Forests and trees on farm in/for sustainable diets

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1. Introduction

1.1 Background and problem statement

• 2010: 925 million people estimated to be undernourished
• 30 % undernourished people in Africa
• ‘hidden hunger’ = micronutrient deficiencies: 2 billion people

• only 30 plant species provide 95% of energy and protein needs in the world
• 30,000 of the 250,000 – 270,000 plants formally described have been collected or cultivated by humans for food
• many of them remain underutilized, although they may have excellent nutritional characteristics
1. Introduction

1.2 Sustainable diet

- can endure or be continued over a long period of time
- will promote good health and ideal weight and prevent chronic disease throughout your life
- conserves and regenerates natural resources
- reduces greenhouse gas emissions
- preserves (agro)biodiversity
- promotes access to healthy food and clean water and optimal health and well-being for all people
1. Introduction

opposed to that an **UNsustainable diet**
- comes from an unsustainable, poor food-choice diet
- is **devoid of nutrients** and filled with too much processed food, meat, fat, and sugar and not enough fruits and vegetables
- **harms planetary health**
- degrades our soil, pollutes our water, adds greenhouse gases to our atmosphere, liberally uses finite resources and energy, and contributes substantially to climate change
- **is a threat to (agro)biodiversity**
- **promotes access to healthy food and clean water and optimal health and well-being for all people**
1. Introduction

1.3 Agrobiodiversity is a vital sub-set of biodiversity: many people’s food and livelihood security depend on the sustained management of various biological resources (both within and outside of their agrarian production systems) that are important for food and agriculture.
1. Introduction

**agrobiodiversity** -consists of ...

- **harvested** crop varieties, livestock breeds, fish species and non domesticated (wild) resources **within field, forest, rangeland** including tree products, wild animals hunted for food and in aquatic ecosystems (e.g. wild fish);
- **non-harvested** species in production ecosystems that **support food provision**, including soil micro-biota, pollinators and other insects such as bees, butterflies, earthworms, greenflies; and
- **non-harvested** species in the wider environment that **support food production ecosystems** (agricultural, pastoral, forest and aquatic ecosystems).
1. Introduction

- in Burkina Faso, and throughout the West African Sahel, rural women carefully collect the fruit, leaves and roots of native plants such as the baobab tree (*Adansonia digitata*), red sorrel leaves (*Hibiscus saderifa*), kapok leaves (*Ceiba pentandra*) and tigernut tubers (*Cyperus esculentus* L.) for use in the families’ diet. These supplement the agricultural grains (millet, sorghum) that provide only one part of the nutritional spectrum and may fail in any given year; more than 800 species of edible wild plants have thus been catalogued across the Sahel.
distinctive features of *agrobiodiversity*, compared to other components of biodiversity (FAO):

- agrobiodiversity is *actively managed* by male and female farmers;
- many components of agrobiodiversity would *not survive* without this human interference; local knowledge and culture are integral parts of agrobiodiversity management;
- many economically important agricultural systems are based on ‘alien’ crop or livestock species introduced from elsewhere (for example, horticultural production systems or Friesian cows in Africa). This creates a high degree of interdependence between countries for the genetic resources on which our food systems are based;
- as regards crop diversity, *diversity within species* is at least as important as *diversity between species*;
- because of the degree of human management, *conservation of agrobiodiversity* in production systems is inherently *linked to sustainable use* - preservation through establishing protected areas is less relevant (also see Raebild *et al*., 2011); and
- in industrial-type agricultural systems, much crop diversity is now held *ex situ* in gene banks or breeders’ materials rather than on-farm.
1. Introduction

Agrobiodiversity can (adapted from Thrupp, 1997):

* increase productivity, food security, and economic returns
* reduce pressure of agriculture on fragile areas, forests and endangered species
* make farming systems more stable, robust, and sustainable
* contribute to sound pest and disease management
* conserve soil and increase natural soil fertility and health
* contribute to sustainable intensification
* diversify products and income opportunities
* reduce or spread risks to individuals and nations
* help maximize effective use of resources and the environment
* reduce dependency on external inputs
* improve human nutrition and provide sources of medicines and vitamins, and
* conserve ecosystem structure and stability of species diversity.
1. Introduction

- food varieties extinction/decrease in agrobiodiversity is happening all over the world—and it's happening fast
  - in the USA, an estimated 90% of the historic fruit and vegetable varieties have vanished; of the 7,000 apple varieties that were grown in the 1800s, fewer than a hundred remain now
  - in the Philippines, thousands of varieties of rice once thrived (see Banaue: picture) now only up to a hundred are still grown
1. Introduction

- food varieties **extinction/decrease** in agrobiodiversity is happening all over the world—and it's happening fast
  - in *China*, 90 percent of the wheat varieties cultivated just a century ago have disappeared
  - experts estimate that we have lost more than half of the world's food varieties over the past century (due to *inter alia* population pressure...)

