are accounted for and that data is complete upon upload. Such an automated system has still yet to be built for dietary intake data, but given that it already exists for species observation data it seems relatively feasible technologically. In this case a system of pushing data to a server is advised, so that manual efforts of data integration are minimized. The pushed data would reside in an online data repository, protected by gateway permissions. There are data security issues when considering the use of a data repository, but providing website disclaimers such as those license agreements provided by CGIAR will help define and legally protect the repository (http://www.cgiar.org/consortium-news/principles-on-management-of-intellectual-assets-approved/).

RECOMMENDATIONS

Answering questions about linkages in biodiversity and nutrition may be essential for sustainable development during this period of worldwide population growth. Data on the topic remains limited for the moment. However, we believe that by making research in biodiversity and nutrition more visible, standardized, with research tools tailored to the topic, research will become quickly more prevalent, and pressing questions about the relationships

between biodiversity and nutrition will be on their way to answers. Thus, creation of a web portal, and research tools will be a necessary addendum to the concept of interoperable datasets.

Creation of a web portal,:

- mapping (visually) initiatives, projects, and research worldwide on the topic
- search engine targeting publications relevant to biodiversity and diet
- news bytes and articles
- links to research tools – dietary intake data and names disambiguation for taxonomy

Towards Interoperable Data

- agreements on standards, involvement of experts and researchers in the field, a symposium, or conference on the topic
- promotion of standards through web portal, and through research tools which not only facilitate data collection and analysis but also streamline data structure and quality standards
- data collection tools, such as dietary intake software which includes modules to identify edibles to species level, automated correction of scientific names
- metadata standards for published datasets
- creating awareness for the benefits and needs of interoperable data in the field

TIMELINE

09/04 09/04 16/04	***Literature review, resource search*** *Protocol Draft 1* *Protocol Draft 2*
19/04	***Creation of a template, open letter to participants and stakeholders***
12/04 - 24/04	***Interviews*** Interviews with team members Interviews with project managers, specialists in the field of ethnobotany, sustainable diet, biodiversity informatics, environmental science Botanical Museums and collections Stakeholders – perhaps FAO, other members of Bioversity team Participants - Data custodians from different disciplines
13/05 – 15/05	Visit to Bioversity, Rome Continuing research on feasibility Meetings with team members on refinements to project concept
01/06 – 30/06	Mid-Term report, Concept Note, Extension of Contract

01/07-30/07	Finalization of Concept Note, Further research for participants
01/08 – 31/08	***Contacting Participants, Phone follow-up***
01/09 – 30/09	***Data Collection Simulation Preparation, Final Report Preparation, Interviews***
01/10-30/10	***Final Report***

PARTICIPANTS

Carl Lachat	UGent, Department of Food Safety and Food Quality	Carl.Lachat@UGent.be
Katherine Smith	UGent, Department of Food Safety and Food Quality	Katherine.Smith@UGent.be
Patrick Kolsteren	UGent, Department of Food Safety and Food Quality	Patrick.Kolsteren@UGent.be
Bernard De Baets	UGent, Department of Applied Mathematics, Biometrics and Process Control	Bernard.DeBaets@ugent.be
Guy De Tré	UGent, Database Document and Content Management	Guy.DeTre@UGent.be
Patrick Van Damme	UGent, Tropical and Subtropical Agronomy and Ethnobotany- UGent	Patrick.VanDamme@ugent.be
John Van Camp	UGent, Department of Food Safety and Food Quality	John.VanCamp@UGent.be
Wouter Vanhove	UGent, Tropical and Subtropical Agronomy and Ethnobotany- UGent	Wouter.Vanhove@UGent.be
Celine Termote	Bioversity International	c.termote@cgiar.org
Gina Kennedy	Bioversity International	g.kennedy@cgiar.org

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Annex I

Biodiversity research groups across the globe have begun efforts to unify data and deploy e-infrastructure and e-science in order to facilitate modeling and monitoring of changes in genetic diversity. Some of these initiatives can be considered data storage banks, others are truly geared towards re-purposing data for analysis, both are developing technical capacities in data mining, inferencing algorithms, open source methods, addition of metadata tags, common ontologies and semantics. Initiatives such as TAPIR-TDWG Task Group, GBIF, FSIN, the Global Biodiversity Informatics Outlook, GEO-BON as well as those initiatives seeking to catalogue: Atlas of Living Australia, Canadensys and LifeWatch.

Agriculture, like biodiversity, requires large datasets to produce meaningful models, as well as to report on time-based trends. CGIAR and IFPRI have proactive initiatives to make interoperable open-access datasets to distribute and connect research, as well as build metadata ontologies to facilitate re-use of information products, avoiding duplication and identifying gaps. http://www.cgiar.org/resources/open/

Nutrition Epidemiology scientists at the University of Ghent, in collaboration with other Belgian universities, have begun planning for projects to standardize, and bring together dietary intake data to monitor trends and food safety issues. This project plans to collect, integrate and curate food intake data, as well as developing new metadata formats.

Nutrition, agriculture and biodiversity all face similar challenges in unifying heterogeneous data and planning construction of interoperable datasets and applications capable of flexible queries. In the future these programs, portals and databases will be able to provide researchers tools to accurately monitor, model, and report time-based trends.

The future outcomes of these new technologies, once developed, will be to enable factors of influence; effects of climate change, land management, population growth, environmental exploitation, and other effecters of ecosystem biodiversity, to be stratified for a particular locality, or summarized globally. In turn these will be used to make predictions about the future of diversity on earth and interactions with human health.

Annex II

Letters of Invitation for Scoping Study

Scoping Study to Characterize Data on Biodiversity and Diet

A collaboration of
Gent University, Belgium and Bioversity International, Italy

Growing concern over the effects of a globalized food supply on human nutrition has sparked research investigation around the world into interactions of biodiversity and diet. Although evidence clearly indicates the modern era's push towards homogeny of crop production has meant a decrease in dietary and ecological diversity (biodiversity), the complex interactions of biodiversity and human diet have yet to be described at scale.

A first step towards large-scale assessment of biodiversity in diet will be to characterize the available data.

We would like to interview researchers in the field of biodiversity and diet to know the type of data collected, the format, its location and some information about accessibility (is it private, is it open-access, is it limited access), therefore no actual data or study results are inquired about during interview.

