EU-ACP NUS Project "Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa"

Report on the National Innovation Platform workshop on developing value chains of amaranth and Bambara groundnut in Benin

14-16 July 2014, Institut des Sciences Biomédicales Appliquées, Cotonou, Benin

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1. Introduction

In Benin, like in many other countries of West Africa, many of the plant species that are cultivated for food are neglected and underutilized while they play a crucial role in the food security, nutrition and income generation of the rural poor. While these crops continue to be maintained by cultural preferences and traditional practices, they remain inadequately characterised and neglected by research and conservation. Lack of attention has meant that their potential value is under-estimated and under-exploited. It also places them in danger of continued genetic erosion and disappearance which would further restrict development options for the poor. Many neglected and underutilized crop species (NUS) are nutritionally rich. Therefore, their erosion can have immediate consequences on the nutritional status and food security of the poor and their enhanced use can bring about better nutrition and fight hidden hunger.

Some neglected and underutilized crop species have many important medicinal properties beside their nutritional value and can be used as nutraceuticals. The semi-domesticated leafy vegetable *Crassocephalum* spp for instance has antibiotic, anti-helminthic, anti-inflammatory, anti-diabetic, anti-malarial and blood regulation properties and also treats indigestion, liver complaints, colds, intestinal worms, and hepatic insufficiency. Recent chemical analysis of leaves extract of this species revealed accordingly the presence of tannins, flavonoids, steroids, mucilage, reducing compounds, coumarins and the C-heterosids that are recognized as possessing pharmacological properties corresponding to the alleviation of many of the foregoing ailments.

Many NUS are adapted to difficult environments unfit for other crops where they can contribute to sustainable food production. Little has been done to identify the most effective means of commercialization, marketing and policy frameworks to promote their use and maximize their economic value. With regard to all these, conservation of, and research on, these NUS is needed for better maintenance of their resource base, to ensure their development and their sustainable use by present and future generations.

For the promotion of NUS to be a reality in Africa, a large cadre of well trained and motivated African agricultural scientists will have to play a critical role in providing farmers with a steady flow of new technologies (improved farming practices, newly developed varieties etc.). Unfortunately, because of decades of under-investment mainly in African regions, the human and institutional capacity required for research, marketing and knowledge sharing on NUS are weak or absent. Four years ago (2010) and in order to address this issue, RUFORUM (Regional Universities Forum for Capacity Building in Agriculture) in collaboration with Bioversity International, the International Foundation for Science (IFS), the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) and four universities/research institutes located in Benin, Ghana, Kenya and Malawi launched in 2010 a project entitled: **'Building human and institutional capacity for enhancing the conservation and use of Neglected and Underutilized Species of crops in West Africa, and Eastern and Southern Africa'**. This project has been successfully implemented and completed with various key recommendations among which the development of a strategic action plan to enhance NUS value chains for improving food and nutrition security, income of smallholder farmers and entrepreneurs and mitigation of, and adaptation to climatic, agronomic and economic risks. This includes:

- Strengthening of capacities for research, development, education on NUS value chain, and for communication of results to society
- Informing policy actors, research and education institutions on the roles and benefits of deploying NUS into strategies and programmes for agriculture, nutrition and adaptation to climate change

For these to be achieved, a new project focusing on Bambara groundnut (*Vigna subterranea*) and grain and leaf amaranth entitled **"Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa"** has been initiated and sponsored by EU-ACP. This project includes Benin, Kenya, Zimbabwe, IFS, Bioversity International and other partners. We report here the results of the first activity planned for Benin in the project which is the **National innovation platform workshop on developing value chains of amaranth and Bambara groundnut** held in Cotonou (Institut des Sciences Biomédicales Appliquées) from 14 to 16 July, 2014.

2. Importance of Bambara groundnut and amaranth

Bambara groundnut is a good source of Ca, K, Mg, P and Fe and this concentration in minerals indicates that it could be useful in the diets of consumers. One hundred grams edible portion of dried seeds of *Vigna subterranea* contain: water 10.3 g, energy 1537 kJ (367 kcal), protein 18.8 g, fat 6.2 g, carbohydrate 61.3 g, fibre 4.8 g and ash 3.4 g. The ranges (mg/100 g dry matter) of the macro minerals in Bambara groundnut are: Ca 37-128, K 1545-2200, Mg 159-335, Na 16-25, P 313-563. For the micro minerals (ppm): Cu 3.0-13.2, Fe 23.0-150 and Zn 13.9-77.0, β-carotene 10 μg, thiamin 0.47 mg, riboflavin 0.14 mg, niacin 1.8 mg and ascorbic acid traces. The content of essential amino acids per 100 g food is: tryptophan 192 mg, lysine 1141 mg, methionine 312 mg, phenylalanine 991 mg, threonine 617 mg, valine 937 mg, leucine 1385 mg and isoleucine 776 mg (Dansi et al. 2012). Bambara groundnut has the unique potential to provide solutions to health and hunger challenges and generate income and agriculture sustainability in developing countries in sub-Saharan Africa. It constitutes a major source of affordable protein, complex carbohydrates, essential micronutrients, dietary fibre, vitamin B, and antioxidants in the nutritionally challenged diets of both the rural and urban poor. Due to its adaptability to marginal production agroecologies and relatively high market value (1 to 2 US$ per kg), Bambara groundnut is extensively cultivated by resource-poor, smallholder farmers for both household food security and as cash crops. Moreover, it is valued by farmers for its contribution to soil fertility and health and compatibility with cereal and root crops in a cropping system.

