All-Africa Summit on Diversifying Food Systems with **African Traditional Vegetables** to Increase Health, Nutrition, and Wealth

POWER ON YOUR PLATE

25-28 JANUARY 2021
Gran Meliá Arusha
Arusha, Tanzania

Ensuring a healthier Africa now and into the future demands a smart, ***sustainable food system*** *to deliver diets rich in nutritious, plant-based foods.*

The time is right to advance knowledge and expand the use of ***traditional vegetables*** *to help bring about this goal.*

Gabriel Rugalema. Power on your plate, 25-28 January 2021, Gran Meliá Arusha, Arusha, Tanzania. 57p. WorldVeg publication no. **22-1053**

DONORS

CONVENORS

PARTNERS

ORGANIZING COMMITTEE

Maureen Mecozzi, Director – Communications, World Vegetable Center

Gabriel Rugalema, Regional Director, World Vegetable Center Eastern and Southern Africa

Ralph Roothaert, Flagship Program Leader – Healthy Diets, World Vegetable Center Eastern and Southern Africa

Nadine Kwazi, Regional Coordinator, World Vegetable Center Eastern and Southern Africa

SCIENTIFIC COMMITTEE

Sognigbe N'Danikou, Scientist – Traditional Vegetables Conservation and Utilization, World Vegetable Center

Jim Simon, Director, New Use Agriculture and Natural Plant Products Program, Rutgers University

Fekadu Dinssa, Vegetable Breeder, World Vegetable Center

Maarten van Zonneveld, Genebank Manager, World Vegetable Center

Ray-yu Yang, Nutritionist, World Vegetable Center

George Kuo, Consultant, World Vegetable Center

PROGRAM

DAY 1 Monday, January 25, 2021

0900-1020 OFFICIAL WELCOME AND OPENING REMARKS

Mr. Caleb Karuga, CEO & Founder Wendy Farms Ltd
CEO & Founder Wendy Farms Ltd.

Dr. Gabriel Rugalema
Regional Director, World Vegetable Center Eastern and Southern Africa

Ms. Jacqueline Mkindi
CEO, Tanzania Horticulture Association (TAHA)

Hon. Peter Mutuku Mathuki
CEO/ED, East African Business Council

Dr. Rob Bertram
Chief Scientist, USAID Bureau for Resilience and Food Security

Dr. Marco Wopereis
Director General, World Vegetable Center

Dr. Mary Abukutsa-Onyango
Professor of Horticulture, Jomo Kenyatta University of Agriculture and Technology

Dr. Iddi Hassan Kimantha
Regional Commissioner for Arusha

Hon. Peter K. Pinda
Former Prime Minister of Tanzania Chairman, Agri Thamani Foundation

1040-1720 SESSION 1: DIVERSITY, BREEDING AND SEED SYSTEMS

DAY 2 Tuesday, January 26, 2021

0830-1120 SESSION 2: VALUE CHAINS AND SCALING

1120-1330 SESSION 3: AGRONOMY AND PRODUCTION SYSTEMS

1130-1515 SESSION 4: FOOD ENVIRONMENTS

1515-1735 SESSION 5: NUTRITION AND HEALTH

DAY 3 Wednesday, January 27, 2021

0900-0930 SESSION 6: BEYOND FOOD

0930-1255 POSTER SESSION

1335-1500 YOUTH PANEL DISCUSSION

1500-1600 HIGH-LEVEL PANEL DISCUSSION

1615-1700 CLOSING REMARKS

Dr. Gabriel Rugalema
Regional Director, World Vegetable Center Eastern and Southern Africa

Dr. Junne-Jih Chen
Chair of the Board, World Vegetable Center

Mr. Gerald Kusaya
Permanent Secretary, Ministry of Agriculture, Tanzania

DAY 4 Thursday, January 28, 2021

FIELD TRIP

OPENING COMMENTS FOR THE 'POWER ON YOUR PLATE' SUMMIT

Marco Wopereis
Director General, World Vegetable Center
Email: marco.wopereis@worldveg.org

Distinguished guests, dear participants,

It is a great pleasure for me to say a few words at the opening of this first All-Africa Summit on 'Diversifying Food Systems with African Traditional Vegetables to Increase Health, Nutrition and Wealth.'

Malnutrition, be it hunger, micronutrient deficiency, or overweight or obesity, is a tremendous problem worldwide, and Africa is not an exception. Vegetables are among the most affordable sources of vitamins, minerals, and plant-based proteins, which are essential for good health and can provide tremendous power on your plate. However, vegetable intake in Africa is far below the minimum of 240 g per person per day recommended by the World Health Organization.

We are familiar with tomatoes, peppers, carrots, and other universally produced, commercialized, and consumed vegetables. We usually call them 'global vegetables.' However, hundreds of locally produced vegetables are socially and culturally accepted as local foods. These 'traditional vegetables' are either endemic crops that were domesticated and cultivated in the same place they originated from or crops that have been introduced into a country and are now recognized as traditional vegetables.

African traditional vegetables are the topic of our discussions over the next three days, which is very timely. The vast diversity in African traditional vegetables could potentially play an important role in ensuring adequate levels of nutrition on the continent. Traditional vegetables often have a much higher nutritional value than their global counterparts. All these colors, shapes, and nutrients can provide tremendous health and nutritional power on your plate! They also contribute to climate resilience by diversifying farming systems and creating important income generation and job opportunities both on- and off-farm.

Unfortunately, traditional vegetables tend to be underutilized, undervalued, and poorly integrated into current markets and diets. Consumers may not recognize their nutritional value and may even consider them as 'old-fashioned and 'poor person's food. Some traditional vegetables are associated with long preparation time and are considered 'not fit to be integrated into 'modern' recipes.

We have to change that picture. To do that, I suggest we embrace a food systems perspective, simplified by the three Ps. We need to 'push' supply and 'pull' demand for traditional vegetables simultaneously using the right 'policy and governance framework' and the right incentives to move forward sustainably and equitably.

Starting with the 'push' side: Quality seed is the main bottleneck to integrating traditional vegetables into food systems. There is a need to find 'local favorites' among the vast diversity that is out there. We

need to identify those traditional varieties that fit best in local environmental settings and diets and connect these with formal and informal seed systems to reach farmers.

Next to quality seed, farmers also need incentives to adopt good agricultural practices that raise productivity, extend growing seasons and guarantee food safety. We need short connection lines between producers and consumers, creating trust and enabling vastly reduced post-harvest losses. Investments in food environments, particularly in wet markets, are also needed to improve food safety and hygiene and reduce waste.

Moving to the 'pull side.' Traditional vegetables must be appealing, easy to prepare, and fit into local recipes. Information campaigns are needed to raise interest in traditional vegetables, and they could include promotion campaigns with chefs and consumer champions to celebrate these vegetables' nutrition, taste, and cultural values.

Healthy eating preferences and habits are also best learned early. The World Vegetable Center (WorldVeg) and partners have conducted school garden programs in Africa and Asia. Through a hands-on experience with gardening and nutritional education, children learned how to grow and appreciate healthy foods such as fruit and vegetables. Children generally became more aware and knowledgeable about vegetables and liked to consume them, but a positive effect on vegetable consumption was rarely found. School gardens are just too small to produce sufficient quantities of vegetables for school lunches. Therefore, these school garden programs worked on the demand side but not the supply side. They must be combined with home garden programs for parents or caregivers. Another way would be to stimulate greater involvement of parents and local farmers in the school meal program and source vegetables locally.

Last but not least is the 'policy and governance framework.' Promoting traditional vegetables must fit within local, national and regional initiatives to reduce malnutrition and get crucial buy-in from policy- and decision-makers to invest in infrastructure and provide the right push and pull incentives. It will help to emphasize that besides the nutritional potential of traditional vegetables, there is also tremendous economic potential, through income generation and job creation along the value chain from seed to retail, with clear opportunities for women and youth.

The tremendous diversity of traditional vegetables is a great asset since it provides many opportunities to adapt to local growing conditions, adding color, taste, nutrition, and health qualities to people's diets. Traditional vegetables may have very important still-to-be discovered nutrition and health qualities and agronomic traits, such as resistance to pests and diseases or tolerance to drought and high temperature. However, the reality is that the diversity of traditional vegetables in farming systems worldwide is on the decline because diets and food production are becoming homogenized, often driven by urbanization.

There is a great need to conserve and document the diversity of African traditional vegetables before this is lost. A recent study led by WorldVeg focusing on 126 African traditional vegetables showed that only a few were conserved well in genebanks in Africa. Less than ten or no accessions represented about one-third of these vegetables. To secure these genetic resources for humanity, we need to organize collection missions for ex-situ conservation, upgrade seed banks in Africa to keep the seed safe and support national conservation programs to improve the in-situ conservation of these vegetables and their wild relatives.

As we enter 2021, the International Year of Fruits and Vegetables, this first All-Africa Summit on 'Diversifying Food Systems with African Traditional Vegetables to Increase Health, Nutrition and Wealth' is a wake-up call about the need to unleash the nutritional and economic power of African traditional vegetables. That power should be on everybody's plate every single day. I look forward to the debates and the recommendations formulated on the last day. We must devise a concrete action plan to realize African traditional vegetables' nutritional and economic power while conserving their diversity.

Thank you.

SESSION 1: DIVERSITY, BREEDING, AND SEED SYSTEMS

INVITED SPEAKER

Exploiting the diversity of African traditional vegetables for improved nutrition: action plan for stakeholders with specific agenda for plant breeders. Enoch G. Achigan-Dako. Laboratory of Genetics, Horticulture and Seed Sciences, Faculty of Agronomic Sciences, University of Abomey-Calavi, Abomey-Calavi BP 2549, Benin. Email: e.adako@gmail.com

The sustainable use of plant genetic resources is a prerequisite for livelihood improvement and food and nutrition security and should receive significant attention in sub-Saharan Africa. Those resources include African traditional vegetables that encompass tremendous diversity. In recent years several interventions have tackled constraints in production, commercialization, and consumption of African traditional vegetables to increase utilization of the vegetables in urban, peri-urban, and rural areas. Despite various interventions, African traditional vegetables still lag regarding resources allocated to develop their value chains. To accelerate the pace of the utilization of African traditional vegetables in sub-Saharan Africa, the following actions need to be considered: 1) developing market and value chains for African traditional vegetables such as leafy amaranth (*Amaranthus cruentus*), gboma (*Solanum macrocarpon*), roselle (*Hibiscus sabdariffa*), Ethiopian kale (*Brassica carinata*), jute mallow (*Corchorus olitorius*), okra (*Abelmoschus esculentus*), bottle gourd (*Lagenaria siceraria*), eru (*Gnetum africanum*), taro (*Colocasia esculenta*), spider plant (*Gynandropsis gynandra*), egusi melon (*Citrullus mucosospermus*), bitter gourd (*Momordica charantia*), among others; 2) creating conducive home gardening strategies for increased consumption of fresh products; 3) intensifying transition to agroecological production of African traditional vegetables in urban and peri-urban areas (e.g., bio-fertilization, biological control of pests and diseases, micro irrigation, weed control with biodegradable materials, and capacity building in regenerative agriculture); 4) generating accurate statistical data for informed policy development and decision making; 5) designing and testing new technologies to scale low-cost production and processing practices for cost-effective food supply. Our experience in domestication and breeding in a model African traditional vegetable, the spider plant, allowed us to recommend breeders six steps to develop quality planting materials for farmers: 1) understanding the reproductive biology and mating systems that increase genetic gains; 2) inventory of available genetic resources and re-assessing gene pool and germplasm for additional collections to increase the geographical coverage; 3) phenotyping and genotyping of germplasms for added value traits; 4) genomic selection and molecular breeding of cultivars to increase

accuracy and reduce selection cycle; 5) multi-environmental testing and end-users' evaluation; 6) setting up quality seed system sectors. Breeders and agronomists should capitalize on cultivar development and deployment progress to set a breeding agenda for target products in line with farmers' and consumers' needs.

CONTRIBUTING SPEAKERS

The World Vegetable Center *Amaranthus* core collections. Roland Schafleitner[1], Fekadu Dinssa[2], Richard Finkers[3], Chen-Yu Lin[1], Tien-hor Wu[1], Sognibe N'Danikou[2], and Maarten van Zonneveld[1]. 1World Vegetable Center, PO Box 42, Shanhua, Taiwan, 74199 Taiwan. [2]World Vegetable Center, Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. [3]Department of Plant Breeding, Wageningen University & Research, PO Box 16, Wageningen 6700, The Netherlands. Email: roland.schafleitner@worldveg.org

The World Vegetable Center (WorldVeg) harbors Africa's largest amaranth (*Amaranthus* spp.) collection in its genebank in Tanzania. The collection currently includes over 1,000 accessions of 18 *Amaranthus* species, too many for breeders to evaluate. A smaller number of accessions (core collection) would be more amenable for germplasm characterization, screening for favorable traits, and subsequently mobilizing crop diversity for breeding and selection. WorldVeg has developed two core collections for amaranth, one representing the diversity of the whole collection and another one containing only four *Amaranthus* species, *A. cruentus*, *A. hypochondriacus*, *A. caudatus*, and *A. dubius*, with the most significant importance for vegetable production in Africa. The core collections were chosen from the whole collection based on diversity analysis using high throughput genotypic data. Comparison using Shannon's diversity index and Nei's expected heterozygosity between the whole and the core collections demonstrated that at least 90% of the diversity of the whole collection was maintained on the genomics level. The diversity of nine quantitative traits conserved reached about 80% in the core collections compared to the whole collection. Agronomic evaluation and drought stress tolerance screening in the amaranth core collection demonstrated significant variation in leaf yield under stress and non-stress conditions, and accessions with favorable traits have been forwarded to amaranth breeding programs.