[Map showing global distribution of food varieties and population density]
although I will further concentrate on wild plant diversity, some of the reasoning also applies to agro-biodiversity in general...
1. Introduction

• Convention on Biological Diversity (CBD, 1992) stresses the importance of agricultural biodiversity for food security and natural resource conservation: ‘Conservation through use’ principle

• evidence is still circumstantial, but: many authors argue that it is compelling to assume that increased agricultural and forest biological diversity leads to a more varied (and sustainable ?!) diet, which in turn improves specific overall health outcomes
1. Introduction

• a crisis is looming: to feed our growing population, we’ll need to substantially increase/double food production.

• yet, crop yields aren’t increasing fast enough, and climate change and new diseases threaten the limited varieties we’ve come to depend on for food.

• luckily we still have the seeds and breeds to ensure our future food supply—but we must take steps to save them...
2. The role of biodiversity

- however: it is still unclear how wild biodiversity actually contributes to the nutrition and livelihoods of the poor (cf. review Peñafiel et al., 2011)
2. The role of biodiversity

2.1 Biodiversity, nutrition and sustainable diets

assumption: diets based on local, wild foods/biodiversity are healthy, but

• what is the evidence?
• what is the contribution of local foods to diets and nutrition?
• how can local diets be promoted?
2. The role of biodiversity

biodiversity, nutrition and sustainable diets

**assumption**: diets based on local, wild foods/biodiversity are healthy, but

- what is the evidence?
- what is the contribution of local foods to diets and nutrition?
- how can local diets be promoted?
Agricultural biodiversity provides goods with: (1) option value (Brush et al., 1992; Rao & Evenson, 1998); (2) direct use value (Johns & Sthapit, 2004); and (3) exploration value (Wilson, 1988). The services offered by agricultural biodiversity can also be categorized into three values: (1) option value (Swanson, 1996); (2) direct use value (Smale, 2006); and (3) indirect use value (Hajjar et al., 2007).
in low- and middle-income countries: evidence of positive associations of dietary diversity with

- food security ([Hoddinott and Yohannes 2002](#))
- nutrient adequacy ([Ruel 2003](#)), and
- improved nutritional status ([Hoddinott and Yohannes 2002](#))
2. The role of biodiversity

Poor nutrition in various forms occurs in all countries around the world. Malnutrition can result from a lack or excess of certain nutrients, or nutrients in the wrong proportions.
2. The role of biodiversity

biodiversity, nutrition and sustainable diets

**Assumption:** diets based on local, wild foods/biodiversity are healthy, but

- what is the evidence?
- what is the contribution of local foods to diets and nutrition?
- how can local diets be promoted?
2. The role of biodiversity

2.2 Contribution to local diets from biodiversity

- method: systematic literature review
- using ten on-line scientific data bases in the systematic search for IF-journal articles
- keywords “food OR diet OR nutrition” AND “biodiversity”

result: articles (only 34 in total !) on energy and micronutrient intake, and dietary diversification
2. The role of biodiversity

Children

- diets with Food Variety Score (number of foods in the diets) of 23 and Dietary Diversity Scores (food groups diversity) of 6 are nutrient-adequate (Hatloy et al., 1998)
- agricultural biodiversity contributes with 48.5% to dietary diversity (Ekesa et al., 2008)
2. The role of biodiversity

Adults

- traditional foods (Kuhnlein et al. 2006; Roche et al. 2008), wild vegetables and local staples (Ogle et al. 2001) highly contribute to micronutrient intakes
2. The role of biodiversity

biodiversity, nutrition and sustainable diets

**Assumption:** diets based on local, wild foods/biodiversity are healthy, but

- what is the evidence?
- what is the contribution of local foods to diets and nutrition?
- how can local diets be promoted?
Biodiverse diets: what determines local food consumption?