Grain and leaf amaranth is the most commonly produced and consumed vegetable in West Africa, including in Benin where it is produced in the field, home and market gardens. It contributes greatly to household income, poverty alleviation and food security by virtue of its rapid productivity and all seasons' availability and the high biomass it generates in very short time. Reports from various studies indicated that grain and leaf amaranth are nutraceuticals that should be exploited. Amaranth has some bioactive peptides that have cancer-preventing and anti-inflammatory properties that protect against inflammation which accompanies several chronic health conditions such as diabetes, heart disease, and stroke. It also prevents cardiovascular disease being a good source of phytosterols, and healthy oil with significant

cholesterol (including LDL and triglycerides) lowering properties. Amaranth leaves have been found to contain some of the highest levels of beta-carotene and lutein. The protein in amaranth is among the most nutritious vegetable-based protein - especially good for children. Amaranth has a significant amount of lysine, an essential amino acid, which helps the body absorb calcium, build muscle, and produce energy. Amaranth is a high fibre food. This makes it filling and means it aids digestion, cholesterol levels, blood pressure, and slows the absorption of sugars to let the body to keep up with energy production. Amaranth is a very rich source of minerals like calcium, magnesium, and copper. It is also a good source of zinc, potassium, and phosphorus. These build strong bones and muscles, aid hydration, boost energy, and are vital in thousands of processes. Amaranth is also a good source of many essential vitamins including A, C, E, K, B5, B6, folate, niacin, and riboflavin. This act as antioxidants, raise energy, control hormones, and much more. Probably thanks to its vitamins, minerals, and antioxidants content, amaranth may boost immune function according to some studies. Some studies reported that amaranth is astringent, haemostatic, antidiarrheal, diuretic, alkalizing and anthelminthic.

With regard to these, Bambara groundnut and grain and leaf amaranth should become an important part of our diet. Therefore the development of their value chains is a great and urgent necessity and justifies their choice in this project.

3. Objectives of the workshop

The overall objective of the workshop was to identify value chain stakeholders and their roles and to report on constraints and opportunities that will guide the development of a national action plans for Bambara and amaranth value chains in Benin. Specifically, the workshop aimed at:

- Informing identified stockholders on the project objectives and activities
- Upgrading stakeholders' knowledge on the concept of value chains, the notion and the importance of neglected and underutilized species as well as bottlenecks of the promotion of their value chains.

- Sharing with participants the level of advancement of research on some neglected and underutilized species, mostly amaranth and Bambara groundnut, and the major research gaps that need to be filled for developing value chains of these two crops in Benin
- Examining with stakeholders the current status of the value chains of amaranth and Bambara groundnut in Benin and elsewhere and the possibility of their promotion through end various products.
- Organizing a mini-exhibition on the existing or newly developed end-products of amaranth and Bambara groundnut to share with, and sensitize food technology researchers and private sector entrepreneurs on possible ways to promote these two crops.

4. Preparation of the workshop and selection of participants

Based on the professional qualifications, experiences and/or the daily activities carried out in improving the value chains of crops in various national or private research and development institutions across Benin, 21 participants (Table 1) were selected and invited to participate in this workshop. These participants came from various institutions in Benin such as: the University of Abomey-Calavi and Parakou, National Institute of Agricultural Research (INRAB), Ministry of Agriculture and its decentralized structures and programmes (PPAAO/ WAAPP), private food processing enterprises, NGOs, International Institute of Tropical Agriculture (IITA), Bioversity International (Cotonou and Rome), IFS (Sweden) and Crops for the Future (Malaysia). They were also of different specialties (agronomy, socio-economy, food technology, genetics and breeding and biotechnology). Producer associations were also represented. For correct mapping of the actors to be invited, nominated participants were visited and interviewed in their respective working places across the country. Some documents on NUS, particularly the Accra statement[1] edited by Bioversity International have been shared with them. Key participants were then formally invited by the manager of the project in Benin.

[1] http://www.bioversityinternational.org/e-library/publications/detail/accra-statement-for-a-food-secure-africa/

Table 1: List of the participants

N°	Name of participants	Institution	Profession and responsibility	Phone number	E-mail
1	ADANDEDJAN Cyrille	Agrotechnic-AGT	Processor; Private sector		
2	ADETONAN Sounkoura	IITA- Bénin	Socio-economist	95068694	s.adetoh@cgiar.org
3	ADJATIN Arlette	LAAPT/FAST-DASSA	Biodiversity and nutrition specialist	97 44 07 98	aarlette2000@yahoo.fr
4	AFFOKPON Antoine	CRA-Sud/ INRAB niaouli	Agronomist and researcher on NUS	97 12 44 08	affokpona@gmail.com
5	AFORA Roger	Farm at Dassa	Responsible of the producers' association	94 91 51 44	
6	AGRE Paterne	FAST-DASSA	Plant Breeder	64 95 84 05	agrepaterne@yahoo.fr
7	ASSOGBA KOMLAN Françoise	PCM/INRAB	Responsible of vegetable programme. INRAB	95 05 41 05	fassogbakomlan@gmail.com
8	COULIBALY Ousmane	IITA-BENIN	Socio-economist	95068694	o.coulibaly@cgiar.org
9	DANSI A. Alexandre	FAST-DASSA	Plant breeder	97276598	adansi2001@gmail.com
10	FELDMAN Aryo	CFFRC	Plant breeder; Manager of Bambara program		Aryo.feldman@cffresearch.org
11	GBAGUIDI Anicet	FAST-DASSA	Researcher on Bambara groundnut	96916885	gbaguidianicet@yahoo.fr
12	HALL Richard	IFS, Sweden	Plant protection; Programme manager		Richard.hall@ifs.se; bladesandowls@gmail.com

13	HONFOGA Barthélémy	FSA/UAC	Socio-economist	97467097	honfoga@hotmail.com
14	HOUNKONNOU Dominique	Facilitator	Agronomist	97583938	dhouk2@yahoo.fr
15	KOUTON Armelle	BISKARA	Processor	975133 66	akouton@hotmail.com
16	LOKO Laura	LAAPT Dassa	Agricultural entomologist	97656000	lokoestelle@yahoo.fr
17	MENSAH Armel	PCM/INRAB	Agronomist; assistant at vegetable program	95 81 46 25	malconico2@gmail.com
18	NOUMAVO Pacôme	FAST-UAC	Agronomist	97 47 42 61	pacome.noumavo@yahoo.fr
19	OKE ASSOGBA Mylène	Entreprise Soleil Divin	Processor	94 43 66 02	mylnedagba@yahoo.fr
20	OROBIYI Azize	FAST-DASSA	Germplasm specialist	97 21 78 56	orobiyiazize@yahoo.fr
21	RUDEBJER Per	BIOVERSITY	Capacity building	+39 34 67 61 44 22	p.rudebjer@cgiar.org
22	SANOUSSI Faouziath	FAST-DASSA	Food technologist	96 27 99 41	sfaouth2000@yahoo.fr
23	TOVIHOUDJI Pierre	FA-UP	Agronomist, researcher on amaranth	96 00 59 50	pierretovihoudji@yahoo.fr
24	VODOUHE Sèna	GTA-EPAC	Food technologist	97 39 33 98 95 37 95 89	vodouhesena@yahoo.fr