Persons and groups interested in contributing to characterization of data, are in no way obligating themselves to submit data, either now or in the future.

The results of these interviews will determine how we might proceed in our assessment of the potential of current technology to consolidate biodiversity and diet data. The knowledge accrued during the scoping process could contribute to the development of an interoperable open-access database system, capable of modeling and describing trends and interactions in biodiversity and diet, particularly with regard to the problem of decreased biodiversity in human nutrition.

We welcome your group's participation with guaranteed confidentiality of all information disclosed.

What's happening now?

The most recent attempt to describe the effects of this worldwide shift in consumption of dietary diversity in foods, published by the *National Academy of Sciences*, uses global food supply data from the FAO as a proxy for dietary consumption. However useful this report may be in confirming a decrease in worldwide crop biodiversity, the study has its limitations. Consumption does not necessarily follow commodity (due to losses), and national food supply data generalizes and underestimates total existing food crop species by overlooking food plants found in smaller quantities, due to seasonality, geographic specificity, or plants which are foraged or wild-crop relatives. It is important to find ways of including these species in global reports, because of their decisive contribution to food diversity and thus micronutrient nutrition.

Future prospects…

Centralized collection of information from individual dietary intake studies could provide a more accurate assessment of what is actually consumed, and where. New technologies, such as web 3.0 applications, are available to make information widely available to researchers. Promoting reliable, detailed and accurate assessment of biodiversity in diet as well as identifying research gaps, conducting meta-analyses, and establishing clear standards for indicators is needed for advancement of the field. At present, specific data on the contribution of biodiversity to diets, where seldom collected, is patchy, fragmented and inaccessible for re-purposing in other analyses. Available reviews indicate only a minority of these studies employ proper botanical identification methods, and most from areas rich in biodiversity. Furthermore, current studies are related to specific disciplines, rather than taking an interest in the linkages between disciplines. This project will analyze the best option for creating value for available data and making it widely accessible to relevant stakeholders, with ethical considerations given to the intellectual property rights of the custodians of this knowledge.

Our contribution....

Researchers at Bioversity International, a member of CGIAR, from the Diet Diversity for Nutrition and Health team in collaboration with a multidisciplinary team of researchers from Ghent University, Belgium will carry out the scoping study. The final report on the scoping exercise will be made available publicly and circulated widely.

Contact:

Carl Lachat, PhD, Katherine Walker Smith

Department of Food Safety and Food Quality, Faculty of Bioscience Engineering, Coupure links 653, 9000 Gent-Belgium +32 9 264 9377 carl.lachat@ugent.be katherinew.smith@ugent.be

Members: Gent University Belgium: Carl Lachat, Patrick Kolsteren, Katherine Walker Smith and John Van Camp (Department of Food Safety and Food Quality), Patrick Van Damme and Wouter Vanhove (Tropical and Subtropical Agronomy and Ethnobotany), Guy de Tre (Database Document and Content Management), Bernard de Baets (Department of Applied Mathematics, Biometrics and Process Control) Bioversity International Italy: Celine Termote, Gina Kennedy

[Type text]

Scoping Study to Characterize Data on Biodiversity and Diet

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Growing concern over the effects of a globalized food supply on human nutrition has sparked research investigation around the world into interactions of biodiversity and diet. Although evidence clearly indicates the modern era's push towards homogeny of crop production has meant a decrease in dietary and ecological diversity (biodiversity), the complex interactions of biodiversity and human diet have yet to be described at scale.

E-infrastructures for biodiversity and diet research will enable descriptions of trends, help to identify research gaps, and bring collaboration among researchers into this very important field.

Our work is to assess the potential of current technology to consolidate biodiversity and diet research, bringing it under one roof.

Those who can contribute knowledge and expertise in the fields of botany, agriculture, informatics, data management and biodiversity are invited into dialogue about possible scenarios. Your expertise and knowledge of your field is essential to creating a useful and tangible product for all disciplines. We ask only that you would be available for interview.

What's happening now?

The most recent attempt to describe the worldwide shift towards monoculture published by the *National Academy of Sciences*, uses global food supply data from the FAO as a proxy for dietary consumption. However useful this report may be in confirming a decrease in worldwide crop biodiversity, the study has its limitations. Consumption does not necessarily follow commodity (due to losses), and national food supply data generalizes and underestimates total existing food crop species by overlooking food plants found in smaller quantities, due to seasonality, geographic specificity, or plants which are foraged or wild-crop relatives. It is important to find

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Contact:

Carl Lachat, PhD, Katherine Walker Smith

Department of Food Safety and Food Quality, Faculty of Bioscience Engineering, Coupure links 653, 9000 Gent-Belgium +32 9 264 9377 carl.lachat@ugent.be katherinew.smith@ugent.be

Members: Gent University Belgium: Carl Lachat, Patrick Kolsteren, Katherine Walker Smith and John Van Camp (Department of Food Safety and Food Quality), Patrick Van Damme and Wouter Vanhove (Tropical and Subtropical Agronomy and Ethnobotany), Guy de Tre (Database Document and Content Management), Bernard de Baets (Department of Applied Mathematics, Biometrics and Process Control) Bioversity International Italy: Celine Termote, Gina Kennedy

Annex III

- **The Center for Indigenous Peoples Nutrition and Environment (CINE), McGill University**
    - **Function:** ethobotanical data collection as well as dietary intake data collection in 15 indigenous groups worldwide
    - **Produced:**
        - A manual for biodiversity/nutrition data collection and intervention, including botanical sampling and identification, laboratory procedures, and food intake questionnaires.
        - Downloadable food composition databases to catalogue the work they have done during selective food composition analysis in these regions.
        - University of Montreal professor, who previously worked at CINE, Malek Batal has also conducted several interesting and innovative studies in traditional and wild foods in diets of people of Lebanon and among First Nations of Canada.
- **Universities and institutions of South Africa**
    - **Function**: Studying consumption of wild (non-cultivated) edibles and food intake data.
    - **Produced:**
        - Researchers in South Africa from Universities country-wide as well as the nutrition unit of the Medical Research Council (MRC), have long since collected data on the topic of biodiversity and diet, making use of the wealth of indigenous knowledge and biodiversity to conduct large-scale studies in South Africa.
- **FAO INFOODS Food Biodiversity (information extracted from website)**
    - **Function:** Advocacy to include botanical names in Food Composition Indices, and advocacy to scale up assessments of wild and forgotten foods contribution to diet, aiming to boost biodiversity and nutrition as an important research theme
    - **Produced:**
        - The FAO website does not contain information related to consumption, but composition, including a report on current activity in the field of biodiversity and nutrition documenting the incidence of data collection through time
        - INFOODS report on biodiversity in nutrition research can be found here: http://www.fao.org/fileadmin/templates/food_composition/documents/Nutrition_Indicators_for_Biodiversity_Poster_2013.pdf