- case study: indigenous group in Ecuador

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Severity</th>
<th>Susceptibility</th>
<th>Cues to Action</th>
<th>Self-Efficacy</th>
<th>Other Determinants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health benefit Nutrition</td>
<td>Economic benefit Easy access Low cost Revenues</td>
<td>Taste Different tastes Self-reliance Cultural significance</td>
<td>Availability and access Biodiversity loss Access to land Pest and Diseases Migration</td>
<td>Nutrition education School education Cooking classes Access to land Biodiversity conservation</td>
<td>Parental rules Junk food taste Convenience</td>
</tr>
</tbody>
</table>
Introduction

pressing public health issues, often co-existing in the same populations:

– acute malnutrition (wasting or thinness)
– chronic malnutrition (stunting or short stature)
– micronutrient malnutrition; and
– overweight and obesity
2. The role of biodiversity underlying causes of malnutrition, i.e.:
– lack of access to sufficient, high-quality, safe and acceptable food;
– deficient health environment; and
– inadequate childcare practices

continue to lead to high rates of (child) malnutrition, morbidity and mortality
2. The role of biodiversity

Biodiversity at three levels—ecosystems, the species they contain and the genetic diversity within species—can contribute to food security and improved nutrition (Toledo Burlingame,...)
2. The role of biodiversity - assumptions

- wild (plant/animal) species and intraspecies biodiversity have key roles in global food security
- different varieties/ecotypes/accessions/... have (statistically) different nutrient contents
- acquiring nutrient data on existing biodiversity is a prerequisite for development of new crops/speculations
- formal nutrient content data need to be among criteria in cultivar development/promotion
- nutrient data for wild foods and cultivars need to be systematically generated, centrally compiled and widely disseminated
- biodiversity questions and/or prompts need to be included in food consumption surveys
- acquiring nutrient data and intake data for varieties/types/... is essential in order to understand the impact of biodiversity on food security
2. **The role of biodiversity** *(Penafiel et al.)*

In general, locally available foods were found to be important sources of energy, micronutrients, and dietary diversification in the diet of rural and forest communities living in highly biodiverse ecosystems. Current evidence shows local food biodiversity as an important contributor to nutritious diets. Findings are, however, limited to populations living in highly biodiverse areas. Research on the contribution of biodiversity to diets of industrialized and urban settings needs more attention. More studies/instruments are needed that would measure the dietary contribution of local biodiversity.
All databases
On-line search
n = 28,365

Refine

Energy Intake
n = 1,356

Duplicates
n = 170

Articles
n = 1,186

Unrelated titles
n = 1,060

Abstract exclusion
n = 118

Full text articles
n = 8

No dietary assessment
n = 3

No biodiversity assessment
n = 1

Selected articles
n = 4

Total n = 34 *

Micronutrient
n = 413

Articles
n = 405

Unrelated titles
n = 320

Abstract exclusion
n = 72

Full text articles
n = 13

No dietary assessment
n = 3

No biodiversity assessment
n = 0

Selected articles
n = 10

Dietary Diversity
n = 1,275

Articles
n = 1,174

Unrelated titles
n = 1,068

Abstract exclusion
n = 89

Full text articles
n = 17

No dietary assessment
n = 5

No biodiversity assessment
n = 2

Selected articles
n = 10

Hand search
n = 13

*after deleting 3 duplicates
2. The role of biodiversity

underutilized crops have traditionally been used for food, fibre, fodder, oil, and medicinal plants. Their potential contribution to food security, nutrition, health, income generation, and ecosystem services for the well-being of mankind is still largely under-documented and under-exploited.
2. The role of biodiversity

the success of the upland NERICA in which resides genetic material of the underutilized and lesser cultivated but highly adapted stress-resistant African rice, Oryza glaberrima, provides an African success story for the promotion and use of underutilized species
2. The role of biodiversity

however, based on our own field research, it is our contention that...

use of underutilised species is indeed/still under-documented
and/but
actual use is probably over-rated and might be under pressure from westernised food habits
3. The Congo case...

DRCongo: facts and assumptions...