5. Workshop Program

DAY ONE 14 July 2014		
Session I – Opening ceremony and General background on NUS in Benin and Sub-Saharan Africa (Chair: Facilitator)		
Time	**Activity**	**Responsible**
08.30-09.00	Arrival and Registration of the participants	**Mr Azize Orobiyi / Mr Paterne AGRE / Olive KPOMALEGNIN**
09.00-09.15	Introductions of the participants and presentation of the workshop program	Facilitator (M. Dominique Hounkonnou)
09.15-09.30	Welcome address and presentation of the objectives of the workshop	**Prof. Alexandre DANSI**
9.30 -9.45	Official opening address	**Ir. Virginie ASSOGBA MIGUEL** / National Coordinator of WAPP (**West African Agricultural Productivity Program**), Ministry of Agriculture
9.45 – 10.15	Group Photo and Coffee / Tea break	**Facilitator**
10.15 – 10.45	Achievements of, and lessons learned from, the first EU-ACP project on NUS in Benin "*Building human and institutional capacity for enhancing the conservation and use of Neglected and Underutilized Species of crops in West Africa, and Eastern and Southern Africa*"	**Dr ADJATIN Arlette**, Assistant Director, Laboratory of Agricultural Biodiversity and Tropical Plant Breeding (LAAPT-BIORAVE); Faculty of Science and Technology of Dassa
10.45-11.00	Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa: project background	**Mr Per Rudebjer**, Head, Knowledge Management and Capacity Strengthening, Bioversity International (Italy)
11.00 – 11.15	Food processing industries and the Valorisation of the Neglected and Underutilised Species	**Mr Cyrille ADANDÉDJAN;** food technologist / economic business man
11.15-11.45	Diversity of the Neglected and Underutilized Crop Species of Importance in Benin (*Findings of the national scoping study on NUS*)	**Dr Laura LOKO**. Researcher; LAAPT / FAST Dassa
11.45-12.05	Bioversity International and	**Dr Raymond VODOUHE**; Bioversity

	the Neglected and Underutilized Species (NUS)	International, Cotonou (Benin)
12.05 – 12.25	IFS and Opportunities for research on NUS	**Dr Richard Hall,** International Foundation for Science
12.25 -13.00	General discussion	**Facilitator**
13.00 – 14.00	**Lunch break**	**Mr Azize Orobiyi / Mr Paterne AGRE (**Organizing committee)
Session II. Understanding value chain analysis (Chair: Facilitator)		
14.00-14.30	Concept of value chain in agriculture	**Dr Ousmane COULIBALY.** International Institute of Tropical Agriculture, Benin
14.30 - 14.50	Value chain of Egussi, a neglected and underutilized seed vegetable in Benin	**Dr ADETONAN Sounkoura;** International Institute of Tropical Agriculture, Benin
14.50 – 15.05	Valorization of Baobab and Moringa in Benin and in the sub-region	**Dr Antoine AFFOKPON**, plant pathologist/nematologist, INRAB; Secretary IFS grantees' alumni
15.05 – 15.20	Model of a strategic action Plan for promotion of NUS value chain and Experiences of Zimbabwe and Malawi	**Mr Per Rudebjer**, Head, Knowledge Management and Capacity Strengthening, Bioversity International (Italy)
15.20 – 15.45	General Discussion	**Facilitator**
15.45 -16.00	Coffee / Tea break	**Mr Azize Orobiyi / Mr Paterne AGRE** (Organizing committee)
16.00 – 17.30	**Exhibition** of, and discussion on, products developed with Bambara groundnut; Baobab; vegetable amaranth, Crassocephalum and Moringa	**Presenters:** Prof Alexandre DANSI; Dr Sènan VODOUHE, Dr Arlette ADJATIN and Ms Faouziath SANOUSSI, Anicet GBAGUIDI **(invitation here of private sector)**

DAY TWO 15 July 2014		
Session I – Bambara groundnut and amaranth value chain (Chair: Facilitator)		
Time	**Activity**	**Responsible**
08.30-08.50	How can Bambara groundnut become a crop for the future	**Dr. Aryo Feldman;** Crops for the Future Research Centre (CFFRC) Malaysia
08.50-09.10	Nutritional value, Economic importance, Production constraints and possibilities of valorization of amaranth and Bambara groundnut in Benin	SANOUSSI Faouziath and TOVIOUDJI Pierre
09.10 – 09.30	Current status of Bambara groundnut value chain in Benin and Research priorities	GBAGUIDI Anicet; University of Abomey-Calavi
09.30 - 10.00	General Discussion	Facilitator
10.00 – 10:15	Coffee break	Mr Azize Orobiyi / Mr Paterne AGRE (Organizing committee)
10.00 – 10.15	Research on amaranth in Benin	Dr ASSOGBA-KOMLAN Françoise; National agricultural research institute
10.30-10.45	Improvement of amaranth production in the semi-arid zone of northern Benin through optimal management of water	AKPONIKPE Pierre; University of Parakou
10.45-11.05	Amaranth value chain in Benin and Research priorities	Dr Arlette ADJATIN; LAAPT (Faculty of Science and Technology of Dassa)
11.05-11.20	Influence of cultural practices on the nutritional and sanitary qualities of amaranth in Benin	Dr VODOUHE Sena, University of Abomey-Calavi
12.20 -13.00	General Discussion	Facilitator
13.00 – 14.00	Lunch break	Mr Azize Orobiyi / Mr Paterne AGRE (Organizing committee)
Session II. Developing strategic action plan (Chair: Facilitator)		
Group 1 (**Chair:** Hounkonnou Dominique)		Group 2 (**Chair**: Prof. HONFOGA Bathelemy)
14.00-16.15	Strategies for the development of Bambara groundnut value chain	Strategies for the development of Amaranth value chain
16.15-16.30	Coffee break	
16.30 – 17.00	Report back from groups 1 and discussion (plenary session)	
17.00 – 17.30	Report back from group 2 and discussion (plenary session)	