- **Bioversity International, Diet Diversity for Nutrition**
    - **Function:** Working to bring attention to nutrition issues, particularly in mothers and young children in West, East and Southern Africa as well as Asia and Latin America, with research initiatives that can be adapted to other regions.
    - **Produced:**
        - Advocacy for sustainable diets involving policy and economic perspectives, forest foods, neglected and underutilized species of crops in West, East and South Africa
        - Characterization off crop wild relatives for support of crop breeding
        - Mainstreaming biodiversity conservation into nutrition and sectors or improving human well-being
        - Role of wild and underutilized foods in the daily cost of diets in Baringo Kenya, nutritional contributions of traditional foods to well-being of rural poor in Africa in general
    - **Bioversity International, Biodiversity for Food and Nutrition Project**
        - **Function:** Bring attention to disappearance of agricultural biodiversity, particularly in traditional crops, wild species with nutritional potential in the countries of: Brazil, Kenya, Sri Lanka, and Turkey

- **Produced:**
    - Policy awareness about importance of traditional and wild foods, creating markets and value chains, policy advice for use of agricultural biodiversity as a solution to nutrition-related health issues
    - Reports: Advocacy and indicators for sustainable diets, Nutrition Sensitive Landscapes (Kenya, Zambia), Biodiversity for food and nutrition, Micronutrient deficiency (Bananas with high Vitamin A)
    - Book: Diversifying Foods and Diets, http://www.b4fn.org/the-book/

- **Ghent University, Belgium, Department of Food Safety and Food Quality, Laboratory for Tropical and Subtropical Agronomy and Ethnobotany**
    - **Function:** The study of agrobiodiversity, ethnobotany, domestication and new crop development, sustainable agricultural systems, market integration of small-scale farmers in developing countries, in relation to nutrition, nutrition epidemiology and public health
    - **Producted:**

Publications and research bridging biodiversity and nutrition, mainly working in biodiverse regions of developing countries, wild, non-cultivated and local foods are used as a denominator for biodiversiu

Annex IV

Metadata sketch - datasets								
1			**2**			**3**		
Category	**Description**	**Source**	**Category**	**Description**	**Source**	**Category**	**Description**	**Source**
author_name	Name of author	SL	Access_yesno	Is data accessible without fee/limitations (yes, no, partly)	SL	Data_use	What is data used for? (epi studies, EU directives, institutional research)	SL
author_affiliation	Institution affiliation	SL	access_nofile	Names of files with no access	SL	Quality	Are quality checks done? (yes/no)	SL
author_contact	Contact person	SL	Access_yesfile	Names of files with access, or partial access	SL	Describe quality check	Repeatability, third party service, monitoring/evaluation	SL
date_submission	Date of system submission	SL	Access_limited	Access is limited to: (government authorities, institutions, special permission, user fee, other)	SL			
pub_title	Title of dataset, or associated publication	SL	Description of access	Describe here access in permissions in own words	SL			
pub_URL	Publication URL if available	SL	Data_storage	How is data locally stored? ○ MySQL ○ Postgre SQL ○ MS SQL ○ Oracle ○ Access ○ Excel ○ Text files ○ Non-digital ○ Other	SL			

pub_ID	Publication DOI or identification number	SL	Mode_access	How is data made available? ○ Web Map Service (WMS) ○ Web Feature Service (WFS) ○ Other map service ○ Other web service ○ Direct database access ○ File(s) for download ○ File(s) sent upon request ○ Non accessible ○ Other	SL			
pub_year	Year of publication	SL	Data_share	Is data shared with other web services? Ie. institutional, governmental	SL			
pub_type	Journal article, data paper, book, not published	SL	Data_georef	Is data georeferenced (yes/no)	SL			
file_name	Name of file(s)	SL	Data_geoco	What geocoordinate system is used? GIS? Google?	SL			
file_format	Xml, Microsoft access, smxl, txt…ect…	SL						
file_number	Number of files submitted	SL						

data_start_year	Start year of data collection	SL						
data_end_year	End year of data collection	SL						
data_ongoing	Ongoing (yes, no)	SL						
Data_country	Country where data was collected	SL						
Sample_size	Total sample size	CDWG						
sex	Male/female/both	CDWG						
Child_adult	Children/adults/both	CDWG						
Age_range_adult	Beginning age, ending age	CDWG						
Age_range_child	Beginning age, ending age	CDWG						
Sample_method	- Simple random - One stage stratified random - Multistage stratified random - Multistage cluster sample - Multistage stratified cluster sample - other	CDWG						

Sample_pop	Sample population: national provincial community *Criteria for determining study population: • National: data are from study that is designed to be nationally representative. • Subnational: study covers multiple communities, e.g. > 3 cities OR > 5 villages OR one or more provinces or states. • Community: study had limited geographical scope; applies to all studies not national or subnational.	CDWG						
Sample_country	List all	CDWG						
Sample_province	List all	CDWG						

Sample_region	List all	CDWG						
Sample_city	List all	CDWG						
scope	Urban/rural/both	CDWG						

1			**2**		
Category	**Description**	**Source**	**Category**	**Description**	**Source**
Di_samplesize	Total population number with dietary intake data		Di_child_age	Age of children with dietary intake, as a range	
Di_method	Dietary intake method (ffq, 24h, dds, hdds, fvs)		Di_adult_age	Age of adults with dietary intake, as a range	
Repeat_no	Number of times survey was repeated (0 – 4)		Di_child_no	Number of children with dietary intake surveys	
Season	Period : 1 – 4 Jan – Mar, Apr – June, July-Sept, Oct - Dec		Di_adult_no	Number of adults iwht dietary intake surveys	
Bi_samplesize	Number of items with botanical names	CB	Di_male	Number of males	
Bi_method	Method of botanical sampling (personal observation, informant, voucher specimen)	CB	Di_female	Number of females	
Nutritional_analysis	Yes/no	CB	acquisition	Was acquisition documented? (ie. wild, cultivated, foraged, purchased…)	CB
Scientific_names	Yes/no	CB	use	Was use documented?(food, medicinal, social, food additive)	CB
Vernacular_names	Yes/no	CB	preparation	Were details on	CB

				preparation included? (boiled, roasted, fried, mixed, raw…etc…)	
Taxonomic_info	Cultivar/variety/assession number/ wild/ breeding clone/ breed/ underutilized	FAO	Specific part	Were details on part of plant/animal used included? (stem, root, leaves…etc)	
SW = Swedish LifeWatch, CDWG = Global Burden of Metabolitic Risk Factors of Chronic Diseases Working Group at Imperial College, FAO = FAO food Composition database for Biodiversity, CB = Cook Book, Economic Botany Data Collection Standards					