- 90 % of population is poor
- 70 % of population depends on the forest for daily life
- Congolese forests are the least known in Africa

⇒ HUGE KNOWLEDGE GAP
⇒ urgent need to revitalize DRC’s (agro-)forestry research
Tshopo District

- Hot and humid climate (Af)
- Annual rainfall: 1,800 mm
- Mean temperature: 23.5 °C
- Mixed moist semi-evergreen forests

- Surface: 197,657 km²
- 1,358,646 inhabitants
3. The Congo case...

Tshopo District

– has an enormous agricultural potential, but food security remains very precarious (± 1,750 kcal/day)

– some local NGOs assume that opportunities must exist to valorize local wild foods for better nutrition and health

– only fragmented information available about WEPs (incomplete, under-documented lists)

– presence of some interesting WEPs with good nutritional qualities: *Gnetum africanum, Treculia africana*, etc.
• **multidisciplinary study approach**

![Diagram showing interdisciplinary study approach]

- **Ethnobotany**
  - Livelihoods (income generation)
  - Local knowledge
  - Cultural identity

- **Nutrition**
  - Production–consumption links

- **Markets**

- **WEPs** (Worldwide Environmental Problems)
  - Food security
  - Cultural identity
Yalungu 54 species

Yasekwe 63 species

Yaoseko 77 species

Turumbu

Yaaleko 68 species

Olife 58 species

Mbole

Lefundelo 62 species

Bali

Bafwabula 59 species

Bavoy 71 species

Bafwambalu 63 species

Turumbu 85 species

Mbole 99 species

Bali 86 species
**Highest ranked fruits**

- Anonidium mannii
- Landolphia owariensis
- Tetracarpidium conophorum
- Panda oleosa
- Aframomum laurentii

**Highest ranked vegetables**

- Megaphrynium macrostachyum
- Talinum triangulare
- Scorodophloeus zenkeri
- Amaranthus dubius
3. The Congo case... WEPs in nutrition - methodology

- study area:
  - 6 municipalities in Kisangani city
  - Yaoseko: rural Turumbu village (34 km west to Kisangani)

- sample:
  - 241 adult women in Kisangani city, all ethnicities mixed (40 per municipality, 41 in Lubunga)
  - 129 Turumbu women in Yaoseko village
  - 122 Turumbu women in Kisangani city

- period of highest WEP availability (July-October)

- two multiple-pass 24h recalls per women

- some socio-economic characteristics

- food composition table

- lucille food analysis software – usual intakes via MSM
WEPs in nutrition – results and discussion

• diet mainly based on cassava tubers (71.8%; 79.9% and 98.8% of recalls in Kisangani, Turumbu city and Turumbu village samples resp.)

• in the city also some rice (62.6%; 45.9% and 5.1% of recalls)

• combined with cassava leaves (54.6%; 54.5% and 62.5% of recalls)

• caterpillars (19.5%; 31.5% and 23.1% of recalls)
**WEPs in nutrition – results and discussion**

- only 15 WEPs figured in a marginal number of recalls
  - 1 wild yam
  - 2 wild nuts
  - 4 wild leafy vegetables
  - 3 wild fruits
  - 5 wild spices