Day 3: 16 July 2014		
Session I. Developing strategic action plan and research topic for young scientists (Chair: Facilitator)		
	Group 1(**Chair**: Hounkonnou Dominique)	Group 2
8.00-10.00	Strategies for up scaling Bambara groundnut value chain (continued)	Strategies for up scaling amaranth value chain (continued)
10.00 – 10.15	Coffee break	
10.15 – 10.30	Report back from groups 1 and discussion	
10.30 – 11.00	Report back from group 2 and discussion	
11.00 – 13.00	Development of good research topics on Bambara groundnut for young scientists	Development of good research topics on amaranth for young scientists
13.00 – 14.00	Lunch break	
14.00 – 14.30	Report from group 1: topics identified and discussion	
14.30 – 15.00	Report from group 2: topics identified and discussion	
15 .00 – 16.00	Plenary session and workshop recommendations	
16.00 – 16.15	Coffee break	
16.15 – 17.00	**Closing ceremony and departure**	

6. Opening ceremony, introduction of participants and group photo

The opening session of the national workshop was chaired by the Director of the West African Agricultural Productivity Programme (Benin component), Mrs. Virginie ASSOGBA MIGUEL, representing the Ministry of Agriculture (Photos 1). This was done together with the Regional Coordinator of Bioversity International, Benin office, Dr. Raymond VODOUHE and the National Coordinator of the Project, Professor Alexandre DANSI, Dean of the Faculty of Science and Technology of Dassa and Director of LAAPT (Laboratory of Agricultural Biodiversity and Tropical Plant Breeding). Professor DANSI Alexandre first welcomed participants and highlighted the importance of neglected and underutilized species particularly Bambara groundnut and amaranth in food security and poverty and malnutrition alleviation in developing countries including Benin. He further expressed the need of joint efforts by different stakeholders to take these species from their current relatively low levels of exploitation and to promote their nutritional and economic potential. Finally he thanked the different partners (including Bioversity International and IFS) who continue to support efforts for the promotion and enhancement of use of NUS and promised to do all of his best for the achievement of the project objectives.

Mrs. Virginie ASSOGBA MIGUEL (Photo 2) underlined the importance of agriculture in Benin's economy and the importance of NUS in poverty reduction in rural communities. She highlighted the nutritional values of the neglected and underutilized species, especially Bambara groundnut and amaranth, which are well known in diet of Benin but undervalued. To finish, she expressed her great wish to see the workshop bringing out the suitable strategies to be developed for the promotion of amaranth and Bambara groundnut and the improvement of their value chains in Benin in the near future.

After this speech, the facilitator of the workshop, Dr Dominique Hounkonnou quickly presented the objectives of this project, which are to ensure food security and fight against malnutrition. He also presented the overall objective of this workshop that is to identify strategies for better use of resources of both species. He then presented the programme around which participants would exchange during the three days of reflection of the workshop. In his role of facilitator, he gave the floor to Dr. Raymond VODOUHE for his address.

In his message on behalf of Bioversity international, Dr Raymond VODOUHE emphasized the critical importance of this project in Benin's agriculture. He highlighted the reasons of the choice of target species in the project by focusing on these two crops' high nutritional value and their adaptability to marginal agro-ecological conditions and climate change (Photo 3).

Photo 1: Professor Alexandre DANSI welcoming participants

Photo 2: Message from Miguel ASSOGBA, PPAAO national coordinator and representative of the Ministry of Agriculture

Photo 3: Message from Dr. Raymond VODOUHE, Coordinator of Bioversity International Cotonou/Benin

Following this series of speeches, the facilitator asked participants to introduce themselves and this in a friendly atmosphere and style (full name, institutional affiliation, background). The ceremony was ended with a group photo (Photo 4) and a coffee break.

Photo 4: Group photo of participants at the national workshop

7. Presentations

After the coffee break, the Communication entitled **Achievement of, and lessons learned from, the first EU-ACP project on NUS in Benin** was presented by Dr. ADJATIN, Vice Director and projects and programme coordinator of LAAPT. The purpose of this presentation was to inform participants of the involvement of Benin in a former project similar to this project and to highlight its importance. She mentioned among other things capacity building of young researchers from different parts of Africa through practical training on various topics focusing on priority neglected species. Apart from lessons and recommendations learned from the previous project, this presentation reported on the number of countries involved, the number of researchers trained and the parallel actions performed by LAAPT to strengthen the project visibility.

After this brief overview of the project, the presentation of Per Rudebjer Head a.i., Knowledge Management & Capacity Strengthening Unit of Bioversity International followed entitled: "**Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa".** The speaker highlighted the constraints related to the management of neglected and underutilized species compared to major cultivated species. By briefly outlining the objectives of the new three year project, he expressed his wishes to see the results of this workshop as a real definition of strategies to boost the value chain of Bambara groundnut and amaranth in Benin.

In his presentations, Mr. ADANDEDJAN Cyrille, food technology entrepreneur and Manager of the Company named AGROTECHNIC, talked about the processing of local products in Benin and the difficulties encountered in the marketing of certain products. He also demonstrated among the range of these processed products his emphasis on neglected species, especially Bambara groundnut. According to him, traditionally, the Bambara groundnut cooking may take more than five hours, but due to the pre-cooking system of Bambara groundnut he developed and brought to market, the cooking takes only 30 minutes. After his presentation, the following questions were asked by the participants:

- Have physico-chemical analyses been performed on the end product to ensure its nutritional quality and safety to consumers?
- What is the shelf life of the product?
- What could be the consequences of pre-cooked Bambara groundnut consumption on consumers' health?

Mr. ADANDEDJAN Cyrille responded by saying that these tests are the next step he has planned to undertake in his approach before going forward on the national and international level of marketing of the products.