Nutritional phenotyping and association between morphological and nutritional traits in vegetable amaranth (*Amaranthus* spp.) lines. Winnie Nyonje[1], Mary Abukutsa-Onyango[1], Ray-Yu Yang[2,3], Anselimo Makokha[1], Willis Owino[1], and Roland Schafleitner[2]. [1]Department of Food Science, Jomo Kenyatta University of Agriculture and Technology, PO Box 62 000, 00200, Nairobi, Kenya. [2]World Vegetable Centre, PO Box 42, Shanhua, Taiwan, 74199 Taiwan. [3]Food and Fertilizer Technology Center for the Asian and Pacific Region, Taiwan. Email: roland.schafleitner@worldveg.org

Amaranth (*Amaranthus* spp.) is an important leafy vegetable and grain crop belonging to the Amaranthaceae family. It is a good source of nutrients and bioactive compounds and is widely consumed in several parts of the world. Different varieties of *Amaranthus* species show significant phenotypic variation and may have different nutritional attributes. This study aimed to phenotypically characterize vegetable amaranth lines of five species (*A. hypochondriacus*, *A. cruentus*, *A. tricolor*, *A. dubius*, and *A. blitum*) by measuring morphological parameters and relating these data to the nutritional attributes of the

leaves. Ten selected amaranth lines developed by the World Vegetable Center were used in the study. The study involved using a high throughput phenotyping system to determine biomass, greenness, plant height, and hue of the leaves using 3D scanning and correlating these data with the nutritional traits, including carotenoids, flavonoids, vitamin C, minerals, and oxalate contents. Analysis of variance for morphological and nutritional traits showed significant ($P \leq 0.05$) difference among the lines for most traits measured. Amaranth line 8 (*A. tricolor*) and line 10 (*A. dubius*) had the highest nutrient contents for most of the nutrients assayed. In contrast, line 2 (*A. hypochondriacus*) and line 3 (*A. hypochondriacus*) had the lowest nutrient content. Leaf greenness was significantly correlated with oxalate and vitamin C contents, and hue was significantly correlated with carotenoids. We conclude that only a few morphological traits of amaranth are associated with their leaf nutrient contents.

Dissecting genetic variation and linking crop functional traits to iron, zinc and carotenoid contents in amaranth (*Amaranthus cruentus*) genetic resources. Eliel B. Sossou[1,2], Enoch G. Achigan-Dako[1], E.O. Deedi Sogbohossou[1,3], Herbaud P.F. Zohoungbogbo[1,4], Nicodeme H. Fassinou[1], and Happiness O. Oselebe[2]. [1]Laboratory of Genetics, Horticulture and Seed Science, University of Abomey-Calavi, BP 2549 Abomey-Calavi, Benin. [2]Department of Crop Production and Landscape Management, Ebonyi State University, Abakaliki, Nigeria. [3]Biosystematics Group, Wageningen University & Research, 6708 PB Wageningen, The Netherlands. [4]World Vegetable Center, West and Central Africa-Coastal and Humid Regions, Cotonou, Benin. Email: e.adako@gmail.com

The evaluation of the germplasm of vegetable amaranth is a prerequisite for developing a breeding program for this vegetable. The present study examined variation in carotenoid, zinc, and iron contents as well as plant architecture and leaf-yield-related traits for 25 accessions of amaranth (*Amaranthus cruentus*) from various origins. Experiments were conducted during the early planting season (April-June) and the late planting season (August-October) 2019 in the experimental field at Ebonyi State University and nutrient content determination in the Laboratory of Biochemistry of Alex Ekwueme Federal University, Nigeria. All horticultural traits showed significant differences among all the accessions except the survival rate after cutting. Regarding nutritional traits, significant differences among accessions were observed only in carotenoids and zinc contents. Seasonal variation significantly affected all the traits. The broad-sense heritability (H) estimates for 19 quantitative traits ranged from $H2 < 0.05$ for carotenoid content in leaves to 0.85 for leaf length: width ratio. The Pearson correlation matrix and genetic correlation indicated significant and strong positive correlations between most yield-related traits (i.e., plant height, leaf width, leaf length, stem diameter, and canopy spread), the total yield, and the marketable fresh vegetable yield. Other yield-related traits include leaf number, branch number, leaf length: width ratio, and days to 50% flowering. A moderate to strong significant correlation was noticed between horticultural traits and all the nutrients except total carotenoid levels. Overall, the accessions were grouped into three clusters based on horticultural traits. These results confirmed the hypothesis that selection could be made for leaf yield, other related traits, and zinc content. The study provides information on the variation for traits of interest to enhance breeding for leaf yield and nutrient content in *A. cruentus*.

Performance of African eggplant (*Solanum aethiopicum*) entries across environments, and directions for selection environment in northern Tanzania. F.F. Dinssa[1], P. Hanson[2], M. Matovolwa[1], R. Mallogo[1], M.S. Mushi[1], O. Mbwambo[1], and G. P. Munuo[1]. [1]World Vegetable Center, Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. [2]World Vegetable Center, West and Central

Africa-Coastal and Humid Regions, Cotonou, Benin. Email: fekadu.dinssa@worldveg.org

African eggplant (*Solanum* spp.) is a widely used fruit and leafy vegetable in Africa. The crop grows in various agroecological zones, and most farmers grow local cultivars. African eggplant breeding is generally in its early stage, although farmers' interest in improved cultivars is growing. Information on Genotype (G) x Environment (E) interaction would help guide breeders in cultivar development and whether the emphasis should be placed on specific and/or broad adaptation. This study aimed to determine the extent of G, E, and GxE interaction (GEI) and identify major selection environments for breeding programs. A total of 21 African eggplant entries were evaluated for fruit yield and horticultural traits in two locations in 2017 and five locations in 2018, targeting two agroecology in northern Tanzania. Trial locations ranged in altitude from 866 m ASL in the Kilimanjaro region to 1,235 m ASL in the Arusha region. Location and year were considered independent environments, so entries were evaluated in seven environments. Entries were arranged in a randomized block design with three replications. Highly significant differences among entries were found for fruit yield and other traits in each environment. G, E, and GEI effects were highly significant in an Additive Main Effect and Multiplicative Interaction (AMMI) analysis. Environment explained about 34% of the sum of squares of treatments (G+E+GEI), while G and GEI accounted for 14% and 52%, respectively. The AMMI analysis partitioned the GEI sum of squares into three significant Interaction Principal Component Axis (IPCA). The G and GEI (GGE) biplot analysis clustered the seven environments into two mega-environments, one representing a relatively high-altitude location in the Arusha region and the other representing a low altitude location in the Kilimanjaro region. The study results indicate that African eggplant multilocation trials in northern Tanzania could be represented by one location in each of the Arusha and Kilimanjaro regions.

A "pre-defense" mechanism for highly drought tolerant genotype in *Solanum aethiopicum* Shum cultivar-group. Godfrey Sseremba[1,2,3], Pangirayi Tongoona[1], John Eleblu[1], Eric Yirenkyi Danquah[1], and Elizabeth Balyejusa Kizito[2]. [1]West Africa Centre for Crop Improvement, University of Ghana, PMB LG30, Accra, Ghana. [2]Department of Agricultural and Biological Sciences, Uganda Christian University, PO Box 4, Mukono, Uganda. [3]National Coffee Research Institute, National Agricultural Research Organization, PO Box 185, Mukono, Uganda. Email: gsseremba16@gmail.com

Some *Solanum aethiopicum* (Shum cultivar-group) genotypes have different levels of drought tolerance, but the underlying behavior of these contrasting genotypes has not been investigated. This study aimed to determine the relationship among selected leaf traits of *S. aethiopicum* (Shum cultivar-group) under drought recovery and compare the response of contrasting genotypes under watering resumption. Three genotypes (E17GP=susceptible, E14GP=moderately tolerant, and E6=highly drought tolerant) were subjected to two watering regimes (WL) over time (DAR). Leaf traits, namely leaf wilting score (LWS), leaves per plant (LPP), leaf relative water content (LRWC), gas exchange (STC), and chlorophyll content (CHL), were measured. Strong linear relationships were observed between trait pairs: CHL and LPP (R2=0.75), CHL and STC (R2=0.56), and STC and LPP (R2=0.53), offering an alternative to the use of any of the three traits for drought phenotyping. The susceptible genotype recovered the slowest and maintained STC irrespective of WL, which predisposes it to severe drought stress effects. The moderately tolerant genotype maintained better overall leaf health (high CHL) irrespective of WL than other genotypes. Based on STC and CHL, the highly drought tolerant genotype exhibited a "pre-defense" mechanism by functioning at a reduced gas exchange and moderate CHL as a mitigating strategy against

drought.

Heritability of drought tolerance in *Solanum aethiopicum* Shum cultivar-group and combining ability of genotypes for drought tolerance. Godfrey Sseremba[1,2], Pangirayi Tongoona[1], John Eleblu[1], Eric Yirenkyi Danquah[1], and Elizabeth Balyejusa Kizito[2]. [1]West Africa Centre for Crop Improvement, University of Ghana, PMB LG30, Accra, Ghana. [2]Department of Agricultural and Biological Sciences, Uganda Christian University, PO Box 4, Mukono, Uganda. Email: gsseremba16@gmail.com

Solanum aethiopicum (Shum cultivar-group) is primarily consumed as a leafy vegetable. Its drought tolerance is a complex trait whose inheritance has not been fully investigated, partly because of perceived cross incompatibilities in the crop. This study relied on 24 successful crosses from an incomplete 9x4 North Carolina II mating design, evaluated under five watering conditions based on plant growth stage and watering level to determine the heritability of drought tolerance and combining ability. Subsequent data analyses were based on restricted maximum likelihood. Overall, specific combining ability (SCA) effects were significant across and within watering environments for all studied traits. Traits identified for their high narrow-sense heritability were the number of leaves per plant (NL), chlorophyll content (CHL), fresh leaf yield (FLY), and dry weight leaf yield (DWLY). Leaf area (LA), leaf relative water content (LRWC), and leaf mass area (LMA) had the least narrow-sense heritability. However, the broad sense of heritability was more than 0.80 for all seven traits. This indicates that dominance gene action surpasses additive gene effects for drought tolerance in *S. aethiopicum* (Shum cultivar-group). Further analysis showed that LA is suited for selecting the best combiners under well-watered and drought-stress (DS) conditions. The LRWC served best in separating the SCA effects of crosses under DS conditions. The CHL produced clear separations of SCA effects under DS and drought recovery, while LMA served best under the latter.

Impacts and sustainability of farmer seed production activities: A case of the Good Seed Initiative (GSI) project in Tanzania. Monica K. Kansiime[1], Mary Bundi[1], Jacqueline Nicodemus[2], Justus Ochieng[3], Damus Marandu[4], Silvestri Samali Njau[4], Frances Williams[1]; Daniel Karanja[1], Justice Tambo[5], and Dannie Romney[1]. [1]CABI-Africa, PO Box 633-00621, Nairobi, Kenya. [2]Inades-Formation Tanzania, PO Box 203, Dodoma, Tanzania. [3]World Vegetable Center, Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. [4]Tanzania Agricultural Research Institute, Tengeru, PO Box 1253, Arusha, Tanzania. [5]CABI-Switzerland, CH-2800 Delémont, Switzerland. Email: m.kansiime@cabi.org

The Good Seed Initiative (GSI) was conducted between 2013 and 2016 in Tanzania and was coordinated by the Centre for Agriculture and Bioscience International (CABI). It aimed to help farmers judge the quality and value of the African indigenous vegetable (AIV) seeds they buy. In turn, it would empower them to demand good quality seeds and improve their income by becoming suppliers of quality seeds themselves. This study assessed the impacts and sustainability of GSI. It focused on two seed production models – contract farming in Arusha in the north and the Quality Declared Seed system in Dodoma in the south. The former is essentially an agreement between a farmer and a processing or marketing company for producing and supplying AIV seeds under a contract. The latter is a protocol to assist people in producing quality seeds. Data were collected during August 2019 through focus group discussions (64 men, 73 women) and interviews with seed sector stakeholders. Results show that farmer seed enterprises under both models continued to thrive, creating avenues for income diversification and substantially

contributing to household incomes (> 50%). Farmers reported an increasing demand for seeds, particularly Dodoma. As a result, farmers trained in the project continued to train other farmer seed producers in order to be able to satisfy the demand. Farmers also reported expanded markets for QDS, including the entry of more agro-dealers and seed merchants. As a result of various advocacy initiatives, QDS seed could be sold outside the locality, which presumably had a significant impact on markets for local farmers in Dodoma. The quality of farmer-produced was rated as being of good quality by local users and agro-dealers; however, this was not ascertained due to the reported breakdown of seed inspection services and lack of access to foundation seed. Farmers in Arusha continued to engage in contractual arrangements with seed companies for bulking seeds of AIVs and exotic vegetables, building on farmers' experience in producing AIV and other vegetable seeds. Reported contracted seed quantities for two interviewed companies increased from 14 t (2016) to 41 t (2019), as well as the number of farmers contracted. Noted challenges at the producer level that need addressing were: farmers' inability to appropriately negotiate contracts with seed companies, especially women; weak seed inspection and access to early generation seed for QDS growers; fragmented markets for QDS; and lack of innovative agronomic technologies to adapt seed production to current environmental risks. The companies mentioned the increased inspection fees, and multiple licenses levied on them as major challenges, affecting the prices paid for seed to contracted farmers. Farmer seed production proved to be a viable strategy for providing quality seed to farmers less served by the formal sector and contributing to improved livelihoods for smallholder farmers engaged in seed production. The sustained relationship and linkage to the formal seed sector and stimulation of local demand through nutritional awareness campaigns were strong contributory factors to the survival of farmer seed businesses.