- safou, a native, underutilized fruit species was mentioned most frequently, but still... (4.0%; 6.4% and 30.1% of recalls)
<table>
<thead>
<tr>
<th>Food group</th>
<th>Kisangani city Energy (kcal)</th>
<th>% total energy</th>
<th>Turumbu city Energy (kcal)</th>
<th>% total energy</th>
<th>Turumbu village Energy (kcal)</th>
<th>% total energy</th>
<th>P²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>539.9 ± 210.9[^a]</td>
<td>25.0</td>
<td>355.2 ± 177.5[^b]</td>
<td>19.7</td>
<td>39.3 ± 81.6[^c]</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>383.4 ± 192.6[^a]</td>
<td>17.5</td>
<td>401.6 ± 168.5[^a]</td>
<td>22.3</td>
<td>847.7 ± 345[^b]</td>
<td>45.4</td>
<td>0</td>
</tr>
<tr>
<td>Wild yam</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Nuts &amp; pulses</td>
<td>170.5 ± 111.8[^a]</td>
<td>7.8</td>
<td>139.5 ± 164.7[^a]</td>
<td>7.7</td>
<td>19.1 ± 70.9[^b]</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>Wild nuts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Vegetables</td>
<td>61.2 ± 23.5[^a,b]</td>
<td>2.8</td>
<td>57.6 ± 25.4[^a]</td>
<td>3.1</td>
<td>62 ± 24.8[^b]</td>
<td>3.3</td>
<td>0.055</td>
</tr>
<tr>
<td>Wild vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.2 ± 7.5</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>39.8 ± 61.9[^a]</td>
<td>1.8</td>
<td>30 ± 49.5[^a]</td>
<td>1.7</td>
<td>95.8 ± 94.1[^b]</td>
<td>5.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Wild fruits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9 ± 40.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Safou</td>
<td>12.1 ± 51[^a]</td>
<td>0.6</td>
<td>11.7 ± 36.7[^a]</td>
<td>0.6</td>
<td>89.6 ± 107.2[^b]</td>
<td>4.8</td>
<td>0</td>
</tr>
<tr>
<td>Meat/Poultry/Offal</td>
<td>58.5 ± 93.6[^a]</td>
<td>2.7</td>
<td>32 ± 82.7[^b]</td>
<td>1.8</td>
<td>27.9 ± 33.7[^b]</td>
<td>1.5</td>
<td>0.0004</td>
</tr>
<tr>
<td>Bush meat fresh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.7 ± 27.6</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Smoked bush meat</td>
<td>17.7 ± 50.3</td>
<td>0.8</td>
<td>9.9 ± 26.2</td>
<td>0.6</td>
<td>19.9 ± 26</td>
<td>1.0</td>
<td>0.11</td>
</tr>
<tr>
<td>Fish and fish products</td>
<td>41.8 ± 35[^a]</td>
<td>1.9</td>
<td>30.7 ± 34.9[^b]</td>
<td>1.7</td>
<td>21 ± 23.2[^c]</td>
<td>1.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Milk/milk products</td>
<td>16.4 ± 40.1[^a]</td>
<td>0.8</td>
<td>11.6 ± 38.7[^a]</td>
<td>0.6</td>
<td>0.5 ± 3.8[^b]</td>
<td></td>
<td>0.0001</td>
</tr>
<tr>
<td>Oils and Fats</td>
<td>719.6 ± 196.1[^a]</td>
<td>33.0</td>
<td>623.8 ± 261.2[^b]</td>
<td>34.6</td>
<td>663.4 ± 236.4[^a,b]</td>
<td>35.5</td>
<td>0.0004</td>
</tr>
<tr>
<td>Sugars</td>
<td>101.9 ± 89.8[^a]</td>
<td>4.7</td>
<td>56.4 ± 72.7[^b]</td>
<td>3.1</td>
<td>29.4 ± 35.3[^c]</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>18.7 ± 30.6</td>
<td>0.9</td>
<td>16.9 ± 53.2</td>
<td>0.9</td>
<td>31.7 ± 84.4</td>
<td>1.7</td>
<td>0.054</td>
</tr>
<tr>
<td>Wild spices</td>
<td>0.2 ± 1.7</td>
<td>&lt;0.1%</td>
<td></td>
<td></td>
<td>0.4 ± 2.4</td>
<td>&lt;0.1%</td>
<td></td>
</tr>
<tr>
<td>Mushrooms</td>
<td>0.4 ± 1.9[^a]</td>
<td>&lt;0.1%</td>
<td>0.6 ± 2.8[^a,b]</td>
<td>&lt;0.1%</td>
<td>1.4 ± 3.7[^b]</td>
<td>0.1</td>
<td>0.0034</td>
</tr>
<tr>
<td>Caterpillars</td>
<td>13.5 ± 27.5</td>
<td>0.6</td>
<td>16.2 ± 19.1</td>