Dr. Laura LOKO then presented on the **Diversity of neglected and underutilized species in Benin**. In her presentation, the speaker listed with pictures the 41 neglected and underutilized species encountered in Benin according to Dansi et al. (2012). She explained the different methods used to prioritize the NUS identified in Benin in order to define the priority NUS that deserve more attention from research and development programmes.

Photo 5: Dr. Laura LOKO presenting the diversity of NUS in Benin

This presentation was followed Dr. Raymond VODOUHE who spoke on **'Bioversity International and the Neglected and Underutilized Species (NUS)'.** The speaker shared with participants what his institution does for the promotion and conservation of the NUS. From his presentation it is important to notice that the audience attention was focused on the fact that many of the Benin NUS remain wild species and uncultivated. However, the presenter highlighted the role that his institution plays on conservation and domestication of the NUS. Finally he encouraged and urged researchers from different institutions to invest more in NUS promotion so that these species' potential will be more exploited in the future.

Dr Richard Hall from IFS presented **"IFS and opportunities for research on NUS".** First of all, the orator introduced to the audience the IFS (International Foundation for Science) and the different opportunities offered by this foundation to researchers. Then he listed the important elements to consider when submitting a research proposal to IFS and some mistakes to avoid when drafting. It is on the note of information related to conditions of acceptability of projects submitted to the IFS that ended the morning session.

After lunch, participants successively attended the presentation of Dr. Ousmane Coulibaly and that of Dr Sounkoura ADETONAH, both socio-economists and value chain experts at the International Institute of Tropical Agriculture Cotonou/Benin. Their presentations focused respectively on "**Concept of value chain in agriculture**" and on "**The analysis of the value chain of *Egusi* (*Citrullus lanatus*) and the role of gender in southern Benin**". In their presentations, the speakers all emphasized the importance of the value chain for the promotion and the development of neglected and underutilized species. From Dr ADETONAH's talk, it was observed that the role of gender in the development of value chains is very important especially in rural communities.

After these presentations, the main questions focused on the need to know the difference between industry and value chain. In waiting to explore these concepts during the training workshops, communicators replied that all value chains represent the industry.

Dr. AFFOKPON Antoine researcher at the INRAB has then invited to present "**Promotion of Baobab and Moringa in Benin and in the sub-region**". In this part of presentation, the speaker mentioned that **Baobab and Moringa** were both neglected in the recent past. Then he focused the audience's attention on the fact that fortunately today, the development of the value chain, these species are advancing at both national and international level through various products. It will be important to follow the example of these two species to develop the value chain of Bambara groundnut and amaranth which are also rich in nutrients just like Baobab and Moringa.

The last presentation of the day was that of Per RUDEBJER who shared the results obtained in Zimbabwe and Kenya as part of the completion of the workshop. In his presentation he also shared the results obtained in other countries such as Peru and Colombia.

Each presentation was followed by a recorded discussion. The coffee break of the afternoon was coupled with the exhibition of some end-products produced using neglected and underutilized species, particularly Bambara groundnut and amaranth.

The aim of this exhibition was to share with participants the diversity of food products developed by the LAAPT laboratory using Bambara groundnut and amaranth as well as to

show products commonly developed by private companies using NUS. It also provided the opportunity to taste different products and discuss the acceptability of new products and promotion or improvement of the various products in order to popularize them at the national, regional and international markets. The exhibition was introduced by Professor Alexandre DANSI (Photo6). Various amaranth-based end-products were displayed:

- Amaranth Powder
- Kangen water with amaranth
- Yoghurt and dèguê enriched with amaranth
- Amaranth tea, amaranth tea with lemongrass, amaranth tea with mint
- Cake enriched with amaranth powder
- Biscuits enriched with amaranth powder,

Products derived from Bambara groundnut were:

- Precooked Bambara groundnut of high quality
- Cakes enriched with Bambara groundnut,
- Biscuits enriched with Bambara groundnut,

Some products are combinations of several NUS. These were:

- Cakes and biscuits enriched with Bambara groundnut and amaranth powder,
- Granulated flour "aklui" of Bambara groundnut enriched with baobab

Other products such as Gbolo obtained from the dried leaves of *Crassocephalum* spp, one of the priority neglected and underutilized species of the previous project, Moringa flour, bébénutri biscuits, Baobab syrup and mango nectar were also exhibited.

During the visit of the stands, each processor or promoter was pleased to present the products he/she had developed and the methodology of the processing (Photos 7 and 8). The promoter of biscuits Bébénutri, Mrs Kouton, usually uses products other than NUS. She expanded her innovation to the use of the NUS and had, by the end of the workshop, developed a specific biscuit Bébénutri enriched with amaranth powder to better help fight child malnutrition.

Photos 6: Presentation of the stand of exhibition of products from the NUS

Photos 7: Presentation of precooked Bambara groundnut by the promoter Mr. ADANDEDJAN

Photos 8: presentation of products from Bambara groundnut and amaranth

Day two

The second day began with a recap of the different activities and discussion of the first day by the facilitator. This was followed by various presentations that focused much more on the Bambara groundnut and amaranth. The first presentation entitled "How Can Bambara be a future crop" was that of Dr. Feldman ARYO of Crops for the Future. In his presentation he showed the nutritional importance of Bambara groundnut (rich in minerals, vitamins and proteins) and its agronomic importance by focusing on its ability to adapt to drought areas and climate change. In addition, the speaker talked about his institution and their research on Bambara groundnut which still remains a neglected crop.

The audience thanked the presenter and explored possible partnership opportunities with his research institution for Benin, similar to the existing ones with Ghana and South Africa.

The presentation of Mr. GBAGUIDI Anicet, researcher on grain legumes at the Faculty of Science and Technology of Dassa, focused on the current status of Bambara groundnut in

Benin. In his presentation he showed the different varieties of Bambara groundnut encountered in Benin which are grouped into 18 types (morphotypes). He also presented the constraints of Bambara groundnut production, including insect pests, the problems of seed storage and seed rots in the fields due to excess of moisture. The speaker also talked about the different local products derived from Bambara groundnut in Benin and pointed out that the processing still remains traditional before suggesting the importance of developing the value chain of Bambara groundnut to promote its rational and efficient use. He finally made recommendations among which were: the development of a fact sheet on the production of Bambara groundnut in Benin and documentation of indigenous knowledge and taboos associated with the consumption of Bambara groundnut including the possibility of anti-nutrient content that represent strategic avenues of research to be undertaken to better understand the plant in the Benin context.