Seed is the natural entry point to agroecology for small scale vegetable farmers in Africa. R. Kahane[1], M. Thomas[2], D. Bazile[3], and D. Clavel[2]. [1]UPR HortSys, [2]UMR Agap, and [3]UPR Green, CIRAD, F-34398 Montpellier, France. Email: remi.kahane@cirad.fr

Farmers' seeds and agroecological practices share the same goal: sustainable food and nutrition security through sovereignty. However, whereas seed autonomy and diversity at the local level are easy to understand but challenging to achieve, agroecological sovereignty is not so easy to conceive because of its holistic approach, and farmers consider the transition phase an economic risk. The present paper underlines how a seed can help smallholder farmers in sub-Saharan Africa enter the agroecological transition, particularly in their vegetable farming activity, while preventing them from food and financial risks. The kind of vegetable seeds used is often not a choice in most African family farms, influencing the cropping system and, on a larger scale, the food system of rural communities. Improved varieties sold by retailers are costly, not locally bred or produced, and not always adapted to the needs of the environmental conditions; in most cases, they do not valorize the still present diversity of varieties and species for the local markets. Farmers' seed is often available on the informal market, with little information on its quality but locally adapted and inexpensive, the reason for its wide use for many species. Since emphasis has rarely been put on these plant species and/or varieties, genetic and phenotypic diversity exists that can be used to (re-)discover relevant nutritional and agroecological characteristics of these plant species and/or varieties, like their positive interactions as bioprotectant or biofertilizer, in crop association, rotation, or application of extracts. Developing a participatory plant breeding program in vegetable seed systems with farmers' organizations would contribute to selecting well-adapted varieties and add value to their various quality and agroecological traits. Such improvement would be a reasonable way to limit financial failures

and increase the socio-cultural adoption of agroecology.

The history of breeding for basil downy mildew resistance in sweet basil (*Ocimum basilicum*). Robert Mattera III[1], Lara Brindisi[1], Robert Pyne[2], Yariv Ben Naim[3], Yigal Cohen[3], C. Andrew Wyenandt[1], and James E. Simon[1]. [1]Department of Plant Biology and Center for Agricultural Food Ecosystems, Rutgers University, New Brunswick, NJ 08854 USA. [2]VDF Specialty Seeds. [3]Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 5290002, Israel. Email: jimsimon@rutgers.edu; robertmattera343@gmail.com

Basil (*Ocimum* spp.) is one of the most critical herb genera in the world and contains over 60 different species, many originating in sub-Sahara Africa, including several economically important ones. Sweet basil (*O. basilicum*), one of these species, is widely grown worldwide as a popular culinary herb. In the past two decades, basil downy mildew (BDM), discovered in Uganda in 1933, has spread throughout the basil growing world, devastating basil crops and forcing growers to adopt costly control measures. Until recently, no commercially grown sweet basils have resisted BDM, resulting in significant losses due to most pesticide regimes having little efficacy. After screening hundreds of basil accessions, including exotic basil species, most from sub-Sahara Africa procured from the USDA-GRIN and commercial sources, multiple basils with resistance were identified. No resistance was found in sweet basils and attempts at crossing exotic resistant basils with sweet basils generally resulted in a lack of fertility and breeding dead-ends. One exotic accession with resistance, named MRI, was identified only as *O. basilicum* after we conducted a genetic diversity analysis of the germplasm collection at Rutgers. When crossed with sweet basil, it resulted in fertile crosses. MRI, purportedly from Zanzibar, was crossed with the Rutgers breeding line SB22 and resulted in four downy mildew-resistant sweet basil cultivars that are now commercially available. Other exotic sources of downy mildew resistance have been successfully introgressed into sweet basil using embryo rescue to overcome the F1 infertility issues. This technique allows new sources of disease resistance from exotic basils to be introgressed into more widely grown sweet basils. Using indigenous wild relatives from other *Ocimum* spp. has been effective in the search for sources of disease resistance, new aromas, and flavors.

Agrobiodiversity, nutrition, and policies: Where are we with the conservation and utilization of African vegetable biodiversity? Sognigbe N'Danikou[1] and Maarten van Zonneveld[2]. [1]World Vegetable Center-East and Southern Africa. PO Box 10 Duluti, Arusha, Tanzania. [2]World Vegetable Center, PO Box 42, Shanhua, Tainan 74199 Taiwan. Email: sognigbe.ndanikou@worldveg.org

Target 2.5 of the UN's Sustainable Development Goals (SDGs) aims, by 2030, to maintain the genetic diversity of cultivated plants and their related wild species through soundly managed and diversified seed and plant banks at the national, regional, and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed. However, sub-Saharan Africa (SSA) is lagging behind this target. About 70% of SSA countries have no proper and functioning genebank infrastructure, and agricultural biodiversity is shrinking. While effort has been made to conserve the genetic diversity of staple crops such as cereals and pulses in genebanks, there is a critically low investment for ex-situ conservation of African traditional vegetables. Also, confusion is emerging with the implementation of international agreements, preventing timely action from safeguarding African vegetable biodiversity. This situation is putting many African vegetable landraces and their wild relatives at risk, which are essential sources to breed nutritious

crops. Therefore, a pan-Africa cooperation, institutional and policy support, and commitment of African governments are critical to safeguard and sustainably use the genetic diversity of African traditional vegetables to meet SDG targets on food and nutrition security.

Collection of genetic resources of selected African traditional vegetables in agroecological zones of Benin. A.M. Salaou[1], N. Soulemane[1], E.B. Sossou[1], G. Bodjrenou[1], H. Nouletope[1], N. Akita1, C. Korogone[1], M. Vigninou[1], C.A.O. Adje[1], Pamela Afokpe[1], N.V. Fassinou-Hotegni[1], S. N'Danikou[1,2], and E.G. Achigan-Dako[1]. [1]Laboratory of Genetics, Horticulture and Seed Science, University of Abomey-Calavi, 01 BP 526 Tri Postal, Cotonou, Benin. [2]World Vegetable Center-East and Southern Africa. PO Box 10 Duluti, Arusha, Tanzania. Email: e.adako@gmail.com

African traditional vegetables improve food and nutrition security and human health in African urban and rural communities. They occupy a prominent place in people's livelihood and are used as traditional medicines. However, this diversity needs to be conserved and made available to users to avoid further loss of diversity within and among species and save them for future generations. In this perspective, the Laboratory of Genetics, Biotechnology and Seed Science of the University of Abomey-Calavi, in collaboration with the World Vegetable Center, organized a germplasm collection mission of 20 African traditional vegetables and their wild relatives in 24 districts covering all the eight agroecological zones of Benin. Collected accessions were accompanied by their passport data. The collection activity generated 1,479 accessions for 19 species, which have been stored in the genebank of the said Laboratory. Most accessions belong to five species *Abelmoschus esculentus*, *Amaranthus cruentus*, *Corchorus olitorius*, *Solanum macrocarpon*, and *Lagenaria siceraria*. About 73% of the accessions collected were obtained from seeds of the previous season's harvest. Local communities cultivate the collected species for multiple purposes. All the species are commonly used as food. Other uses of the species include income generation, medicine, forage, arts, rituals, and firewood. The present germplasm collection provides insights into the variability within African traditional vegetables and opens doors for more research and improvement of targeted species.

Diversity and use of traditional vegetables in Itasy and Vakinankaratra regions of central Madagascar. Tendro Radanielina[1], Juvet Henrinet Razanameharizana[1], and Denis Randriamampionona[2]. [1]DBEV and [2]AT2D–ESSA, University of Antananarivo, BP 906, Antananarivo, Madagascar. Email: rtendro@yahoo.fr

The diversity and use of traditional vegetables were assessed in two densely populated regions, Vakinankaratra and Italy, of the Central Highland of Madagascar. Main farming activities in these regions are conducted by family labor. Peasant farmers in these regions face the challenge of providing food for their families. A survey was conducted to understand the diversity and use of traditional vegetables in the two study regions. Sampling was done at two levels: first, four villages per region, representing the main agroecological zones of the country, were sampled, and then ten farmers per village representing three main farm types (farms handled by smallholder resource-poor farmers, medium-size farms handled by average income farmers, and relatively large farm handled by wealthy farmers) were sampled. Focus group discussions were carried out in each sample village, with the discussion of male and female farmer groups held separately. Collected data included food crops grown, food use of wild and semi-wild species, and the productivity of each harvested species. Results show a high diversity of traditional vegetables in

the two regions, a total of 32 species were identified. Amaranthaceae and Asteraceae were the main families, with each family having an average of eight traditional vegetable species. The species were harvested as wild vegetables except for one species, the cultivation of which started. Eight species from four botanical families were also traded. This diversity of traditional vegetables is vital in supporting food and nutrition security, particularly diversifying diets in both regions. Traditional vegetables are amply available during the rainy season and are primarily helpful during this season when staple food crops are scarce.

Differential response of two cultivar-groups of *Solanum aethiopicum* to water-deficit stress. Mildred Julian Nakanwagi, Godfrey Sseremba, Nahamya Pamela Kabod, and Elizabeth Balyejusa Kizito. Department of Agricultural and Biological Sciences, Uganda Christian University, PO Box 4, Mukono, Uganda. Email: julianmildrednakanwagi@gmail.com

Two cultivar groups (Shum and Gilo) of *Solanum aethiopicum* were evaluated for drought stress response under greenhouse conditions. A factorial experiment in a completely randomized design with four replications of potted plants was employed. The evaluation was done at three growth stages (seedling, vegetative and flowering) under two water regimes (well-watered and reduced watering). Optimum watering was applied until the desired stage was reached. Data on leaf length, leaf width, number of green leaves, chlorophyll contents, stomatal conductance, and visual wilting score were collected. Soil moisture content in the pot was also routinely monitored. Results from the general analysis of variance exhibited significant differences between two cultivar groups, among growth stages and between water regimes. There was a significant decrease ($p < 0.01$) in the number of green leaves, leaf length, leaf width, stomatal conductance, and soil moisture content with increasing drought stress. On the other hand, chlorophyll content was significantly increased with a reduced moisture regime ($p <0.01$), and a high leaf wilting score was observed under a reduced moisture regime. At all evaluated growth stages, water-deficit stress negatively affected both the Shum and Gilo cultivar groups of *Solanum aethiopicum*. However, the vegetative stage was significantly constrained compared to the other stages. Despite the significant constraint caused on both cultivar groups under water-deficit treatment at the vegetative stage, different drought tolerance mechanisms were exhibited. Furthermore, the Shum cultivar group depicted a relatively higher degree of drought tolerance than the Gilo cultivar group, thereby providing a more reliable source of drought tolerant genes that could be transferred to other *Solanum* species.