Annex V

Institution	Lead Researcher	Publication	Description of work
University of Montreal	Malek Batal	Robidoux M.A., Imbeault P., Blais J.M., Pal S., Seabert T., Krümmel E., Batal M. and Haman F. (2012) Traditional Foodways in Two Contemporary Northern First Nations Communities. CANADIAN JOURNAL OF NATIVE STUDIES Vol. 32 Robidoux M.A., Haman F., Blais J.M., Pal S., Seabert T., Krümmel E.M., Batal M, Thériault A., and Imbeault P. (2009) An examination of land-based dietary practices in 2 northern First Nations communities and their potential contribution to the reduction of obesity and type 2 diabetes. APPLIED PHYSIOLOGY, NUTRITION, AND METABOLISM. Vol. 34(2): pp. 255-256. Batal M, Gray-Donald K, Kuhnlein HV, and Receveur O. (2005) Estimation of Traditional Food Intake in Indigenous Communities in Denendeh and the Yukon. INTERNATIONAL JOURNAL OF CIRCUMPOLAR HEALTH. Vol. 64(1) pp. 46-54.	Methodology for studies in Lebanon and in First Nations were similar – first they carried an ethnobotanical survey, then followed with FFQ and 24hr recall. For Lebanon a local group interested in promoting local foods took up the task of catering the survey and events. The Nature conservation center at the University of Beirut/ American University used local informants to survey the local species and do an ethnobotanical classification system. This group created an illustrated in color document on local foods - identifying foods down to variety/cultivar, including common names. There were several common names and they did a pre-survey procuration of common names.
Medical Research Council (MRC)	Mieke Faber	INDIGENOUS AND TRADITIONAL PLANTS: SOUTH AFRICAN PARENTS' KNOWLEDGE, PERCEPTIONS AND USES AND	This study determined the seasonal availability and dietary intake of β-carotene-rich vegetables and fruit in a rural South African community growing these crops at household level. Monitoring year-round availability of vegetables and fruit in five local shops during 2004 showed that β-carotene-rich vegetables and fruit

		THEIR CHILDREN'S SENSORY ACCEPTANCE. Seasonal availability and dietary intake of beta-carotene-rich vegetables and fruit of 2-year-old to 5-year-old children in a rural South African setting growing these crops at household level. HOME GARDENS FOCUSING ON THE PRODUCTION OF YELLOW AND DARK-GREEN LEAFY VEGETABLES INCREASE THE SERUM RETINOL CONCENTRATIONS OF 2-5-Y-OLD CHILDREN IN SOUTH AFRICA.	were seldom available in the shops. The dietary intake of 2-year-old to 5-year-old children was determined during February, May, August and November in 2004 and 2005 using an unquantified food frequency questionnaire and 5-day repeated 24-h recall (2005 only). The children's habitual intake of specific food items, especially animal products and fruit and vegetables that are rich in provitamin A, was determined by a questionnaire administered to their caregivers. The frequency of the children's consumption of prespecified food items during the past month was recorded; the participants had a choice of 5 options: 1) every day, 2) most days (not every day but ≥4 d/wk), 3) once a week (<4 d/wk but ≥1 d/wk), 4) seldom (<1 d/wk), and 5) never.
North West University South Africa	Marinka van der Hoeven	INDIGENOUS AND TRADITIONAL PLANTS: SOUTH AFRICAN PARENTS' KNOWLEDGE, PERCEPTIONS AND USES AND THEIR CHILDREN'S SENSORY ACCEPTANCE.	Parents (n = 29) responsible for food preparation for children in grade 2 to 4 in two schools were purposively selected for four focus group discussions. A sensory evaluation assessed the children's (n = 98) acceptance of, preference for and intended consumption of dishes made with leafy vegetables. The dishes were made of AMARANTHUS SPP., CLEOME GYNANDRA, CUCURBITA MAXIMA, VIGNA UNGUICULATA and BETA VULGARIS.
Uppsala University Sweden	Britta M. Ogle	Legacy of the chameleon: edible wild plants in the Kingdom of Swaziland, Southern Africa: a cultural, ecological, nutritional study. Part II-Demographics, species availability and dietary use, analyses by ecological zone.	From a nutrition viewpoint it is important to pay attention to this group of traditional foods for several reasons. Their direct nutritional contribution is often significant but neglected. Very little is known about the health benefits of regular consumption of small quantities of medicinal foods and an important