He also suggested the introduction in Benin of varieties of Bambara groundnut meeting the criterion of consumer preference (less time of cooking) and the development of a potential market for Bambara groundnut.

Mrs. Faouziath SANOUSSI, Researcher in food technology at the Faculty of Science and Technology of Dassa presented the topic entitled “Nutritional value, economic importance and potential for enhancing the value of amaranth and Bambara groundnut in Benin”. Initially, the speaker reported on the food and nutritional importance of Bambara groundnut and amaranth, namely their richness in micronutrients and amino acids and their economic importance (contribution to household income, vendors and producers). She also highlighted that the production of amaranth is facing many constraints such as pest attacks, lack of quality seeds, and non-mastering of farming practices by producers. Then she insisted that no institution is involved in the production of seeds of amaranth and Bambara groundnut and that the seeds system of these species is still traditional. From this situation, the value chain is still at the embryonic stage. To finish his presentation, the speaker listed the various local products traditionally obtained from amaranth and Bambara groundnut and other various ways of potentially to promoting these two species.

The activities pursued by the communication of Dr. Françoise ASSOGBA KOMLAN, Researcher at INRAB, on "Review of research activities carried out in Benin on amaranth." In her presentation, she emphasized the achievement of important activities of research on

farming practices, identification and management of pests of amaranth, seed multiplication, variety selection and fertilization. However, she noted that much remains to be done to make amaranth a valuable crop. According to her, to improve the value chain of amaranth, special measures should be taken to alleviate problems such as:

- Lack of high yielding varieties
- Attacks of insects
- Problems of post-harvest conservation.

In his comment after the presentation, Mr. Rudebjer mentioned that it is the demand that justifies the organization of value chains and indicated that consumers are a very important link that should not be ignored in the value chains.

Following this intervention, the facilitator invited Mr. Pierre TOVIHOUDJI Research Assistant at the University of Parakou to share with the audience his innovations on irrigation systems of amaranth in dryland areas of Benin based on the topic "**Improvement of amaranth production in the semi-arid zone of northern Benin through optimal management of water**." Here the presenter showed the importance of amaranth in the dryland areas of Benin. However he noted that the production in these areas is facing water shortage. To remedy this situation, different irrigation techniques (sprinkler, the drop method, watering can and irrigation by capillary) were experimented on amaranth. This allowed the research team to conclude that it is the capillary irrigation system which is more interesting for the rational water management.

Dr. Senan VODOUHE then presented the topic on "Influences of cultural practices and cooking methods on nutritional and health qualities of *Amaranthus cruentus* in southern Benin." During her presentation she talked about the cultural practices and physico-chemical analysis of amaranth leaves which confirmed the wealth of minerals.

One of the workshop participants had suggested to the audience that the management and mastering of the perishability of amaranth, lack of certified seeds, identifying criteria for consumer preference, the search for quality products derived from amaranth should be considered for a more effective promotion of amaranth in Benin. Also, the use of chemical fertilizers for amaranth production in market gardens leads some consumers to be reluctant to

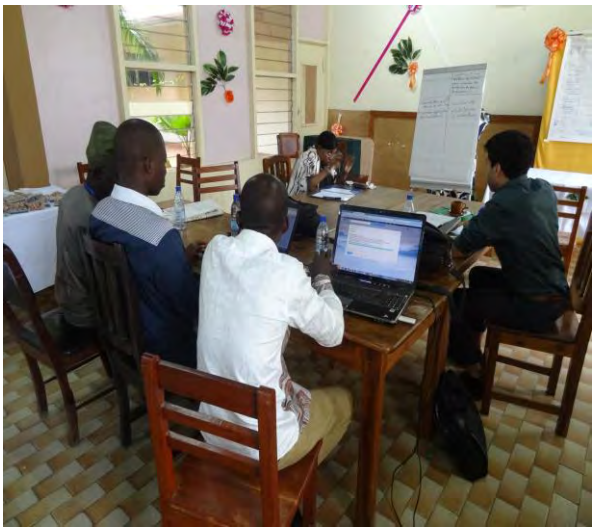
consume this vegetable. For this reason it will be important to promote organic farming while controlling cultural practices.

The presentations were completed in the morning with that of Dr ADJATIN who gave an overview of the value chain of amaranth in Benin. After a brief introduction showing the interspecific diversity of amaranth, highlighting species of amaranth with seed availability in Benin and which, by their high nutritional value, could be food complements to traditional cereals, she presented the mapping of the value chain of amaranth in Benin which can be reduced to three links: producers, traders and consumers - input suppliers and processors being almost nonexistent. The constraints identified from the SWOT analysis were used to propose strategies, activities and action plans that will ensure the development of production and diversification of end-products of amaranth for domestic and international markets.

These presentations were followed by group works that took place in the afternoon after lunch. From the various presentations on both Bambara groundnut and amaranth that showed their nutritional importance, it is clear that it is important to work out strategies to develop the value chain of these neglected and underutilized species. To do this, the workshop participants were invited to register for the crop of their choice, amaranth or Bambara groundnut.

In each group (Photos 9), participants were asked to debate on two major points A and B. Part A is devoted to identifying the constraints of different components of the value chain of Bambara groundnut and amaranth and propose solutions. Part B is to identify opportunities and propose actions to improve the value chain. The objective of this work is to identify the constraints of different parts of the value chain and propose solutions to these constraints in order to bring out existing opportunities and actions to be undertaken.