Yield stability of onion lines grown across locations and seasons in Ghana and Mali. Jean Baptiste De La Salle Tignegre[1], Peter Hanson[2], Victor Afari-Sefa[1], Paul Zaato[2], Moussa Kanoute[1], Mamadou Kabirou N'Diaye[1], Irmgard Hoeschle-Zeledon[3], Fred Kizito[4], and Birhanu Zemadim[5]. [1]World Vegetable Center, West and Central Africa-Dry Regions, BP 320 Bamako, Mali. [2]World Vegetable Center-Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin. [3]Africa RISING West Africa and East/Southern Africa, Ibadan, Nigeria. [4]Africa RISING West Africa, Ghana. [5]International Crops Research Institute for the Semi-Arid Tropics, West and Central Africa Regional Hub, BP 320 Bamako, Mali. Email: jean-baptiste.tignegre@worldveg.org

Onion is one of the most economically and nutritionally essential crops in West Africa. However, few high-yielding varieties are available to farmers. Onion lines from the World Vegetable Center's Allium program were evaluated during the cool and dry season from September to March for three years to

identify adapted onion lines suitable for sustainable intensification of production systems in the Africa RISING project intervention zones of northern Ghana and south Mali. The trials were implemented in the Upper East and Northern Regions of Ghana and two districts in the Sudan savanna zones of Mali (Bougouni and Koutiala). Nine onion lines, including check varieties, were assessed for yield stability. The trials were carried out in technology parks under the joint management of farmers and researchers. Onion bulb weight was recorded for each plot after harvest. A separate analysis of variances was performed for each location and season in a randomized complete block design. Location, season, and line combined analysis of variance was conducted to determine the most stable genotypes using the line superiority measure and ecovalence stability coefficients. Our results indicated that lines AVON1310 and AVON1325 were the most stable for yield performance over locations and seasons. From the genotype main effects and genotype-by-environment interaction (GGE) biplot analysis, the best performing lines were AVON1310 (33.3 t/ha), AVON1308 (28.8 t/ha), and AVON1325 (31.7 t/ha). These lines are potential candidates for sustainable intensification of onion production in Ghana and Mali.

Andromonoecy in *Cleome gynandra* and effects on fruit and seed production. Herbaud Phanuel Fortunat Zohoungbogbo. World Vegetable Center-Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin. Email: herbaud.zohoungbogbo@worldveg.org

Spider plant (*Cleome gynandra*) of the Cleomaceae family is a traditional leafy vegetable widespread in sub-Saharan Africa that is also valued for its medicinal properties. Developing a breeding program for the species requires detailed knowledge of its phenology, floral morphology, and pollination system. This study investigated the effects of floral morphology and pollination mechanisms on reproductive success. The experiments were conducted in two locations in Benin. Three accessions were evaluated for their fruit and seed sets under five pollination mechanisms (i.e., natural self-pollination, hand self-pollination, open-pollination and hand cross-pollination, and geitonogamy which is the pollination of a flower by pollen from another flower of the same plant). A split-plot arrangement was used, with the whole plot laid out in a randomized complete block design with four replications. Accessions were grown in the whole plot and the pollination mechanisms in the sub-plot. The three accessions were randomly assigned to the whole plots, and the five treatments were laid out in the sub-plots. We observed that individual plants exhibited 70% of staminate (male) flowers and 30% of hermaphrodite flowers. *C. gynandra* was andromonoecious, representing functionally staminate short gynoecium floral type and functionally hermaphrodite medium and long gynoecium floral types. All the flowers took one week from the bud's appearance to the blooming flowers. Anthesis occurred during the night. Open pollination and hand cross-pollination led to higher fruit and seed sets. Natural self-pollination and hand self-pollination resulted in lower fruit and seed production. *C. gynandra* is a self-compatible and predominantly out-crossing species. Cross-pollination resulted in a significant increase in fruit set. This study set the ground for developing improved cultivars in *C. gynandra*.

SESSION 2: VALUE SCHAINS AND SCALING

CONTRIBUTING SPEAKERS

Catalyzing strengthening of vegetable value chains in Africa. Elijah Mwashayenyi and Stuart Morris. East-West Seed Knowledge Transfer (EWS-KT) in Africa. Email:

elijah.mwashayenyi@eastwestseed.com

East-West Knowledge Transfer supports smallholder farmers in the vegetable sector with extension services. By providing long-term technical support, EWS-KT catalyzes the uptake of improved production practices in communities struggling with low yields. Over the past few years, East-West Seed and its partners went into Tanzania, Uganda, and Nigeria to support smallholder farmers with training to increase their knowledge and skills. In northern Uganda, it was to re-invigorate vegetable production and marketing in communities previously displaced by war. In West Nile (Uganda), it was to work with communities that included a large population of refugees from South Sudan, whose livelihoods solely depended on UN handouts. In Nigeria, the focus was to work with communities in northern Nigeria (especially Kaduna and Kano) that are relatively fragile but produce 60% of Nigeria's vegetables. In Tanzania, it has been to strengthen existing vibrant vegetable value chains. While this work is not exclusive to traditional vegetables, they form a significant component of the company's seeds, with African eggplant, pumpkin, amaranth, nightshade, Ethiopian mustard, watermelon, and okra being among the list. They are also on the vegetable menu in these three countries' fields, backyard gardens, and markets. Serious engagements were done and are still being done with farmers, agro-dealers, and markets. A few years later, the effort is beginning to bear fruit. Over 100,000 farmers have been reached in three countries. EWS-KT plans to train a further 100,000 farmers in Africa by the end of the year 2022.

Value addition of vegetables for increased access and consumption by urban consumers. Jane Ambuko. Department of Plant Science and Crop Protection, University of Nairobi, PO Box 30197-00100, Nairobi, Kenya. E-mail: jane.ambuko@uonbi.ac.ke

Consumption of African indigenous vegetables (AIVs) in Kenya has grown exponentially over the years due to increased consumer awareness of the health benefits of vegetables. In the last two decades, AIVs have moved from rural farms and markets to urban markets, including supermarkets. Although some AIVs are now more accessible in urban grocery stores, their uptake and consumption are still low. Consequently, the desired pull effect that spurs increased production and incomes for smallholder farmers has not been maximized. Preparation of AIVs is generally more laborious compared to most exotic vegetables, a factor that could contribute to lower uptake and consumption of AIVs despite their availability. A random survey of grocery shops in major cities shows a significant increase in value-added products of exotic vegetables, including kale, spinach, carrots, peas, and salad vegetables. The value added to the exotic vegetables includes plucking, shredding, dicing, packaging, mixed vegetable pre-packs, drying, and freezing, among others. The survey showed that the price of the vegetables increased significantly with every value-added. For example, the value of kale increased from KES 20 (USD 0.2) per 400-g bunch to KES 90 for 250 g of shredded/packaged kales and KES 250 for 100 g of the solar-dried form. Solar drying is the standard value-addition option for AIVs, such as cowpeas, black nightshades, and leafy amaranth. Like the exotic kales, 100 g of solar-dried AIVs retail for KES 250. Generally, the uptake of dried vegetables (AIVs or exotic) is deficient, which is attributed to the negative consumer perception of dried vegetables. This paper explores various value addition options for selected vegetables to enhance access, availability, and convenience for urban consumers. The preservation of the vegetables' nutritional, safety, and physical quality attributes is vital in choosing and applying the various value addition options. Commercialization of value-added products, particularly in the case of AIVs, requires a market study to determine the willingness of the targeted consumers to pay.

Traditional vegetable value chains: A gendered analysis of perceptions of labor, income and expenditure in producers' and traders' households. Gundula Fischer[1], Justus Ochieng[2], Henry Mvungi[2], and Nicolas Patt[3]. [1]International Institute of Tropical Agriculture, Arusha, Tanzania; [2]World Vegetable Center-Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. [3]Centre for Rural Development (SLE), Humboldt-University of Berlin, Germany. Email: G.Fischer@cgiar.org

Horticulture is one of the fastest-growing subsectors of agriculture in Tanzania. Gender relations in vegetable producing and trading households must be understood to make value chain development equitable. This study, carried out in northern and central Tanzania, is based on data from surveys, focus group discussions, and semi-structured interviews. We investigated the perceptions of men and women traders and producers concerning labor participation in the value chains of traditional vegetables and corresponding income and expenditures. Farmers reported more balanced intra-household labor arrangements paired with less balanced income and expenditure. At the same time, traders indicated less balanced labor contributions that went hand in hand with more balanced shares of benefits. Farmers related limited household development to imbalances in benefits and a lack of trust and cooperation between spouses. We emphasize the importance of gender-transformative approaches in agricultural value chains.

Production and utilization of African traditional vegetables in Madagascar. Ritha Luoga[1], Sognigbe N'Danikou[1], Justus Ochieng[1,2], Pepijn Schreinemachers[3], Bodovololona Rabary[4], Denis Randriamampionona[5], Tendro Radanielina[5], Maarten van Zonneveld[6], and Fekadu Dinssa[1]. [1]World Vegetable Center-East and Southern Africa. PO Box 10 Duluti, Arusha, Tanzania. [2]Bayesian Consulting Group, PO Box 44817, 00100, Nairobi, Kenya. [3]World Vegetable Center-South and Central Asia, PO Box 1010, Bangkok 10903, Thailand. [4]Centre Régional de Recherche FOFIFA, BP 230, 110 Antsirabe, Madagascar. [5]AT2D, Université d'Antananarivo, BP-175, Antananarivo. 101- Madagascar. [6]World Vegetable Center, PO Box 42, Shanhua, Tainan 74199, Taiwan. Email: ritha.luoga@worldveg.org

African traditional vegetables (ATVs) are nutrient-rich and affordable sources of food contributing to healthier diets in sub-Saharan Africa. Madagascar is home to many ATVs, yet the country has high malnutrition rates, with 48.9% stunting among children and anemia affecting 36.8% of women of reproductive age. Against this background, the objective of this study was to understand the production and utilization of ATVs in Madagascar. Farm household surveys were conducted in Antsirabe and Itasy, two vegetable-producing regions. A total of 396 randomly selected women were interviewed. The most common ATVs were leafy amaranth, African nightshade, blackjack (*Bidens pilosa*), and African eggplant. On average, 647 m2 was allocated for vegetable production per household. Vegetable diversity at the household level was low, with an average of five vegetable types for both cultivated and wild species. Households consumed an average of 70 g of vegetables per person per day, which is below the recommendation of the World Health Organization of 3 servings (240 g) per day. About 78% of the households ranked ATVs as having a minor contribution to their income. On average, households earned 20 USD per season from selling African eggplant and 25 USD from African nightshade. Pests, diseases, and lack of markets were the main constraints to vegetable production. There is a need to raise people's awareness of the nutritional and economic value of ATVs. Capacity building on ATVs' production, handling, and marketing could enhance utilization.

Farmers' knowledge, attitudes and practices regarding production, preservation and utilization of African leafy vegetables in western Kenya. Charity Muchoki[1], Jasper Imungi[1], and Solomon Shibairo[2]. [1]Department of Food Technology and Nutrition, University of Nairobi, PO Box 30197-00100, Nairobi, Kenya. [2]Kibabii University, PO Box 1699-50200, Bungoma, Nairobi, Kenya. Email: charity.muchoki@yahoo.com

Many African leafy vegetables are grown and consumed in the western region of Kenya. They include spider plant (*Cleome gynandra*), black nightshade (*Solanum* spp.), pumpkin leaves (*Cucurbita* spp.), cowpea leaves (*Vigna unguiculata*), amaranths (*Amaranthus* spp.), jute mallow (*Corchorus olitorius*), slenderleaf (*Crotalaria brevidens*), and Ethiopian kale (*Brassica carinata*). Though nutritionally superior to exotic vegetables, people have neglected them in favor of exotic vegetables. This negligence, coupled with widespread poverty, poor feeding habits, and over-reliance on starchy foods, has triggered persistent high malnutrition and micronutrient deficiencies. In the recent past, however, various organizations have started to promote these vegetables. To promote these vegetables, a study was conducted to determine the farmers' knowledge, attitudes, and practices regarding the production, preservation, and utilization of African leafy vegetables in western Kenya. Purposeful and random sampling strategies were used to identify participants from farmers' groups. Twelve gender-disaggregated focus group discussions were held, six groups in each county. Many sources of knowledge were identified, led by family/neighbors/friends/relatives, followed by various institutions. The participants identified 19 different vegetables which are consumed in western Kenya. Thirteen vegetables were encouraged in some focus groups for health benefits. They include leaves of amaranth, jute mallow, arrowroot (*Colocasia esculenta*), vine spinach (*Basella alba*), spider plant, African nightshade, Capsicum pepper, pumpkin, Ethiopian kale, moringa (*Moringa oleifera*), bean (*Phaseolus vulgaris*), cassava (*Manihot esculenta*), and shirietso (*Erythrococca bongensis*). Similarly, 12 vegetables were discouraged in other focus groups, primarily due to myths, which partly overlapped with the vegetables identified as beneficial for health. Participants outlined postharvest handling of vegetables for the market and home consumption. Cultivated vegetables were sold and consumed at home, while vegetables harvested in the wild were only used for home consumption. Some participants described how they preserved vegetables for long periods by drying them in the sun. The participants identified any challenges and suggested possible solutions. This information strengthens local development initiatives that are active in this region.