	Britta M. Ogle, Ho Thi Tuyet, Hoang Nghia Duyet, Nguyen Nhut Xuan Dung	FOOD, FEED OR MEDICINE: THE MULTIPLE FUNCTIONS OF EDIBLE WILD PLANTS IN VIETNAM	"medicinal role" of traditional plant medicines may be the contribution of small quantities of trace minerals and vitamins. The parallel functions as livestock feeds make animal products more accessible to poor households and help improve the quality of their diets.
Center for Indigenous Peoples Nutrition and Environment (CINE) at McGill University	Harriet Kuhnlein	Animal food diversity in Indigenous Peoples' food systems. In: Proceedings: Asia and Pacific Symposium on Sustainable Diets: Human Nutrition and Livestock. Food and Agriculture Organization of the United Nations and Ministry of Industry and Agriculture of Mongolia, Ulaanbaatar.) Biodiversity and sustainability of Indigenous Peoples' Foods and Diets. In: Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. Canadian Arctic Indigenous Peoples, traditional food systems and POPs.	Dietary data were collected during 2 seasons in 3 major dietary surveys of adults and a study of Dene children residing in Yukon and Northwest Territories (NWT) communities as described earlier (8–11). For this article, data from 24-h food intake recalls and frequency interviews, comprised of lists of traditional food (TF) species, were derived from these studies. Community meetings were conducted to create complete food lists of species currently known and used and to develop lists of species and their consumed parts, which were incorporated into frequency interviews for each cultural group. Daily intake from 24-h recall data was dichotomized into the TF and MF. Over 100 species of wildlife animals, fish, and plant foods were known and used by populations in each cultural group. Species are distributed in 5 TF groups, with those often consumed by adults in the study regions (**Table 1**). The most frequently consumed animal species were caribou (R. TARANDUS) and moose (A. ALCES), and the most important fish were whitefish (COREGONIS sp.), salmon (ONCHORHYNCHUS sp.), char (S. ALPINUS), and trout (SALVELINUS sp.). Muskox (OVIBOS MOSCHATUS), several birds, and other fish were also shown to be important. Although many plant species were known and appreciated, they were infrequently consumed (<0.1 d/wk as seasonal average). An exception is the seasonal use of cloudberry and crowberry (RUBUS CHAMAEMORUS, EMPETRUM NIGRUM) by Inuit.

			http://jn.nutrition.org/content/137/4/1110.full?related-urls=yes&legid=nutrition;137/4/1110
University of Kent	Rory McBurney	The nutritional composition of African Wild Food Plants, from Compilation to Utilisation. African Wild Harvest: Linking the Fields of Botany, Nutrition, Relief and Development Plant Resources of Tropical Africa.	Data recycling in Food Composition data – a history of Food composition related to African wild food plants McBurney may have done/ or be doing data collection in connection with Kent
Bioversity International	Gudrun Keding	Consumption of Traditional and exotic vegetables and their perceived and real contributions to nutritional health in Tanzania	176 women were interviewed on their eating habits using a seven-day-recall. Additionally, they were checked for their nutritional health status (i.e., vitamin A deficiency measured as low retinol-binding protein). The traditional vegetables mainly consumed were dark green leaves, which are good sources of vitamin A. In all districts, traditional vegetables were eaten in higher numbers and greater diversity than exotic vegetables.
Bioversity International Ghent University	Celine Termote	A Biodiverse Rich Environment does Not Contribute to a Better Diet. A Case Study from DRCongo Eating from the Wild: Turumbu Indigenous Knowledge on Noncultivated Edible Plants, Tshopo District, DRCongo	This study measured the contribution of wild edible plants (WEP) to the dietary quality in the high biodiverse context of DR Congo. The habitual dietary intake was estimated from 2 multiple-pass 24 h dietary recalls for 363 urban and 129 rural women. All WEP were collected during previous ethnobotanical investigations and identified and deposited in the National Botanical Garden of Belgium (BR). The focus group in Yaoseko counted 6 men and 1 woman; these totaled 6/2 and 8/2 in Yasekwe and Yalungu, respectively. During the first session in each village, we asked participants to enumerate all “wild” plants they know and use as food (“free listing”;\ Cotton 1996). Plant names were recorded in their native language Turumbu and per village a list of WEPs was compiled. In each village, all species mentioned on the list were collected during field trips with the key informants (“Walks in the Wood”; sensu

			Alexiades 1996) to constitute a reference herbarium collection.
Centre for International Forestry Research, McGill University	Bronwen Powell	Powell, B, R Bezner-Kerr, SL Young and T Johns. (forthcoming) The importance of biodiversity for dietary diversity and nutrition: perspectives from the East Usambara Mountains, Tanzania Powell, B, K Gray-Donald, A Herforth, M Oluoch , J Msuya and T Johns. (submitted). Children's dietary diversity, energy and nutrient intake, and mean adequacy ratio (MAR) and the context of a rural Tanzanian diet. Powell, B, J Hall, H and T Johns. 2011. Effects of Forest Cover and Use on Dietary Intake in the East Usambara Mountains, Tanzania. International Forestry Review 13(3):305-317. Vinceti, B, A Ickowitz, B Powell, K Kehlenbeck, C Termote, B Cogill and D Hunter. 2013. The contributions of forest foods to sustainable diets. Unasylva 241: 64. Powell, B, R Bezner-Kerr, S Young and T Johns. 2013. The importance of biodiversity for dietary diversity and nutrition: perspectives of small-scale farmers in rural Tanzania. Oral presentation at the AFHVS / ASFS 2013 Conference: Toward Sustainable Foodscapes and Landscapes. June 19 to 23, 2013. Michigan State University, East Lansing, MI, USA.	

World Agroforestry Centre Kenyatta University	Parnwell Simitu, Ramni Jamnadass, ɔeland Kindt, J Kimiyw ɪngu	CONSUMPTION OF DRYLAND INDIGENOUS FRUITS TO IMPROVE LIVELIHOODS IN KENYA: THE CASE O MWINGI DISTRICT	A structured questionnaire was used to interview 104 household members, equally distributed among women, men, girls, and boys. Fifty-seven species were documented as useful to local people. Average fruit consumption per person per day of these species was low at around 20 g http://outputs.worldagroforestry.org/record/4802/files/MM08428.pdf
INSTITUT DE L'ENVIRONNEMENT ET RECHERCH AGRICOLE Tougan, Burkina Faso	Lamien, N., Lingani-Coulibaly, P., Traore-Gue, J. 2009	Importance of local fruits consumption in diet balance in Burkina Faso, West Africa	The contribution of local fruits (LF) consumed as snack food was assessed. The study consisted of recording the daily consumption of LF as snacks in 270 households from October 2005 to June 2006. The chemical composition of the LF found during the survey was recorded from literature. Taking into account their nutritional values, our findings show that LFs play a pivotal role in balancing the diets in rural areas. The LFs contribute to satisfying the human body's need for proteins, lipids, sugars, minerals and mainly vitamins which are generally found in non-cooked foods. It can be concluded that many deficiency diseases in Burkina Faso have been probably avoided through LFs consumption as snack foods.
Kenyatta University, Department of Foods, Nutrition and Dietetics	Judith Kimiywe Judith Waudo,Dorcus Mbith' and Patrick Maundu	Utilization and Medicinal Value of Indigenous Leafy Vegetables Consumed in Urban and Peri-Urban Nairobi	24-hour recall and 7-day food frequency http://www.bioline.org.br/request?nd07032
Kenyatta University, Department of Food, Nutrition and Dietetic Bioversity Int	BN Ekesa, J Kimiywe, MW Davey, C Dhuique-Mayer, I Van den Berg, D Karamura, G Blomme	Banana and plantain (Musa spp.) cultivar preference, local processing techniques and consumption patterns in Eastern Democratic Republic of Congo.	http://oaji.net/articles/30-1394266950.pdf A 24hour diet recall on all the food that had been consumed by the households indicated that 64 - 67% of all respondents had consumed EAHB cooking varieties within the last 24 hrs