Photos 9: Discussion within the amaranth working group



Photos 10: Discussion within the Bambara groundnut working group

Day three

Groups continued their work in the third day and came out with identified constraints and proposition of solutions. The results are presented in the following tables (2, 3, 4, 5):

Table 2: Constraints and corresponding solutions for amaranth

Category	Value chain constraint	Solutions
1. Consumer demand/market access	Available varieties do not match consumers' preferences (odour, perishability, susceptibility to pests, etc.)	- Determination of criteria of consumer preference - Introduction of improved varieties that meet consumer preferences
	Lack of sufficient end-products developed from food technology	- Development of new products for the market - Promotion of the newly developed products through participatory approach and network involving various stakeholders
	Reduced availability and fluctuations of price during dry season.	- Test of various irrigation systems (pump, water retention, sprinkler, watering can) - Development of aeroponic culture
2. Input supply: seeds, fertilizers, pesticides, etc.	Lack of quality seeds	- Establishment of a viable system for clean seeds production and distribution - Creation of community seed banks

	Lack of safe pesticides to combat pests	- Supply of pesticides is recommended - Promotion of biological control
	Overuse of chemical fertilizers	- Development of Natural or organic fertilizers suitable for amaranth and other vegetables production - Training and education on the best practices of fertilizer application
3. Agronomy, technology, production development	Ignorance of amaranth varietal diversity in Benin	- Germplasm survey, documentation and collection in different agro ecology - Morphological and Molecular Characterization and evaluation of the collected local varieties
	Lack of improved varieties	- Introduction and creation of improved varieties meeting the preferences of consumers and producers
	Attack of pests and diseases	- Development of an integrated approach for protection against pests and diseases
	Presence of pesticide, nitrates and heavy metals residues in the vegetable	- Promotion of organic farming practices -Training and education on the best practices of fertilization
	Lack of knowledge of the nutritional values of species of amaranth	Conduct nutritional assessment and chemical screening of various species of amaranth
	Inadequate processing technologies	Development of various and new food products derived from amaranth
4. Organization & management	Lack of a platform of stakeholders of the amaranth industry	Creation of a platform of stakeholders of the amaranth industry
	Low use of amaranth in the case studies of school programs	Strengthening the use of amaranth nutritional and nutraceutical value in the curricula of primary, secondary and university programs
	Lack of inputs distribution networks	Establishment of networks for input distribution
	Limited access to lands for production	Provide farmers with lands and water system for intensive production
	Lack of strategy of promotion and marketing	Development of strategy of promotion and marketing
	Difficult access to production areas	- Construction and repair of access roads to production areas
5. Regulatory aspects and policy	Non-existence of governmental strategies and policies to accompany the sector	Development of governmental strategies and policies to accompany the sector
	Non-existence of standards for the control of the derived products	Development of legislations for the control of the derived end-products

Tableau 2: Opportunities & actions needed for amaranth group

Category	Value chain opportunity	Actions needed
1. Consumer demand/market access	Existence of strong demand	- Increase Production - Strengthening of the processing chain
	Existence of market	- Development and promotion of derived products - Creation of relationships between the various stakeholders
2. Input supply: seeds, fertilizers, pesticides, etc.	Availability of stakeholders (producers, distributors, etc.)	- Implementation of platform - Training and education on the best practices of fertilization and plant-care treatment
	Existence of inputs distribution institutions	Distribution of specific inputs
	Existence of high demand of seeds	- Establishment of a seed production system - Creation of community seed banks -Training of seed producers
3. Agronomy, technology, production development	Availability of skilled human resources	capacity building of human resources
	Existence of varietal diversity	selection and breeding of varieties
	Existence of processing institutions and the possibility of diversification of derived products	- Technological innovation in processing - Training in good hygiene practices (GHP), packaging practices and HACCP (Hazard Analysis and Control Critical Point) control
	Existence of organic vegetable consumers	- Documentary research on existing production techniques - Promotion of organic and sustainable agriculture - Training in good agricultural practices
	Existence of research institutions	research and training
	Existence of low-cost irrigation systems	- Adaptation of existing irrigation systems to produce amaranth - Training and awareness of gardeners on the use of irrigation systems -Awareness of market gardeners on the quality of water to be used - Wastewater Recycling
4.Organisation & management	Existence of the industry stakeholders	- Creation of a platform for stakeholders in the amaranth industry - Training of stakeholders
4. Regulatory aspects and policy	Existence and flexibility of teaching units in home economics and school gardens in the study programs	Reinforcement of the use of the amaranth in the case studies of the school syllabus
	Existence of agencies and communication channels	Promotion and marketing of derived products

From the group works, the following 21 research topics emerged, that could serve as basis for research proposals:

1. Diagnostic study on the preference criteria of amaranth consumers
2. Development of a business model for the promotion and marketing of amaranth derived products
3. Market and acceptability study of amaranth-derived products
4. Study of the amaranth traditional seed system in Benin
5. Ethnobotanical investigation and collection of amaranth species in Benin
6. Agromorphological characterization of amaranth species and varieties in Benin
7. Molecular characterization of amaranth species and varieties in Benin
8. Analysis of the nutritional values of the amaranth species and varieties in Benin
9. Phytochemical screening of amaranth species in Benin
10. Evaluation of elites varieties of amaranth in different agro-ecological zones of Benin
11. Selection of improved amaranth varieties for food security and poverty alleviation in Benin
12. Evaluation of the agronomic performances of introduced varieties of amaranth in Benin
13. Effect of different drying technologies and types of packaging on the quality of amaranth powder and shelf life of derivatives
14. Designation of advanced equipment and processing techniques for processing amaranth in powder
15. Assessment of pest diversity of amaranth across zones Benin
16. Mapping amaranth diseases and pathogenic agents in Benin
17. Identification of plants with insecticidal effects and their effectiveness on amaranth pests
18. Identification of plants with nematicidal effects and their effectiveness on amaranth nematodes
19. Identify plants with fungicidal effects and their effectiveness on the amaranth soil born fungi
20. Effect of different types of organic fertilizers on the productivity of amaranth
21. Study of the economic and financial profitability of the integrated approach developed methods of integrated control