Promotion of African traditional vegetables in Cameroon: the need for a postharvest loss reduction strategy. Regine Tchientche Kamga[1], Guillaume Hensel Fongang-Fouepe[1], Isaac Roger Tchouamo[1], and Victor Afari-Sefa[2]. [1]World Vegetable Center-Cameroon Liaison Office, Yaounde, Cameroon. [2]World Vegetable Center-Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin. Email: reg.kamga@gmail.com

African traditional vegetables (ATV) receive little research attention despite their economic potential, role in ensuring food and nutritional security, and cultural acceptance. The enhancement of ATV value chains requires characterizing the actors involved in the sector and their interactions by identifying and analyzing constraints for innovation in the ATV value chains in Cameroon. Data on ATV value-chain actors was collected through focus group discussions with producers from the south and southwest regions. A Venn diagram was used to identify actors with direct or indirect relations with producers. The actors identified as directly active in the ATV value chain were invited to a one-day multi-stakeholder participatory

workshop at each site. The study revealed that the ATV value chain is short and poorly developed. Only five main actors interacting directly were identified: producers, retailers, agro-dealers, consumers, and transporters. All the actors identified the ignorance of storage and processing techniques as the primary constraint for innovation in the ATV value chain. An innovation platform was set up to address these constraints due to the research action process described above. This innovation platform's reduction of ATV postharvest losses is thus the entry point. ATVs are often sold at a loss during the season of availability, hence the need for an appropriate postharvest loss reduction strategy.

SESSION 3: AGRONOMY AND PRODUCTION SYSTEMS

CONTRIBUTING SPEAKERS

Extrapolation suitability for improved vegetable technology packages in Babati and Karatu districts of Tanzania. Francis Muthoni[1], Justus Ochieng[2], Inviolate Dominic[2], and Jean-Marc Delore[3]. [1]IITA-Tanzania, Arusha, Tanzania. [2]World Vegetable Center, East and Southern Africa. PO Box 10, Duluti, Arusha, Tanzania. [3]Wageningen University & Research, Wageningen, The Netherlands. Email: F.Muthoni@cgiar.org

Land suitability assessment provides a way to match crop requirements with available natural resources to promote sustainable agricultural productivity. A recent study based on on-farm trials in Babati district demonstrated that improved vegetable cultivars grown under integrated management practices (IMP) doubled yield and net income compared to conventional farmers' practices. One of the challenges for extension agencies is to scale out proven IMP for vegetable cultivars. In this study, biophysical conditions of the trial sites where the improved vegetable technology packages showed a low yield gap and high net income were used as reference sites to identify other potentially suitable sites for extrapolating improved tomato (*Lycopersicon esculentum* 'Tengeru 2010') and African eggplant (*Solanum aethiopicum* 'Tengeru white'). Input variables include remote sensing data representing biophysical conditions that limit the productivity of these two vegetables. The extrapolation suitability index (ESI) for the two cultivars is generated by comparing the dissimilarity between biophysical conditions encountered at the reference trial sites to those of the wider extrapolation area. ESI maps identified areas where the improved vegetable cultivars under IMP can be extrapolated with a potentially low risk of failure in Babati and Karatu districts. A map has been generated showing the most limiting factor for each cultivar at each grid cell to guide the targeting of appropriate management practices, especially for areas with sub-optimal biophysical conditions. Maps generated from this study can support the setting of multi-location trials to test further the adaptability of improved cultivars and management practices within specific biophysical contexts.

Adapting fluted pumpkin for greenhouse cultivation: How much water do the plants need? Isaac Aiyelaagbe and Ajoke Oyeniyi. Department of Horticulture, Federal University of Agriculture, PMB 2240 Abeokuta, Nigeria. Email: ola_olu57@yahoo.com

Fluted pumpkin (*Telfairia occidentalis* Hook F.) is a traditional leaf vegetable in high demand in urban centers in Nigeria. This necessitates research on intensification for all-year-round production, such as adaptation to protected cultivation. A study at the said university (7°15'N, 3°25'E) was conducted twice to determine its irrigation needs under protected cultivation. Three-week-old seedlings of fluted pumpkin

potted in sandy soil received 0.25, 0.50, 0.75, and 1.0 L water/plant/week for 12 weeks. In the first trial, the effects of irrigating with 1.0 L water/plant/week did not differ significantly from those of 0.75 L water/plant/week regarding vine length and the number of leaves. However, it elicited significantly higher foliar N and Mg content and total dry matter accumulation than 0.75 L water/plant/week. In the second trial, the effects of irrigating with 1.0 or 0.75 L water/plant/week on vine length and the number of leaves were as in the first trial. However, their effects on root length, dry matter accumulation, and foliar P and Ca content did not differ significantly. In both trials, irrigation with 0.25 L water/plant/week produced significantly shorter vines, fewer leaves, shorter roots, less dry matter, and foliar P than those irrigated with 1.0 L water/plant/week. Since the effects of 0.75 L water/plant/week were often at par with those of 1.0 L water/plant/week, an irrigation rate of 0.75 L water/plant/week is recommended for the greenhouse cultivation of fluted pumpkins in southwest Nigeria.

Participatory evaluation of introduced African traditional vegetables by women farmers in Madagascar: opportunities and challenges. Bodovololona Rabary[1], Tatiana L. Rakotoson[1], Lalaina B. Ranaivoson[2], Andrianajoro Rakoto[1], Andotiana Andrianarivony[1], Justus Ochieng[3,4], Juvet Razanameharizaka[5], Tendro Radanielina[5], Herimiamina Andriamazaoro$_2$, Denis Randriamampionona$_5$, Ritha Luoga[3], Marteen van Zonneveld[6], and Sognigbe N'Danikou[3]. [1]Centre Régional de Recherche FOFIFA, BP 230, 110 Antsirabe, Madagascar. [2]Centre FOFIFA, BP 1690, 101 Antananarivo, Madagascar. [3]World Vegetable Center-East and Southern Africa. PO Box 10, Duluti, Arusha, Tanzania. [4]Bayesian Consulting Group, PO Box 44817, 00100, Nairobi, Kenya. [5]AT2D, Université d'Antananarivo, BP-175, Antananarivo. 101- Madagascar. [6]World Vegetable Center, PO Box 42, Shanhua, Tainan 74199 Taiwan. Email: bodo.rabary@gmail.com

African traditional vegetables (ATVs) are nutritious, easy to grow, and hardy. In Madagascar, local or wild leafy vegetables are prevalent. Some of them, such as *Galinsoga parviflora* and *Bidens pilosa*, remain in the wild, picked and sold when needed. For amaranths, there are no cultivated species. Wild amaranths are only used for feeding pigs. The objectives of this study were: 1) to assess the adaptation of these ATVs (i.e., amaranths, African nightshade, African eggplant, Ethiopian mustard) to the local growing conditions of women and to understand their appreciation for these vegetables; and 2) to estimate their potential in improving nutrition and as a source of income. A participatory survey was conducted in Itasy and Antsirabe regions. Seed kits of 12 species of ATVs were introduced from the World Vegetable Center in 2019 and shared with 200 women: 4 varieties of African nightshade, five varieties of amaranth, 1 African eggplant, and two varieties of Ethiopian kale. The results showed that the introduced vegetables could adapt well to the local growing conditions. The germination rate was fair (76% of the described species had more than 75% germination rate). The mortality rate was low (84% had less than 25%). However, about 40% of the women had difficulties with poor soil fertility and insect attacks, especially on Ethiopian kale. Watering was also an issue for 18% of the seed kit recipients. The taste of the ATVs was highly appreciated though the preferences differed. Nightshade species, already familiar in Madagascar, are the most sold. These new ATVs have great potential for improving household nutrition and income.

SESSION 4: FOOD ENVIRONMENTS

CONTRIBUTING SPEAKERS

A renaissance on the plate: A look back at Bioversity International's research and promotion of African leafy vegetables. Danny Hunter. Bioversity International, Rome, Italy. Email: d.hunter@cgiar.org

Bioversity International has a long-standing commitment to promoting the conservation and use of the enormous reservoir of the diversity of Africa's traditional edible plants, going back many decades to the present. African leafy vegetables - vital for food security, nutrition, and poverty alleviation - represent a significant component of Africa's traditional food basket and have been a focus of Bioversity International's work in several countries. This has established essential partnerships and networks between researchers and development specialists linking the conservation of African leafy vegetables' genetic resources to development outcomes. Multi-sectoral and cross-disciplinary approaches, based on community partnership and combining indigenous and scientific knowledge, have successfully identified suitable entry points to better mainstream African leafy vegetables into food systems for improved nutrition and well-being. This presentation focuses on the work which Bioversity International has undertaken on African leafy vegetables to explore their nutritional diversity; link farmers and farmer organizations to markets; reconnect consumers to traditional foodways through the revival of traditional recipes and cooking demonstrations; enhance community awareness through diversity and food fairs; promote nutrition and health education; build capacity; and strengthen policy advocacy. It focuses on more recent work using schools as a platform to promote dietary diversity and healthy eating habits among schoolchildren by integrating African leafy vegetables into school gardens and school meals.

Evolution of culturally-bound preferences for traditional vegetables in East Africa. Bronwen Powell[1,2]. [1]Department of Geography, Pennsylvania State University, State College, PA, 16802, USA. [2]Center for International Forestry Research, Bogor, Indonesia. Email: bxp15@psu.edu

While food aversions are primarily innate, preferences are strongly shaped by culture. We generally know little about how cultural food preferences have evolved, except for a few cases of co-evolution between diets and human genetics. In East Africa, preference for bitter or slimy vegetables is a marker of ethnic group identity. To better understand if and how traditional dietary practices are adaptive for human health and well-being, we examine the factors associated with preference for and use of slimy and bitter vegetables for 73 East African ethnic groups. Ethnic groups with a strong preference and consumption of bitter vegetables all live in areas with a high malaria prevalence. Most ethnic groups who prefer slimy vegetables speak a Nilotic language but are not pure pastoralists (i.e., they also practice some form of agriculture). Both slimy and bitter vegetables may have biologically beneficial properties: losing these culturally-bond traditional foods could negatively affect health and nutrition. The results of this study should support further inclusion of traditional vegetables in nutrition education and programs.

Pathways to improved food and nutrition security of the poor: The promise of African indigenous foods and technologies. S.E. Schoustra[1,2], F. Rampa[3], E.G. Lammers[4], A.R. Linnemann[1], and D. de Winter[5]. [1]Wageningen University & Research, Wageningen, The Netherlands. [2]Department of Food

Science and Nutrition, University of Zambia, Lusaka, Zambia. [3]European Centre for Development Policy Management, Maastricht, The Netherlands. [4]Independent researcher, The Netherlands. [5]DBMResearch, The Netherlands. Email: sijmen.schoustra@wur.nl

Local and indigenous foods have a great potential to contribute to improved food and nutrition security and economic empowerment for poor and marginalized farmers and consumers in sub-Saharan Africa. Better knowledge is needed on the production, processing, and marketing opportunities of valuable indigenous crops and foods. In addition, policymakers need to come on board. They play an important role in promoting value chains that include poor, rural, and female farmers and producers who aspire to bring these nutritious indigenous foods to a broader market. However, to capitalize on all these opportunities, indigenous foods need to become part of policymaking. Local and national policymakers in the project countries showed interest, especially when there were positive market prospects. However, because "money talks," the project results stress that in liaising with policymakers, critical questions must be raised about who will benefit from promoting indigenous foods - smallholders or commercial producers. Women or men? Rural or urban consumers? - and how this can best be achieved, considering formal versus informal value chains, production for the rural or urban market, or domestic consumption or export. Openly and critically discussing the political and market dynamics and trade-offs are vital to ensuring that the promotion of indigenous foods will, first and foremost, benefit the food and nutrition security of the poor and marginalized.

A sustainable food systems approach to integrate African traditional vegetables in Nakuru, Kenya, and Arusha, Tanzania. K. Dekeyser[1], C. D'Alessandro[1], F. Rampa[1], J. Msuya[2], H. Knaepen[1], and P. Bizzotto Molina[1]. [1]European Centre for Development Policy Management, Maastricht, The Netherlands. [2]Department of Food Sciences and Technology, Sokoine University of Agriculture, Morogoro, Tanzania. Email: kde@ecdpm.org

Food systems worldwide and in Africa face unprecedented environmental, social, and economic challenges and demands. More robust integration of African traditional vegetables (ATVs) in food systems can result in better nutrition, livelihood opportunities, and environmental sustainability. However, the crucial role of supporting environments necessary for these benefits to materialize is highly context-specific and less understood. The multidisciplinary Sustainable Agrifood Systems Strategies (SASS) project analyzed the potential economic, social, and environmental outcomes of a more robust ATV integration in Nakuru, Kenya, and Arusha, Tanzania. This included agronomic, biologic, anthropologic, nutritional, and political economy analysis based on a food system approach over two years. We present several 'pathways' focused on maximizing the sustainability benefits of better-integrated ATVs through governance, production, distribution, and consumption changes. The trade-offs and synergies of each pathway are presented in combination with likely local stakeholder coalitions - based on political economy analysis - and existing policy processes. Furthermore, the pathways were co-produced through the active involvement of stakeholders, which increases local relevance and, ultimately, uptake. As such, the SASS project not only tested the food systems approach but also described the structure and sustainability features of the studied food systems. This project also explored the conditions for ATVs to materialize their benefits and develop pathways that informed and mobilized stakeholders.