Helen Keller International, Cambodia and Asia-Pacific Regional Office, Phnom Penh, Cambodia	Talukder, A.,	'Homestead food production model contributes to improved household food security and nutrition status',	http://www.bioversityinternational.org/fileadmin/user_upload/online_library/publications/pdfs/CS7_Diversifying_diets_using_agricultural_biodiversity.pdf To diversify production systems, the HFP programme encourages the conservation of indigenous varieties of fruits and vegetables (de Pee et al., 2010), particularly underutilized species, and the introduction of micronutrient-rich species from similar agro-ecosystems to complement and improve increased intake of a wide range of nutrients. Improved local breeds of poultry are promoted as animal-source foods in addition to fish. more than ten infrequently cultivated indigenous varieties of vegetables and fruits. These include varieties of mint (Menthasp.), black arum (Xanthosoma atroviren),kangkong (Ipomoea aquatica), pigeon pea (Cajanus cajan, drumsticksMoringa oleifera), helencha (Enhydra fluctuans) Thankuni pata (Centella asiatica neem (Azadirachta indica), basil (Ocimum.),countrybean (Lablab niger), cowpea (Vigna), taro (Colocasia esculenta, and coriander (Coriandrum sativum).
Helen Keller International, Jakarta Pusat, Indonesia.	de Pee S, Bloem MW, Satoto, Yip R, Sukaton A, Tjiong R, Shrimpton R, Muhilal, Kodyat B.	IMPACT OF A SOCIAL MARKETING CAMPAIGN PROMOTING DARK-GREEN LEAFY VEGETABLES AND EGGS IN CENTRAL JAVA, INDONESIA.	a social marketing campaign promoting eggs and dark-green leafy vegetables was initiated in March 1996. The nutritional surveillance system (December 1995-December 1996) found the following. The campaign's messages were well noticed. Consumption of at least one egg in the past week increased from 80% to 92% in mothers and from 78% to 92% in children 12-36 months old. It increased in all socio-economic groups and was

		REAPPRAISAL OF THE ROLE OF VEGETABLES IN THE VITAMIN A STATUS OF MOTHERS IN CENTRAL JAVA, INDONESIA	independent of ownership of chickens. Most eggs had been purchased. The quantity of vegetables prepared increased from 93 to 111 g/person daily and most was purchased. A nutrition surveillance system in Central Java, Indonesia, assessed the vitamin A intake and serum retinol concentration of women with a child < or =24 mo old with a semiquantitative 24-h recall method that categorized vitamin A-containing foods into 3 categories of plant foods and into 2 categories of animal foods and identified portions as small, medium, or large.
Department of Preventive Medicine, Nagoya University School of Medicine.	Suzuki S	CHANGES IN SERUM CONCENTRATIONS OF BETA-CAROTENE AND CHANGES IN THE DIETARY INTAKE FREQUENCY OF GREEN-YELLOW VEGETABLES AMONG HEALTHY MALE INHABITANTS OF JAPAN.	A POSITIVE ASSOCIATION WAS FOUND TO EXIST BETWEEN CHANGES IN THE INTAKE FREQUENCY OF GREEN-YELLOW VEGETABLES AND CHANGES IN SERUM BETA-CAROTENE LEVELS, WHEREAS CHANGES IN ALCOHOL INTAKE AND SMOKING WERE DISCOVERED TO BE NEGATIVELY ASSOCIATED WITH CHANGES IN SERUM BETA-CAROTENE LEVELS. THE POSITIVE ASSOCIATION BETWEEN CHANGES IN THE INTAKE FREQUENCY OF GREEN-YELLOW CHANGES IN SERUM CONCENTRATIONS OF BETA-CAROTENE AND CHANGES IN THE DIETARY INTAKE FREQUENCY OF GREEN-YELLOW VEGETABLES AMONG HEALTHY MALE INHABITANTS OF JAPAN. vegetables and changes in serum beta-carotene levels was preserved after adjustment for these negative factors.
Akershus University College, Lillestrøm, Norway	L E Torheim	NUTRIENT ADEQUACY AND DIETARY DIVERSITY IN RURAL MALI: ASSOCIATION AND DETERMINANTS	CROSS-SECTIONAL STUDY ASSESSING FOOD INTAKE BY A VALIDATED 7-DAY QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE. TWO DIFFERENT DIETARY DIVERSITY INDEXES WERE CREATED: FOOD VARIETY SCORE (FVS), A SIMPLE COUNT OF FOOD ITEMS, AND DIET DIVERSITY SCORE (DDS)

			A COUNT OF FOOD GROUPS
Ghent University, Belgium	Chai Zhou	FOOD SECURITY AND THE CONTRIBUTION OF WILD FOODS TO DIETS, NUTRITION AT THREE VILLAGES OF SINHARAJA FOREST IN SRI LANKA	HOUSEHOLD SURVEYS WERE CARRIED OUT TO UNDERSTAND THE SOCIO-ECONOMIC INFORMATION PROVIDED BY THE PARTICIPANTS. DIETARY INTAKE WAS ASSESSED BY USING A 24-H FOOD RECALL ON 2 NON-CONSECUTIVE DAYS. DIETARY DIVERSITY WAS MEASURED BY A 7-DAYS FOOD FREQUENCY QUESTIONNAIRE. THE PARTICIPANTS' HEALTH STATUS WAS MEASURED BY ANTHROPOMETRIC MEASUREMENTS. QUESTIONNAIRES WERE CONDUCTED TO UNDERSTAND PARTICIPANTS' PERCEPTION AND KNOWLEDGE ABOUT WILD FOODS. THE CONTRIBUTION OF WILD FOOD TO DIET WAS ASSESSED THROUGH A 24-H FOOD RECALL.
Ghent University, Belgium	Daniela Penafiel	NONE	DATA FROM ECUADOR, 24 HR RECALL IN 430 INDIVIDUALS
Ghent University, Belgium Bioversity International	Margaret Bechem	CONTRIBUTION OF LOCAL BIODIVERSITY TO COMPLEMENTARY FEEDING PRACTICES OF CHILDREN (12-23 MONTHS) IN THE NORTH WEST REGION OF CAMEROON	A SURVEY WAS DONE WITH 125-MOTHER CHILD PAIRS FROM THREE VILLAGES IN BATIBO USING A QUESTIONNAIRE WHICH COMPRISED OF THREE PARTS: THE *PROPAN* CHILD FEEDING MANUAL, TWO 24-HOUR RECALLS AND PERCEPTION AND CONSUMPTION OF INDIGENOUS FOODS. Some micronutrient rich wild edible plants (WEPs) were consumed by the children but these too less frequently and in very small amounts. "Eru" (*Gnetum africanum*) and "bitterleaf" (*Vernonia amydalina)* are rich in folate (105mg/100g and 113mg/100g respectively) and "njansa" (*Ricinodendron heudelotti*) is rich in calcium (639mg/100g).