Table 3: Constraints and corresponding solutions for Bambara groundnut

Types	Value chain opportunity	Solutions
1. Consumer demand, market access	Presence of anti-nutritional substances (Indigestion, sore hip, Infertility etc.)	- Documentation on consumer perceptions - Identification of anti-nutritional substances responsible for various ailments - Creation of varieties with low concentration of anti-nutrients
	Long cooking time	- Identification of traditional varieties and development of new varieties with short cooking time
	Low promotion of Bambara groundnut products (low quality, packaging Problem)	- Creation of derivatives of Bambara groundnut - Marketing: mark on the package "Bambara groundnut 30mn"
	Accessibility (High cost, landlocked Zone of producers)	- Increased Production
2. Input supply: seeds, fertilizers, pesticides, etc	Attack of seeds by insects	– Improvement of methods for seeds treatment
	Seeds rot	- Improvement of methods of drying
	Lack of specific fertilizer formulation	- Identifying specific fertilizer formulations
	Lack of appropriate pesticides	- Use of aqueous extracts or appropriate pesticides
	Lack of quality seed	- Exploration, collection and characterization of traditional varieties of Bambara groundnut -Establishment of a system of seed production
3. Agronomy, technology, product development	High pest pressure of insects and diseases on Bambara groundnut in pre-harvest and post-harvest	- Development of integrated pest management techniques (biological and agronomic control)
	Effects of climate change (Excess of rainfall, droughts)	- Identification of risks or mitigation strategies.
	Shelling difficulty	-Documentation on cultural practices of Bambara groundnut - Development of new cultivation methods for the production improvement
	Shelling difficulty	- Design of specific shellers for Bambara groundnut(PTA, COBEMAG)

4.Organization, management	Poor organization of producers of Bambara groundnut	- Establishment of an exchange platform of Bambara groundnut growers at the national level
	Non-existence of the Bambara groundnut value chain	- Involvement of producers, state institutions (Carder, SONAPRA INRAB), NGOs, processors and traders

Tableau 4: Opportunities and actions needed for Bambara groundnut group

Types	Value chain opportunity	Actions needed
1. Consumer demand, market access	Availability of markets (existence of demand)	- market Study (consumer preference, product quality) - Study of the value chain in the innovation platforms
2. Input supply: seeds, fertilizers, pesticides, etc.	-Existence of institutions of seed production and those of distribution of pesticides and fertilizers for other crops - Existence of research and coaching structures	- Quality seeds available for producers (short Cycle, quick cooking) -Formulation And distribution of fertilizers and pesticides
3. Agronomy, technology, product development	-Existence of local varieties	- Development of improved varieties adapted to biotic and abiotic factors and meeting the preferences of producers and consumers.
	-Existence of actors coaching	-Strengthening of the capacity of extension agents and researchers
	- Existence of structures of technological research (PTA, SONGHAÏ) and specialized equipment suppliers	- Development of equipment for reducing the cooking time
	Existence of processing facilities	- Development of competitive products
4. Organization, management	Existence of platform for other cultures (PPAAO, COS, DONATA)	– information sharing and exchange through these platforms - Training of stakeholders and development of an innovation platform in the Bambara groundnut value chain

The group suggested the following research topics:

1. Collection and genetic characterization of Bambara groundnut varieties grown in Benin
2. Agronomic evaluation of local varieties of Benin for abiotic (water excess and water stress) and biotic (pests and diseases) stress
3. Development of an integrated approach to fight Bambara groundnut pests in the fields and in stock
4. Determination in the context of climate change of the optimal planting periods of Bambara groundnut in the producing areas of Benin
5. Determination of specific chemical fertilizer formulas for the Bambara groundnut production
6. Improvement of Bambara groundnut productivity by using nitrogen-fixing rhizobia
7. Influence of fertilization on the incidence and severity of some pests and major diseases of Bambara groundnut
8. Influence of the types of plooughing and sowing density on the productivity of Bambara groundnut in the production areas of Benin
9. Assessment of preference criteria, perceptions about the side effects of the consumption of Bambara groundnut and identification of anti-nutritional factors.
10. Evaluation of the nutritional value of some derivatives of Bambara groundnut.
11. Development of new products from Bambara groundnuts
12. Evaluation of processing technologies on the anti-nutritional substances content of Bambara groundnut.
13. Influence of storage methods on Bambara groundnut seeds viability in Benin.
14. Influence of the different methods of storing and conservation on the quality of Bambara groundnut

The research topics identified during this workshop on both amaranth and Bambara groundnut are very important and need more attention for the development of value chains. These results will be published to serve as research themes for students and young researchers.

Public awareness action

To sensitize the Beninese on the importance of NUS in food security, fighting malnutrition and preserving human health, a TV session was scheduled for the second day of the workshop

at the national TV publicity branch called BB24. The channel covers the whole country. Ms Faouzitah Sanoussi, food technologist at the University of Abomey-Calavi represented the project team. Her presentation was organized around three points:

- The framework and justification/background of the workshop
- The diversity and importance of NUS in Benin with a focus on their nutritional or nutraceutical value, socioeconomic importance and adaptability to climate change conditions
- The various possibilities of developing the value chain of NUS with particular focus on amaranth and Bambara groundnut

The full TV session was recorded on a DVD attached herewith. In addition to the TV session, the national radio and a newsletter (copy attached) also reported the action.

Closing Ceremony

The regional coordinator of Bioversity International, Dr Raymond VODOUHE emphasized the importance of the workshop and suggested that the results be widely disseminated. He thanked Professor DANSI ANAGONOU Alexandre for his major role in the promotion of agriculture in general and in particular minor crops (NUS). A representative of the producers reported that producers are generally left on their own and it was recommended that they be more involved in NUS programmes and decision making. The presentation of Dr. Fernand ARYO focused much more on the Bambara groundnut which showed that the main problems to be solved in this culture are the overly long cooking time, and seed conservation. Therefore, he invited researchers to cooperate in order to address these issues. Mr Rudebjer praised the organization for the workshop, which was most successful in both logistic and technical terms. He also emphasized the need to identify constraints in the value chains including the financial aspects, and that these be addressed jointly by stakeholders. He proposed both crops to be integrated into research projects at national level. Finally, the manager of the project for Benin, Professor Dansi thanked the organizing committee and all participants who, despite their busy routines, agreed to participate in the workshop. He particularly thanked Bioversity International for the multiple efforts for the promotion of NUS.