SESSION 5: NUTRITION AND HEALTH

INVITED SPEAKER

From royalty to pauper, and back again? Lawrence Haddad and Saul Morris. Global Alliance for Improved Nutrition (GAIN), Brighton, Brighton and Hove, UK. Email: lawrence.haddad@gainhealth.org

Vegetables are critically under-consumed in sub-Saharan Africa (SSA), whether traditional or 'modern.' On the demand side, affordability may be part of the reason - fruit and vegetables are generally more expensive than starchy staples. However, vegetables, particularly African traditional vegetables (ATVs), are an inexpensive source of micronutrients. The promotion of production and consumption of ATVs is an exciting business opportunity that would be good for the planet and good for people's health. To realize the potential of ATVs, three factors need to be present: demand generation, supply response, and creating an enabling environment to boost supply and demand. On the demand side, differences in vegetable consumption between low- and high-income groups in SSA are generally low. Creating demand is, therefore, critical. This will require shifting norms and borrowing marketing savviness from the private sector to make consuming vegetables a desirable proposition. On the supply side, vegetable yields are generally meager in SSA, and accessibility to food vendors selling vegetables may be a critical factor in urban contexts. Boosting supply will require innovation and investing in raising yields and reducing food losses. An enabling environment and conducive policies to promote the production and consumption of ATVs are primarily absent in SSA. Vegetables, in general, are neglected, including in international agricultural research. As a result, the knowledge base on ATVs, both on the supply and demand side, is thin. The potential seems good for ATVs to promote nutrition, biodiversity, and resilience. However, leadership in multiple domains is required to realize that potential.

CONTRIBUTING SPEAKERS

Bioactive compounds from *Ceratotheca sesamoides*: a neglected vegetable from Nigeria. Oluwasesan M. Bello[1,2,3], Pius S. Fasinu[4], Zulfiqar Ali[3], Ahmed A. Zaki[3], Ikhlas A. Khan[3,5], Usman L. Ajao[2], and Oguntoye S. Olubunmi[2]. [1]Department of Applied Chemistry, Federal University, Dutsin-Ma, Katsina State, Nigeria. [2]Department of Chemistry, University of Ilorin, Kwara State, Nigeria. [3]National Center for Natural Products Research, University, MS 38677, USA. [4]College of Pharmacy & Health Sciences, Campbell University, Buies Creek, NC 27506, USA. [5]Division of Pharmacognosy, Department of BioMolecular Sciences, School of Pharmacy, University of Mississippi, University, MS 38677, USA. Email: obello@fudutsinma.edu.ng

The leaves and flowers of *Ceratotheca sesamoides* are consumed as a traditional vegetable in West Africa. The plant is also used to manage stomach aches, aphrodisiac, conjunctivitis, diarrhea, jaundice, pain, snake bites, and skin ailments. However, little is known about its phytochemistry or its biological evaluations. Methanolic extracts of dried leaves of the plant were subjected to fractionation and isolation using vacuum layer and column chromatography techniques. The structures of the isolated compounds were elucidated using spectroscopic techniques including IR, 1D-, 2D-NMR and high-resolution electrospray ionization mass spectrometry by docking with Schrodinger software. They were then bio-assayed in vitro with different laboratory techniques. Ten compounds isolated are 6β-hydroxyloganin, phlomiol, lamalbid, adenosine, 3-methylpentylbenzoate, decaffeoylceratoside, diosmetin-7-0-glucoronide, ceratoside b,

ceratothecine, and vitexoside 2. The latter three are new compounds. Ceratothecine, a new pyrimidine, displayed a fair selective activity against monoamine oxidase (MAO) B (1C50 (µg/mL) of 86.2) to MAO-A (1C50 (µg/mL) of >100). 6β-hydroxyloganin showed good inhibition against kidney fibroblast with IC50 (µg/mL) of 8.9, while ceratothecine (47) displayed the least activity with IC50 (µg/mL) of 57.9. Vitexoside 2 and 6β-hydroxyloganin exhibited good antifungal activity against *Candida albicans* with IC50 (µg/mL) of 21.6 and 26.0, while ceratothecine and 6β-hydroxyloganin displayed good activity against *Aspergillus fumigatus* with IC50 (µg/mL) of 23.50 and 31.5. This study provided insight into the phytochemical profiles and pharmacological importance of *C. sesamoides* beyond fundamental nutritional values. *C. sesamoides* could play a protective role against diseases after a thorough clinical examination of the isolates from the plants.

Indigenous vegetables in Ghana: distribution and consumption patterns. R.A. Atuna, F. Amagloh, L. Dari, J. Djah, S. Bakker, I. Koomen, G.K. Mahunu, and M. Osei-Kwarteng. SNV, Ghana. Email: ratuna@uds.edu.gh

Indigenous vegetables (IVs) may make up a limited proportion of the greens consumed in Ghana as locally produced exotic types dominate the market. These IVs could be essential sources of nutrients to improve the nutrition security of most rural dwellers, usually with relatively high nutritional deficiencies. A cross-sectional descriptive survey (Google forms, n=345; and at a community level, n=1028) was used to assess the types of IVs, their frequency of consumption, preparation preferences, and the potential benefits ascribed to them by consumers. The survey included respondents from each of the sixteen regions in Ghana. The most common IVs consumed were cocoyam leaf, jute mallow, baobab leaf, African eggplant, okra, roselle (*Hibiscus sabdariffa*), and kenaf (*H. cannabinus*). Among the vegetables consumed daily, the selected IVs constituted, on average, 46%. The respondents consuming IVs daily varied per region, from 0.36% (Savannah) to 5.2% (Upper West). Daily consumption of IVs was 33% (teenagers); 36% (youth); 31% (adult) and 37% (aged) per each group. The IVs were generally wet-cooked and consumed as a stew (sauce) or soup, and this may have implications on nutrient availability in terms of losses and bioavailability. Some reasons for not consuming IVs were non-availability, lack of (economic) access, and non-familiarity. Consumption of IVs was reported to "give blood," "give energy and strength," and aids digestion. Generally, the consumption of IVs is relatively low compared with the exotic types. A catalog of selected IVs will be developed to increase and disseminate knowledge on their nutrition and health benefits.

Enhancing the nutritional quality of vegetable amaranth through specific food preparation methods. Winnie Nyonje[1], Wan-Jen Wu[2], Mary Abukutsa-Onyango[1], Anselimo Makokha[1], Willis Owino1, and Ray-Yu Yang[2,3]. [1]Jomo Kenyatta University of Agriculture and Technology, Kenya. [2]World Vegetable Center, PO Box 42, Shanhua, Taiwan. [3]Food and Fertilizer Technology Center for the Asian and Pacific Region, Taiwan. Email: ray-yu.yang@fftc.org.tw

Food preparation methods applied to African traditional vegetables vary greatly depending on the preferences of various consumers. Amaranth is one of the most preferred vegetables, with high nutritional quality, especially high iron content. However, iron's bio-accessibility is low since it is non-heme and, in most cases, reduced due to anti-nutrients such as oxalates. This study aimed to evaluate the nutrient retention of amaranth vegetable dishes prepared using selected Kenyan traditional recipes and enhance

the iron bioavailability of amaranth dishes using food preparation methods. Nutrient retentions of amaranth prepared by three standard food methods were analyzed. In-vitro iron bioavailability of amaranth dishes with and without bioavailability enhancers and an amaranth meal, including common staple food, "ugali," were studied. The nutrient retention of the dishes used in this study was fairly high, with at least 85% retention of minerals and an increase of up to 45% in three carotenoids. We conclude that incorporating vitamin C into an iron-rich vegetable and boiling the vegetable significantly improves the iron bioavailability and hence improves the iron uptake by the body. Incorporating lemon juice enhanced dialyzable iron of the selected recipe by up to 66%. There was also no significant ($P \leq 0.05$) effect by the amaranth components on the iron bioavailability of "ugali." These methods could therefore be incorporated into household recipes to increase micronutrient intakes.

Year-round supply of affordable, nutritious foods for low income consumers through commercialization of dried African indigenous vegetables. Mercy Mwende. Sweet and Dried Enterprises Limited, Nairobi, Kenya. Email: sweetndried@gmail.com

African indigenous vegetables (AIVs) play an important role in food and nutrition security in Kenya for both rural and urban poor. Although the benefits of AIVs (for nutrition and household incomes- especially for women) are undisputed, there are several challenges in the value chain. Key among them is the seasonality of production and the high post-harvest losses. In Kenya, AIVs are produced mainly during the rainy season. A glut happens for very short periods (a few months during the year), after which the vegetables are unavailable or whatever is available is out of reach for the majority of the low-income consumers due to their high prices. Sweet and Dried Enterprises Ltd., based in Tharaka-Nithi county in Kenya, is a woman-owned agro-processing enterprise specializing in processing fruits, vegetables, and grains into dried products and assorted flours. Through a portfolio of public-private partnerships supported by the 2SCALE program, the company has expanded its vegetable range to include AIVs such as nightshade, spider plant, amaranth, cowpea leaves, and pumpkin leaves. Post-harvest losses of AIVs during the high production season have been reduced through value addition such as drying, which extends the shelf-life to as long as 12 months from a mere seven days. This, in turn, has made AIVs available throughout the year at relatively stable prices affordable to the bottom of the pyramid markets. The reduction in post-harvest losses is expected to improve incomes for smallholder farmers while the processing provides stable employment opportunities for women and youth employed at the factory.

Factors influencing consumption patterns of African leafy vegetables in western Kenya. M. Odendo, C. Ndinya-Omboko, E. Onyango, and F. Wayua. Kenya Agricultural and Livestock Research Organization, PO Box 169-50100, Kakamega, Kenya. Email: odendos@yahoo.com

African leafy vegetables (ALVs) contribute significantly to household food and nutrition security by adding diversity to cereal-based staple diets. However, the consumption patterns of the ALVs and factors that influence preference for ALVs in Kenya remain unclear. The objectives of this study were to evaluate the frequency of household consumption of ALVs and assess factors that influence preference for ALVs. Primary data were collected from a random sample of 324 households in western Kenya using a semi-structured questionnaire between June and July 2018. Data were collected on the frequency of consumption of ALVs and reasons for preference ALVs and analyzed using descriptive statistics. The results showed that 40-50% of the households consumed one or more ALVs per week. Spider plant was

the most frequently consumed daily by 36% of the households, followed by amaranth (32%). Cowpea was the most frequently consumed in the three or more times/week category by 29% of households. The main reasons for the low frequency of ALV consumption were seasonal availability on farms (64%), high ALV prices in the local market (54%), and undesired taste associated with recipes used in cooking (42%). However, perception of health and medicinal values of ALVs influenced consumption by 48% and 51% of the households, respectively. The findings of this study call for the need to facilitate farmers to access critical inputs, significantly improve seed and water to minimize seasonal production, and conduct behavior change communication to promote the consumption of ALVs.

Identifying culturally specific nutrition interventions in Kenya to increase consumption of African indigenous vegetables. Emily V. Merchant[1,2], Martins Odendo[3], Christine Ndinya[3], Naman Nyabinda[4], Eunice Onyango[3], Norah Maiyo[4], Daniel J. Hoffman[5], and James E. Simon[1,2]. [1]Dept. Plant Biology and New Use Agriculture and Natural Plant Products Program, Rutgers University, New Brunswick, NJ 08901, USA. [2]Center for Agricultural Food Ecosystems, New Jersey Institute for Food, Nutrition, and Health, Rutgers University, New Brunswick, NJ 08901, USA. [3]Kenya Agricultural and Livestock Research Organization, PO Box 169, 50100, Kakamega, Kenya. [4]Academic Model Providing Access to HealthCare (AMPATH), PO Box 4606, 30100, Eldoret, Kenya. [5]Center for Childhood Nutrition Education and Research Program in International Nutrition, Rutgers University, New Brunswick, NJ 08854, USA. Email: evr.merchant@rutgers.edu; jimsimon@rutgers.edu

Malnutrition is an increasing concern in sub-Saharan Africa (SSA). African indigenous vegetables (AIVs) can contribute to SSA's household food and nutrition security. The objective of this study, as part of the larger USAID Feed the Future grant *Improving Nutrition with African Indigenous Vegetables in Zambia and Kenya*, was to identify culturally appropriate nutrition interventions to increase household consumption of AIVs. This study utilized a mixed methods approach. Researchers collected quantitative data through a questionnaire-style interview administered by trained field enumerators in the regional language (n=500) and qualitative male and female focus groups (n=7). All quantitative analyses were conducted using the IBM SPSS Statistics version 26. The focus group notes were open-coded and organized based on key themes related to the impact pathway using NVivo (Version 12). In Kenya, 10% of respondents' dietary diversity scores fell below the minimum threshold, and 13% experienced some level of household hunger. The qualitative and quantitative research tools further identified drivers and barriers to AIV consumption. Respondents noted AIV health benefits (94%) and improved recipes (93%) as a motivator for consuming AIVs in the household. The focus groups listed ease of preparation, abundance, affordability, and health as motivators for consuming AIVs. Among survey respondents, 33% mentioned nightshade, 16% mentioned cowpea leaves, and 14% mentioned spider plants as their preferred AIVs. The Conceptual Pathway between Agriculture and Nutrition was used to identify an intervention package that was subsequently delivered at the household and community level. In addition, the culmination of this intervention package led to the development of culinary skills and a recipe book.