<td>0.9</td>
<td>14.9 ± 23.6</td>
<td>0.8</td>
<td>0.59</td>
</tr>
<tr>
<td>Nutrient</td>
<td>Kisangani (n=182)</td>
<td>% women under RDA²</td>
<td>Turumbu city (n=108)</td>
<td>% women under RDA²</td>
<td>Turumbu Yaoseko (n=80)</td>
<td>% women under RDA²</td>
<td>P³</td>
</tr>
<tr>
<td>---------------------------------</td>
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</tr>
<tr>
<td>Weight (g)</td>
<td>1039.64 ± 275.14ᵃ</td>
<td>872.35 ± 271.83ᵇ</td>
<td>1062.88 ± 354.48ᵃ</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>2102 ± 444.19ᵃ</td>
<td>1715.08 ± 599.57ᵇ</td>
<td>1779.37 ± 564.85ᵇ</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy density (kcal/100g)</td>
<td>205.47 ± 23.0ᵃ</td>
<td>196.13 ± 26.21ᵇ</td>
<td>169.34 ± 21.9ᶜ</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy from protein (%)</td>
<td>9.24 ± 2.13ᵃ</td>
<td>9.36 ± 2.1ᵃ</td>
<td>7.56 ± 1.98ᵇ</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Energy from lipids (%)</td>
<td>44.78 ± 5.42</td>
<td>46.19 ± 6.4</td>
<td>44.18 ± 8.06</td>
<td>0.0686</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total carbohydrate (g)⁴</td>
<td>260.79 ± 64.1ᵃ</td>
<td>211.71 ± 64.82ᵃ</td>
<td>241.62 ± 94.55ᵇ</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fibre (g)⁴</td>
<td>22.48 ± 8.73</td>
<td>17.59 ± 8.76</td>
<td>18.81 ± 7.56</td>
<td>0.4021</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (µg RE)⁴</td>
<td>4240.06 ± 898.37ᵃ</td>
<td>3886.47 ± 764.4ᵇ</td>
<td>4301.83 ± 768.44ᵇ</td>
<td>&lt;0.001</td>
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<tr>
<td>Vitamin C (mg)⁴</td>
<td>89.39 ± 23.46ᵃ</td>
<td>86.17 ± 29.34ᵇ</td>
<td>165.61 ± 74.22ᶜ</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Thiamine (mg)⁴</td>
<td>1.03 ± 0.27ᵃ</td>
<td>0.95 ± 0.36ᵇ</td>
<td>1.07 ± 0.41ᶜ</td>
<td>61.25 &lt;0.001</td>
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<tr>
<td>Riboflavin (mg)⁴</td>
<td>2.07 ± 0.73ᵃ</td>
<td>2.55 ± 1.88ᵇ</td>
<td>2.52 ± 2.02ᵇ</td>
<td>13.75 &lt;0.001</td>
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<tr>
<td>Niacin (mg)⁴</td>
<td>9.12 ± 2.87ᵃ</td>
<td>8.08 ± 3ᵇ</td>
<td>7.44 ± 2.76ᵃ</td>
<td>97.5 &lt;0.001</td>
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<tr>
<td>Vitamin B-6 (mg)⁴</td>
<td>1.73 ± 0.51ᵃ</td>
<td>1.55 ± 0.43ᵇ</td>
<td>2.40 ± 1.1ᶜ</td>
<td>21.25 &lt;0.001</td>
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<tr>
<td>Folate (µg)⁴</td>
<td>219.18 ± 58.84ᵃ</td>
<td>202.9 ± 65.88ᵇ</td>
<td>238.08 ± 86.34ᶜ</td>
<td>&lt;0.001</td>
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<tr>
<td>Vitamin B-12 (µg)⁴</td>
<td>1.44 ± 0.58ᵃ</td>
<td>1.28 ± 1.49ᵃ</td>
<td>87.03 0.6 ± 0.57ᵇ</td>
<td>97.5 &lt;0.001</td>
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<tr>
<td>Calcium (mg)⁴</td>
<td>406.23 ± 104.98ᵃ</td>
<td>384.87 ± 138.13ᵇ</td>
<td>541.91 ± 245.64ᶜ</td>
<td>&lt;0.001</td>
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<tr>
<td>Iron (mg)⁴</td>
<td>11.89 ± 3.67ᵃᵇ</td>
<td>8.93 ± 2.89ᵃ</td>
<td>10.42 ± 4.22ᵇ</td>
<td>100 0.0154</td>
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<tr>
<td>Zinc (mg)⁴</td>
<td>6.46 ± 2.1ᵃ</td>
<td>5.04 ± 1.8ᵃ</td>
<td>3.89 ± 1.9ᵇ</td>
<td>97.5 &lt;0.001</td>
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</tr>
</tbody>
</table>
**WEPs in nutrition – results and discussion**