Ghent University, Belgium Bioversity International	Boedecker, Julia	Dietary contribution of Wild Edible Plants to women's diets in Benin – an underutilized potential	A SURVEY WAS CARRIED OUT WITH 120 WOMEN, COVERING WEP KNOWLEDGE AND PERCEPTIONS WITH TWO NON-CONSECUTIVE 24-HOUR RECALLS DURING THE LONG DRY SEASON. THE CONTRIBUTION OF WEPS TO TOTAL DIETARY INTAKE WAS SMALL DUE TO LOW CONSUMPTION FREQUENCY AND SMALL PORTION SIZES
Nutrition Research Institute, University of North Carolina at Chapel Hill, Kannapoli	Sara E. Schaefer	SOURCES OF FOOD AFFECT DIETARY ADEQUACY OF INUIT WOMEN OF CHILDBEARING AGE IN ARCTIC CANADA http://www.bioline.org.br/request?hn11057	THIS CROSS-SECTIONAL STUDY WAS CONDUCTED AMONG THREE REMOTE COMMUNITIES IN THE KITIKMEOT REGION (FIG.) OF NUNAVUT, THE EASTERNMOST OF THREE TERRITORIES IN ARCTIC CANADA. OF A POPULATION OF APPROXIMATELY 30,000, ~85% SELF-IDENTIFY AS INUIT. INUKTITUT AND INUINNAQTUN ARE THE LOCAL LANGUAGES. WITH A MEDIAN AGE OF 23 YEARS, NUNAVUT HAS THE YOUNGEST POPULATION OF ANY PROVINCE OR TERRITORY IN CANADA Dietary data were collected during June–October 2008 using an interviewer-administered, culturally-appropriate quantitative food-frequency questionnaire (QFFQ) developed specifically for Inuit in Nunavut (23). The QFFQ was designed using single 24-hour recalls (n=87) to capture all foods/beverages typically consumed, including traditional foods not available in stores and those available seasonally.
Book Indigenous peoples food systems: the many dimensions of culture, diversity and environment for nutrition and health - 2009	Bhattacharjee, L.	The Bhil food system: links to food security, nutrition and health	HTTP://WWW.CABDIRECT.ORG/ABSTRACTS/20093209337.HTML;JSESSIONID=D06E83FD0752C35ED2339BF827EF141C?FREEVIEW=TRUE Employing community-based participatory research methods, the Bhil traditional food system was documented, pointing to the use

			of 94 foods - including a variety of plants, small domestic animals and local fish - with preparation and processing methods unique to the Bhil culture. Dietary assessments showed that for children and mothers the percentage of energy from local cultivated and wild indigenous foods was 68 percent for children and 59 percent for women.
Centre for Indigenous Peoples' Nutrition and Environment and School of Dietetics and Human Nutrition, McGill University, Macdonald Campus, Ste-Anne-de-Bellevue, Québec, H9X 3V9 Canada	Louise Johnson-Down and Grace M. Egeland	ADEQUATE NUTRIENT INTAKES ARE ASSOCIATED WITH TRADITIONAL FOOD CONSUMPTION IN NUNAVUT INUIT CHILDREN AGED 3–5 YEARS	DIETARY HABITS AMONG ARCTIC PRESCHOOLERS ARE UNKNOWN. A CROSS-SECTIONAL HEALTH SURVEY OF 388 INUIT, AGED 3–5 Y, WAS CONDUCTED IN 16 COMMUNITIES IN CANADA'S NUNAVUT TERRITORY. TWENTY-FOUR–HOUR RECALL AND FFQ WITH PARENTS AND PRIMARY CAREGIVERS QUANTIFIED DIET FROM MARKET AND TRADITIONAL FOODS (TF).
Groupe d'études en nutrition publique, Département des sciences des aliments et de nutrition, Université Laval, Québec, Canada Centre de recherche du Centre hospitalier universitaire de Québec and Université Laval, Québec, Canada	Doris Gagné, Rosanne Blanchet, and Huguette Turgeon O'Brien	TRADITIONAL FOOD CONSUMPTION IS ASSOCIATED WITH HIGHER NUTRIENT INTAKES IN INUIT CHILDREN ATTENDING CHILDCARE CENTRES IN NUNAVIK	DIETARY INTAKES OF CHILDREN WERE ASSESSED WITH A SINGLE 24-HOUR RECALL (N=217). TF CONSUMPTION AT HOME AND AT THE CHILDCARE CENTRES WAS COMPARED. DIFFERENCES IN CHILDREN'S NUTRIENT INTAKES WHEN CONSUMING OR NOT CONSUMING AT LEAST 1 TF ITEM WERE EXAMINED USING ANCOVA. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3417681/#__ffn_sectitle
Center for Indigenous Peoples Nutrition and Environment (CINE) at McGill University	Various Book: Indigenous Peoples' food systems: the many	Englberger, L., Lorens, A., Levendusky, A., Pedrus, P., Albert, K., Hagilmai, W., Paul, Y., Nelber, D., Moses, P., Shaeffer, S. & Gallen, M. 2009. Documentation of the traditional food system of Pohnpei. In H.V. Kuhnlein, B. Erasmus and D. Spigelski.	