SESSION 6: BEYOND FOOD

INVITED SPEAKER

African traditional vegetables: From health and nutrition to income generation. James E. Simon[1,2], and with Stephen Weller[3], Daniel Hoffman[4,2], Ramu Govindasamy[5], Xenia K. Morin[1,2], Emily V. Merchant[1,2], Fekadu F. Dinssa[6], Emil Van Wyk[7], David Byrnes[1], Martins Odendo[8], Christine Ndinya[8], Henry H.A. Mvungi[6], Justus Ochieng[9], Norah Maiyo[10], Mebelo Mataa[11], John Shindano[11], Himoonga Bernard Moonga[11], J. Steve Yaninek[12], Qingli Wu[1], Rodolfo Juliani[1], Dena Seidel[1], Lara Brindisi[1], Surendran Arumugam[5], Naman Nyabinda[10], Victor Afari-Sefa[13], [1]New Use Agriculture & Natural Plant Products Program, Department of Plant Biology, Rutgers University, 59 Dudley Road, New Brunswick, NJ 08901, USA, [2]Center for Agricultural Food Ecosystems, New Jersey Institute for Food, Nutrition, & Health, Rutgers University, 61 Dudley Road, New Brunswick, NJ 08901, USA, [3]Dept. Horticulture & Landscape Architecture, Purdue University, West Lafayette, IN 47907, USA, [4]Dept. Nutritional Sciences, Program in International Nutrition; New Jersey Institute for Food, Nutrition, and Health, Center for Childhood Nutrition Education and Research, Program in International Nutrition, Rutgers University, New Brunswick, NJ 08901, USA, [5]Department of Agricultural, Food & Resource Economics, Rutgers University, 55 Dudley Road, New Brunswick, NJ 08901, USA, [6]World Vegetable Center (Worldveg), Eastern & Southern Africa, P. O. Box 10, Duluti, Arusha, Tanzania, [7]AgriSmart, Lusaka, Zambia, [8]Kenya Agricultural and Livestock Research Organization (KALRO), P.O. Box 169, Code: 50100, Kakamega, Kenya, [9]World Food Programme (WFP) P.O Box 44482-00100, Nairobi, Kenya, [10]Academic Model Providing Access to Health Care, P. O. Box 4606, code: 30100, Eldoret, Kenya, [11]University of Zambia, School of Agricultural Sciences, P.O. Box 32379, Lusaka, Zambia 10101, [12]Dept. Entomology, Purdue University, West Lafayette, IN 47907, USA, [13]World Vegetable Center, West and Central Africa-Coastal and Humid Regions, IITA-Benin Campus, 08 BP 0932 Tri Postal, Cotonou, Benin. Email: jimsimon@rutgers.edu

Food insecurity directly impacts about a third of the world's population and perpetuates a cycle of hunger and malnutrition that is inherited through generations. The prevalence of micronutrient deficiencies continues to remain alarmingly high in sub-Saharan Africa while dietary diversity, in general, remains low. One potential solution to undernutrition is to promote the consumption of African traditional vegetables (ATVs), those indigenous or naturalized plants that are rich in vitamins, minerals and health-promoting phytochemicals. From a genetics and commodity group of plants, the ATVs are considered as orphan and minor crops, undervalued and underrecognized. Yet, these plants, often found growing in the wild in poor soil, are inherently climate resilient and well adapted to the African landscape. Our research has shown these ATVs are rich sources of vitamins and minerals found to be lacking in the diets of many in sub-Saharan Africans. To break the cycle of food insecurity, poverty, and hunger, over the last 20 years we have developed a transferable holistic model that uses a market-first science-driven approach and builds upon local ecosystem and cultural knowledge. Embedded into this seed-to-plate model is a community lead entrepreneurship focused on commercialization and production for family use. Introduced to several sub-Saharan African countries, this model includes agribusiness and technical skills training to strengthen the participation of farmers and local entrepreneurs, particularly women and youth, in profitable value chains. Applying this approach to NonTimber Forest Species, Botanicals (spices and medicinals), fresh market European type vegetables, and now to African traditional vegetables, we have successfully demonstrated how this approach improves access to, availability of, affordability and

adoption of production and consumption of African traditional vegetables. This model has consistently generated real income for families at the community level as local products enter informal and formal markets regionally and internationally. This overview will summarize the research and development activities of a diverse group of stakeholders and scientists and social scientists who came together to improve management, production, distribution, and consumption of nutritious ATVs in sub-Sahara Africa. We hypothesized that good management techniques, including the use of improved germplasm, along the value chain from seed to consumption would be essential to improving access and availability of AIVs for food and income insecurity. In parallel, we hypothesized that by increasing the supply of nutrient dense ATVs into the local markets, and by empowering women, who are the major decision makers on household diets, the sales of ATVs would increase the availability, accessibility, and consumption of vegetables, conferring various micronutrients and health-relevant phytochemicals to both the farming and nonfarming consumer communities. We have found the greatest income generation opportunities and the lowest barriers to market entry are with local sales and markets. We also observed greater acceptance and interest in producing and consuming the ATVs when coupled with improved workshops on cooking and food preparation and recipes developed by local communities. Favorable and enabling public policies that support and provide incentives to growers, researchers and industry, coupled with educational awareness programs that can impact and change behavior of growers, consumers, and buyers/traders and retailers can foster and alter the current paradigm and increase the access, availability, affordability and adoption (production and consumption) of these nutrient-rich African traditional vegetables. Market-first, science-driven solutions that combine concepts from food security and food sovereignty discourse need to incorporate a community resiliency framework that rebuilds local economies, regenerates ecosystems, and mitigates climate impact. This model engages farmers and consumers directly in the formulation of the research agenda and actively involves them in the process of technological innovation and dissemination through hands-on demonstrations and storytelling that captures shared experiences, strengthening local community resilience and improving nutrition outcomes.

POSTER ABSTRACTS: ALPHABATICAL ORDER BY POSTER TITLE

A review of taxonomic inventory of vegetable amaranths in Ghana and an outlook on characterization of local amaranth species for farmers. M. Osei-Kwarteng[1] and D.M. Brenner[2]. [1]Department of Horticulture, University for Development Studies, PO Box TL 1882, Tamale, Ghana. [2]Department of Agronomy, Plant Introduction Station, Iowa State University, Ames, IA 50011, USA. Email: misokwart@yahoo.com

Amaranths (*Amaranthus* spp.) are popular traditional African leafy vegetables that have almost gained the status in some African markets as a mainstream grain and vegetable crop that was earlier categorized as an underutilized vegetable. However, the characterization of the local varieties in national catalogs and herbaria have received inadequate focus from researchers. This makes it difficult to recommend and supply accessions with farmers' desired characteristics. In this review, we aim to achieve two objectives: 1) a preliminary inventory of vegetable amaranth species originating or introduced in Ghana; and 2) to review methods of characterizing germplasm of amaranths and summarize their application to enhance local characterization of vegetable amaranths in Ghana. Objective one will be achieved by employing scientific search engines such as Web of Science, Science Direct, Agricola, Scopus and visiting websites

of germplasm databases such as ECP-GR (European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources) and GRIN-Global (Germplasm Resources Information Network of U.S. Department of Agriculture) published floras and other national catalogs to inventory vegetable and grain amaranths of Ghana. To achieve objective two, we will compile amaranth descriptors from online and published amaranth literature, combined with characteristics of interest to amaranth farmers in Ghana.

Agro-morphological characterization of African traditional vegetables cultivated in the highlands of Madagascar. Tatiana L. Rakotoson[1,4], Bodovololona Rabary[1], Andotiana Andrianarivony[1], Andrianajoro Rakoto[1], Lalaina Ranaivoson[2], Herimihamina Andriamazaoro[3], Tendro Radaniela[5], Juvet Razanameharizaka[5], Denis Randriamampionona[6], and N'Danikou Sognigbe[7]. [1]FOFIFA-CRR Antsirabe, BP 230, Antsirabe 110, Madagascar. [2]FOFIFA-Ampandrianomby, BP 1690, Antananarivo 101, Madagascar. [3]FOFIFA - DRA Ambatobe, PO Box 1444, Antananarivo 101, Madagascar. [4]Institut d'Enseignement Supérieur d'Antsirabe-Vakinankaratra, BP 108, Antsirabe 110, Madagascar. [5]Mention Biologie, Écologie Végétale, Université d'Antananarivo, Madagascar. [6]Mention Agriculture Tropicale et Dévelopement Durable, ESSA, Université d'Antananarivo, Madagascar. [7]World Vegetable Center, Eastern and Southern Africa, PO Box 10, Duluti, Arusha, Tanzania. Email: tatianarakotoson@gmail.com

Malagasy agriculture is mainly characterized by subsistence farming. The smallholder farmers diversify their cropping system to cope with yield uncertainty and ensure their food availability. African traditional vegetables (ATVs) are important in this cropping system. ATVs are easy to grow, have high levels of micronutrients, and could be an important income source for farmer households. The Darwin Initiative project introduced several ATVs accessions to the Malagasy farmers to increase income and improve food and nutrition security. This study aimed to characterize ATV accessions to evaluate their adaptation in Madagascar and to multiply these vegetable seeds for household farmers. Twelve accessions of African nightshade, amaranth, African eggplant, and Ethiopian mustard were characterized on-station at Antsirabe for their agro-morphological traits using a randomized complete block design with three replications in 2019/2020. Data were analyzed using R software. The results indicated distinct and wide variations between accessions. Accessions had a significant variation (α=0.01) on total biomass. Days to flowering, total biomass, stem color, petiole color, leaf blade width and length, stem pigmentation and pubescence, leaf pigmentation, and inflorescence color were the parameters to discriminate the accessions. The tested African traditional vegetables had the potential to be adapted, multiplied, and distributed to household farmers in Madagascar.

Agronomic and yield performance of amaranth varieties based on the common farmers practices. Digna Swai[1] and Somnath Bhattacharya[2]. [1]East-West Seed Tanzania, Kilimanjaro 8204, Moshi, Tanzania. [2]East-West Seed India, Manjalpur, Vadodara-390011. Gujarat State, India. Email: digna.swai@eastwestseed.com

Amaranth is one of Tanzania's critical indigenous and commercially cultivated leafy vegetables. Amaranth grows in adverse conditions and provides high nutritional benefits for human health. Commercial farmers usually grow the crop through broadcasting seeds and reap from its harvest once per growing season. The crop's ability to flower early poses a severe challenge to farmers significantly when the crop exceeds 21-24 days. Once amaranth has developed inflorescences, its consumer quality is reduced, and its value is lowered. This leads to low economic returns. Identifying late flowering amaranth

varieties that align with the farmers' standard practices is essential to ensure good crop performance and high economic returns. An ongoing experiment has been established to compare the agronomic, phenology, and yield performance of 3 introduced and four local varieties of amaranth. The experiment has been laid out in a completely randomized design with three replications, and each variety occupies a plot size of 1 m2. The following data will be collected after 25 days on plot bases: Total biomass of the harvested plants of each variety, leaf size, plant height, and days to flowering. The results will be subjected to a one-way ANOVA in GenStat to identify the best-performing varieties with respect to agronomic, phenology, and yield traits. Identifying the best performing varieties for cultivation is helpful to farmers as they would maximize their return on investment and reduce losses by utilizing varieties.

An ethnobotanical survey on the traditional uses and medicinal perceptions for domesticated and wild-gathered vegetables of the Lugbara community in Arua District, Uganda. M. Eyokia, E. Katuura, C. Obbo, and S.M. Asiao. Kyambogo University, PO Box 1, Kampala, Uganda. Email: eyokiam@yahoo.com

Vegetables are vital for the human diet, playing a significant role in the body as far as their nutritional and medicinal values are concerned. Having a critical look at the vegetable consumption pattern in the current generation, there is a remarkable decline in the consumption of both domesticated and wild vegetables. Indigenous knowledge about vegetables seems to be disappearing due to lifestyle changes. Therefore, this survey was conducted in 2013 in two sub-counties to document the indigenous and introduced domesticated vegetables and wild vegetables, how they are prepared and preserved, and the medicinal values attached to them. Considering women's roles in bringing food to the table, their involvement in maintaining the vegetables throughout the year in rural settings, and income generation activities, men and women were interviewed. Of the individuals interviewed, 15 (21%) were men, while 45 (79%) were women. The age of the respondents ranged from 15-87 years. The study was carried out in two villages; each village had an equal number of respondents randomly selected from homesteads. The study used primary and secondary data sources and applied quantitative and qualitative methods. Results show that this community had many cultivated indigenous and introduced vegetables and wild vegetables. Fifty-six (56) vegetable species distributed in nine families were listed. Different preparation and preservation methods were documented. It was realized that communities preferred indigenous vegetables to the introduced and knew about the nutritive and medicinal values of the vegetables. The younger generation also noted a decreased knowledge of wild vegetables and medicinal attributes compared to the elderly. Women mainly did the collection or maintenance, and cooking of the vegetables. This information helps increase community awareness of the health benefits of vegetable-rich diets.