- huge gap between knowledge and effective use of WEPs
- WEPs are insufficiently consumed to contribute to nutrition security
- urban nor rural people valorize their knowledge on WEPs to complement and ameliorate their diets
- despite they are not frequently used, there exists a lot of WEPs in the region with interesting nutritional characteristics such as
  - *Gnetum africanum; Treculia africana*; etc.
- women were eager to know more about WEPs and their health characteristics
- development of food-based dietary guidelines based on local foods and integrating WEPs
3. The Congo case... future research

• Ethnobotany
  – mapping of WEPs and preferences in other ethnic groups
  – local/folk classifications of plants and plant names
  – ethnographic research on ethnic groups living in Tshopo
  – vegetation studies
  – etc.

• WEP commercialization
  – value chain analysis of priority species
  – production calendar of species
  – consumer studies
  – conservation and processing techniques
  – participatory domestication, etc.
**Future research**

- WEPs and biodiversity in diets
  - nutritional values of priority species
  - research on actual and potential contributions of biodiversity to diets
  - further conceptualization of *food systems approaches* and links between biodiversity, dietary diversity and health outcomes

Successful interventions to support use of biodiversity for health are likely to be multi-sectoral, multidisciplinary, community-based and problem-focused.

The challenge is to address a problem for which the causes and consequences span culture, health, agriculture, markets and environment.
4. The Benin case: research question

How do Wild Edible Plants (WEPs) contribute to diets of women in the Lama Forest in Benin?
Methodology

• Participants: 120 adult women (non pregnant, non lactating)

• Period of research: long dry season

• Questionnaire
  1. Socio-economic information
  2. Information on WEPs
  3. Dietary intake: 24-hour recall
Results - WEPs

- 13 WEPs known on average (62 in total)
- WEPs considered as tasty, nutritious, healthy, important during difficult periods, affordable
- however: cultivated plants more popular than WEPs
- constraints: long cooking time, high perishability, selling difficulties
Results – WEPs found in 24-hour recalls

- 37% of recalls contain at least one WEP
- average WEP portion: 22 g
Struchium sparganophorum (L.) Kuntze (Asteraceae)
Results – contributions of WEPs to micronutrient intake

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>% women under RNI</th>
<th>WEP contribution to nutrient intake in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (μg RE)</td>
<td>0.00</td>
<td>0.69</td>
</tr>
<tr>
<td><strong>Vitamin C (mg)</strong></td>
<td><strong>35.97</strong></td>
<td><strong>8.12</strong></td>
</tr>
<tr>
<td>Vitamin D (μg)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>1.75</td>
<td>5.36</td>
</tr>
<tr>
<td><strong>Riboflavin (mg)</strong></td>
<td><strong>39.74</strong></td>
<td><strong>4.55</strong></td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>60.53</td>
<td>0.30</td>
</tr>
<tr>
<td>Vitamin B-6 (mg)</td>
<td>6.14</td>
<td>1.73</td>
</tr>
<tr>
<td><strong>Folate (μg)</strong></td>
<td><strong>40.35</strong></td>
<td><strong>1.68</strong></td>
</tr>
<tr>
<td>Vitamin B-12 (μg)</td>
<td>85.97</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Calcium (mg)</strong></td>
<td><strong>60.53</strong></td>
<td><strong>4.96</strong></td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>9.58</td>
<td>6.32</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>0.00</td>
<td>1.27</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>0.00</td>
<td>2.16</td>
</tr>
</tbody>
</table>
4. The Benin case - discussion

- only a small contribution of WEPs to diets
- BUT: potential to improve nutrient adequacy of 3 critical nutrients: riboflavin, calcium, vitamin C
- recommendation: guidance on WEP cultivation, use and commercialization
- strengths of the study: we have data on individual recipes, 2 recalls on non-consecutive days
- limitations of the study: missing nutrient values, neglect of bioavailability, reliance on respondent’s memory and honesty, seasonality
5. Overall conclusions

• there are numerous **indications** that biodiversity is important for food security (population growth, climate change, simplification of diets) – need to substantiate !!
• biggest challenge for food security: **provision of micronutrients**
• there is a potential for WEPS to help to improve micronutrient adequacy
• there is an **urgent need to further investigate potential of biodiversity**, including WEPs, to people’s diets
• under-researched/documented
• currently their position is over-estimated ?