	dimensions of culture, diversity and environment for nutrition and health,	Iwasaki-Goodman, M., Ishii, S. & Kaizawa, T. 2009. Traditional food systems of Indigenous Peoples: the Ainu in the Saru River region, Japan Salomeyesudas, B., Kuhnlein, H.V., Schmid, M.A., Satheesh, P.V. & Egeland, G.M. 2013. The Dalit food system and maternal and child health in Andhra Pradesh, South India. Correal, C., Zuluaga, G., Madrigal, L., Caicedo, S. & Plotkin, M. 2009. Ingano traditional food and health: phase 1, 2004–2005. In H.V. Kuhnlein, B. Erasmus and D. Spigelski. Okeke, E.C., Ene-Obong, H.N., Uzuegbunam, A.O., Ozioko, A., Umeh, S.I. & Chukwuone, N. 2009. The Igbo traditional food system documented in four states in Southern Nigeria. In H.V. Kuhnlein, B. Erasmus and D. Spigelski. Creed-Kanashiro H, M Roche, I Tuesta Cerron and HV Kuhnlein (2009) Traditional Food System of an Awajun Community in Peru. In: Kuhnlein HV, B Erasmus and D Spigelski. Indigenous Peoples' Food Systems: the Many Dimensions of Culture, Diversity and Environment for Nutrition and Health. pp	

		59–81. United Nations Food and Agriculture Organization, Rome. Egeland GM, G Charbonneau-Roberts, J Kuluguqtuq, J Kilabuk, L Okalik, R Soueida and HV Kuhnlein (2009) Back to the Future: Using Traditional Food and Knowledge to Promote a Healthy Future among Inuit. In: Kuhnlein HV, B Erasmus and D Spigelski. Indigenous Peoples' Food Systems: the Many Dimensions of Culture, Diversity and Environment for Nutrition and Health. pp 9–22. United Nations Food and Agriculture Organization, Rome.	
Centre for Indigenous Peoples' Nutrition and Environment (CINE), McGill University, Macdonald Campus, 21 111 Lakeshore Road, Ste. Anne de Bellevue, Quebec, Canada, H9X 3V9 School of Dietetics and Human Nutrition, McGill University, Montreal, Canada Instituto de Investigación Nutricional (IIN), Lima, Peru	ML ROCHE, HM CREED-KANASHIRO, I TUESTA AND HV KUHNLEIN	Traditional food system provides dietary quality for the Awajún in the Peruvian Amazon	FROM MARCH TO APRIL 2004, TWO STANDARDISED 24-HOUR DIETARY RECALLS WERE OBTAINED FROM EACH OF 49 MOTHERS AND 34 CHILDREN WITH A SEPARATION OF 3–4 DAYS BETWEEN REPEAT RECALLS[13]. THE INTERVIEWERS WERE TRAINED AND THEY WERE ASSISTED BY AN AWAJÚN INTERPRETER. TO IMPROVE QUALITY OF DIETARY RECALLS[14], SEVERAL SAMPLES OF CASSAVA (Manihot esculenta), sachapapa (Dioscorea trifida), BANANAS AND PLANTAINS WITH KNOWN WEIGHTS WERE USED AS REFERENCES DURING INTERVIEWS. Dietary recall data were reviewed and checked for accuracy, and food codes were added that corresponded to the Instituto de Investigación Nutricional (IIN) food composition table of (raw) Peruvian foods. With respect to the vitamin A content of foods, the Peruvian food composition table used retinol equivalents (RE) at the time of this study; 11 food items were added from other tables using the international literature for food composition[15–18]. Information from the Peruvian food

		Infant and young child feeding in the Peruvian Amazon:the need to promote exclusive breastfeeding and nutrient-dense traditional complementary foods	composition tables or the nutrient labels was taken at the time of the study for the small number of foods imported into these communities. http://journals.cambridge.org/action/displayFulltext?type=6&fid=1828276&jid=PHN&volumeId=11&issueId=05&aid=1828272&bodyId=&membershipNumber=&societyETOCSession=&fulltextType=RA&fileId=S1368980007000560 Traditional foods provided 85% of energy and were more nutrient dense than market foods The study objective was to understand the role of traditional Awajún foods in dietary quality and the potential impacts on growth of Awajún infants and young children 0–23 months of age. Research took place in April and May of 2004, along the Cenepa River in sixAwajún communities.Anthropometry estimated nutritional status for 32 infants (0–23 months). Repeat dietary recalls and infant feeding histories were completed with 32 mothers.

Annex VI

Contact Name	Institute affiliation	Contact email address
Dr. Schmidt-Kloiber	BioFresh	astrid.schmidt-kloiber@boku.ac.at
Mary Arimond	UC Davis	marimond@ucdavis.edu
Grace Marquis	McGill University	grace.marquis@mcgill.ca
William Milliken	KEW	m.milliken@rbkew.org.uk
Mark Nesbit	KEW	M.Nesbitt@rbgkew.org.uk
Ben Scott	NHM London	b.scott@nhm.ac.uk
Jessica Fanzo	Columbia - Bioversity	jf671@columbia.edu
Alex Hardisty	Cardiff - Informatics	Alex.Hardisty@cs.cardiff.ac.uk
Anne-Marie Wremp	Swedish LifeWatch	anna-maria.wremp@slu.se
Dr Aline Van der Werf	Biodiversity Platform BE	contact@biodiversity.be
Aaike de Wever	Ghent University	aaike.dewever@naturalsciences.be>
Malek Batal	University of Montreal	malek.batal@umontreal.ca
Mieke Faber	University of Pretoria - MRC	mieke.faber@mrc.ac.za
Britta Ogle	Uppsala University Sweden	britta.ogle@ibutv.slu.se
Harriet Kuhnlein	Mcgill University	harriet.kuhnlein@mcgill.ca
Chris Golden	Harvard School of Public Health	chrisgolden05@gmail.com

Annex VI

Acronyms

API - Application Programming Interface

EUROFIR - European Food Information Resource

FAO INFOODS - Food and Agriculture Organization - International Network of Food Data Systems

GBIF - Global Biodiversity Information Facility

KEW - Royal Botanical Gardens, London

MOBOT - Missouri Botanical Garden

NHM - Natural History Museum, London

TNRS - Taxonomical Names Resolutions Service

UGENT - Ghent University Belgium

VRE - Virtual Research Environment

WAC - World Agroforestry Center