Characterization of amaranth germplasm in response to bacterial wilt disease caused by *Ralstonia solanacearum*. J. Honfoga[1], K. Azoma[1], V. Afari-Sefa[1], R. Sikirou[2], E. Dossoumou[2], B. Zocli[2], M.L. Paret[3], and W.B. Legesse[4]. [1]World Vegetable Center, West and Central Africa-Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin. [2]Laboratoire de Défense des Cultures, Institut National des Recherches Agricoles du Bénin, Cotonou 01 BP 884, Benin. [3]North Florida Research and Education Center, University of Florida, Quincy, FL 32351, USA. [4]World Vegetable Center, Eastern and Southern Africa, ILRI Campus, Addis Ababa PO Box 5689, Ethiopia. Email: judith.honfoga@worldveg.org

Amaranth is one of sub-Saharan Africa's most produced and consumed African traditional vegetables

(ATVs). Both leaves and seeds are consumed. Increasing consumption and production of amaranth species is facing challenges, including diseases such as the bacterial wilt caused by *Ralstonia solanacearum*. This disease is becoming important and causing farmers a significant yield loss. Therefore, there is a need to select and develop resistant amaranth lines against bacterial wilt for use in infested production areas. This study aims to characterize ten amaranth lines and identify stable sources of resistance to the disease. The experiments were conducted both in an open field and under screenhouse conditions. A randomized complete block design with three replications and ten amaranth lines, including Madiira 1, Madiira 2, BRESIL (B)-Sel, AC-LN, A 2002, AM-NKGN, GARE ES13-7, IP-5-Sel, UG-AMES13-2, Benin local variety were used. To assess germplasm performance, we included the harvesting technique as a variable (cut and uncut plant) to measure its influence on the plant infection level. In field trials, the amaranth lines showed that the disease severity increased over time for a cut and uncut plants, but high attack levels were observed on cut plants. AM-NKGN, UG- AMES13-2, Madiira 2, and the local variety showed a low severity mean (range 1) for uncut plants. In contrast, only UG-AMES13-2 and the local variety had low severity mean scores for cut plants. When cut or uncut, AC-LN and IP5-Sel lines presented a high severity mean (range 4 and 5). Overall, AC-LN and IP-5-Sel were most susceptible, showing between 70 and 95% of wilting plants for both cut and uncut plants. UG-AMES13-2, AM-NKGN, and the local variety are the most resistant lines with 0, 5.13, and 6.41 % of wilted uncut plants and 5.13, 21.79, and 12.82 % of the wilted cut plant. The screenhouse results showed that IP-5 Sel, AC-LN, A2002, Madiira 1, Bresil (B) Sel were most susceptible with 20 to 26.7% Bacterial Wilt Index (BWI). The Bacterial Colonization Index (BCI) varied between 26.7 and 80%. At the same time, AM-NKGN, GARE-ES 13-7, UG-AMES 13-2, Benin-local-variety, and Madiira 2 are tolerant to the bacterium presence with a BWI between 0 and 13.3% and BCI between 6.7 and 33%. The findings suggested three lines (UG-AMES13-2, AM-NKGN, and Benin local variety) that can be proposed to farmers in the infected areas to cope with bacterial wilt. Those lines can be further tested in future breeding programs.

Development of high yielding and nutritious Mung bean lines using heterosis and combining ability analysis by diallel method. Md. Golam Azam[1], Md. Amir Hossain[2], Md. Alatfhossain[1], Md. Shahin Iqbal[1,3], and Md. Faruk Hossain[4]. [1]Pulses Research Centre, Bangladesh Agricultural Research Institute, Ishurdi, Pabna, Bangladesh. [2]Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, Bangladesh, [3]School of Agriculture and Environment, University of Western Australia, Crawley-6009, WA, Australia. [4]Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Ishurdi, Pabna, Bangladesh. Email: azamprcbari@gmail.com

Mung bean (*Vigna radiata* L. Wilczek) is a short-duration legume crop. It is a rich source of protein with an essential amino acid profile and unsaturated fats like linoleic and linolenic acid that advance human health and support economic growth. Genetic information concerning combining ability and heterosis give some clue for choosing the most suitable donors for hybridization. Thus, the examination has embraced the nature and extent of hereditary effects overseeing yield component behavior and general and specific combining abilities of Mung bean utilizing the diallel cross method. Fifteen crosses from a half-diallel method through six different Mung bean parents for heterosis and combining ability investigation. The investigation was conducted at Pulses Research Center, BARI, Ishurdi, Pabna, in a randomized block design with three replications. Results showed highly significant variations within parents and F1 segregates and demonstrated a wide genetic variability for the studied characters. Thus, there is a chance of hereditary improvement utilizing genetic pools of Mung bean. The mean square of general combining

ability (GCA) and specific combining ability (SCA) were significant for all the characters, except the mean square due to SCA for days to flowering, days to maturity, and pod length. This indicates the significant role of both additive and principal components in the inheritance of the studied characters. A higher effect of SCA than GCA was observed for plant height and seeds per pod, brought up to be the preponderance of non-additive gene effects in the statement of these characters. Based on per se performance and GCA of the parents, BARI Mung-1, PS-7 and BMXK1-14004 were seen as the best general combiners for proteins and yield per plant. Considering SCA, five hybrids viz. BMXK1-14004×Sonali mung, BMXK1-14004×PS-7, BMXK1-14004×BINA Mung-8, Sukumar×PS-7, and BARI Mung-1×BINA Mung-8 were perceived as promising. The most significant heterosis to the degree of 26.1% over standard variety and 20.2% over better parent for seed yield per plant were observed in the cross BMXK1-14004×Sonali mung and BMXK1- 14004×PS-7, respectively, which showed high heterosis rate for yield and yield contributing traits with high level of proteins. These parents and crosses could be used for further breeding programs for the improvement of the yield and genetic components of Mung beans.

Diversification and tackling malnutrition in cocoa communities in Cameroon through African traditional vegetable home gardening. Regine Tchientche Kamga[1], Armel Awah[1], Lyliane Pousseu[1], Ronald Chendjou[1], and Victor Afari-Sefa[2]. [1]World Vegetable Center-Cameroon Liaison Office, Yaounde, Cameroon. [2]World Vegetable Center-Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin. Email: reg.kamga@gmail.com

Cocoa farmers in Cameroon do not earn sufficient income to meet their household needs and to ensure their food and nutrition security since they mainly rely on staple crops that lack essential micronutrients to attain a balanced diet. However, diversifying cocoa farms with African traditional vegetables (ATVs) could contribute to tackling the problem through diet diversification. A rapid assessment study was conducted among 150 Cameroon cocoa producers from four targeted cocoa communities of Barry Callebaut (BC), one of the world's largest chocolate manufacturers, to ascertain the current ATV production and utilization status. The project implementing partner, the World Vegetable Center (WorldVeg), showcased different vegetable crops/varieties and sensitized the target cocoa communities on good agricultural practices for vegetable production using demonstration plots. An in-depth individual hands-on training covering the whole vegetable production process for each cocoa farmer who subscribes to BC's funded individual training program was then conducted. Results show that cocoa farmers apprehend their communities' health status as critical, with the prevalence of non-communicable diseases relatively common. About 200 cocoa producers were sensitized to the importance of ATV consumption for nutrition. About 2.5 t of ATV was produced within the demonstration plots (4000 m2) in one season and distributed to beneficiary farmers. Fifty cocoa farmers subscribed to the program received vegetable seed kits of 24 different crops/varieties and established a home garden of at least 50 m2 each. Twenty-four varieties of seven crops include: African eggplant (2), African nightshade (6), amaranth (2), jute mallow (4), tomato (4), habanero pepper (2), chili pepper (2), and okra (2). Among these, farmers had to choose the crops/varieties of interest for a subscription. The trained cocoa farmers produced about 2.2 t of ATV within their home gardens. The majority of the farmers preferred to consume their produce rather than to sell as earlier anticipated; they appreciated the taste and shelf-life of the produce. Strategies and enabling policies aimed at promoting vegetable diversification can contribute to tackling malnutrition in cocoa communities and enhance the sustainability of the cocoa sector.

Eat a different vegetable each day in a week – (im)possible for smallholder farm families? A case study in Teso-South Sub-County, Kenya, and Kapchorwa District, Uganda. Irmgard Jordan[1], Eleonore C. Kretz[1,2], Annet Itaru[3], Paulina Kossmann[1], Daizy Alum[4], Maria Gracia Glas[1,2], Sahrah Fischer[5], Samuel M. Mwonga[6], Margaret Kabahenda[4], Thomase Pircher[7], Thomas Hilger[5], and Lydiah M. Waswa[3]. [1]Center for International Development and Environmental Research, Justus Liebig University Giessen, 35390 Gießen, Germany. [2]Department of Nutritional Sciences, Justus Liebig University Giessen, 35390 Gießen, Germany. [3]Department of Human Nutrition, Egerton University, PO Box 536-20115, Egerton-Njoro, Kenya. [4]Department of Food Technology and Nutrition, Makerere University, Kampala, Uganda. [5]Institute of Agricultural Sciences in the Tropics (Hans Ruthenberg-Institute), University of Hohenheim, 70599 Stuttgart, Germany. [6]Department of Crops, Horticulture and Soils, Egerton University, PO Box 536-20115, Egerton-Njoro, Kenya. [7]Hohenheim Research Center for Global Food Security and Ecosystems (GFE), University of Hohenheim, 70599 Stuttgart, Germany. Email: I.Jordan@cgiar.org

A balanced diet includes an adequate amount of different vegetables. However, in sub-Saharan African countries, the consumption level of vegetables is often poor. This study aimed to improve the consumption of vegetables in terms of variety, supply, quantity, and quality. From February to October 2019, trials of improved practices were carried out in Teso-South, Kenya, and Kapchorwa District, Uganda, targeting 103 households with children under eight years of age. Six counseling visits were conducted to improve the families' vegetable consumption patterns. Tailored interview guides were used to capture the experiences and perceptions of the participants on the improved practices. The responses were analyzed by performing a qualitative structured content analysis using QDA-Software. The recommendation "Eat a different vegetable every day for seven days" was practiced successfully by 82% of Teso-South households and 67% in Kapchorwa. Important drivers for those who implemented the recommendation successfully were a general willingness to change behavior and to purchase vegetables, in addition to family members' approval who experienced an increased appetite for vegetables. The introduction of mixed-vegetable dishes and dishes made from dried vegetables facilitated vegetable consumption at both sites. The diversification of vegetable consumption helped to increase vegetable portion sizes. However, participatory cooking trials with innovative recipes and tastings are needed and should be linked with agronomic trials to enhance vegetable availability for sustainable dietary behavior change. The study was conducted within the EaTSANE-project and financially supported by BMEL/ptble (Germany) and MOEST (Kenya) within the LEAP-Agri initiative.

Effect of chicken manure on leaf yields of selected African leafy vegetables in western Kenya. C. Ndinya[1], N. Makete[1], E. Minyatta[1], M. Odendo1, F. Wayua[1], L. Okitoi[1], P. Mudy[2], and S. Kweyu[3]. [1]Kenya Agricultural and Livestock Research Organization, PO Box 169-50100, Kakamega, Kenya. [2]Anglican Development Services-Western Region, Kenya. [3]Agrokenya, Shianda, Kakamega County, Kenya. Email: christinendinya@gmail.com

For food security and income, African leafy vegetables (ALVs) are important in western Kenya. They require sufficient fertilizer for good yields. However, inorganic fertilizers are rarely used for ALV production because of their high costs. Chicken manure can be a cheap alternative source of fertilizer because 90% of households keep chicken. A study was done in Busia, Vihiga, and Kakamega counties in western Kenya among five farmer groups per county to determine the performance of ALVs when planted

with manure. Each group collected chicken manure and planted two sets of trials of spider plant (*Cleome gynandra*), amaranth (*Amaranthus* spp.), African nightshade (*Solanum* spp.), cowpea (*Vigna unguiculata*), and slenderleaf (*Crotolaria brevidens*); one set with and the second set without chicken manure. Manure samples collected from farmers were tested for nutrient contents and disease. Data were taken on the fresh and dry weight of harvested leaves. Results of disease analysis showed that samples did not have *Ralstonia solanacearum* bacteria or pathogenic nematodes. However, non-parasitic nematodes and Fusarium spp. fungus was present in 63 and 44 percent of the samples, respectively. Leaf yields in plots with chicken manure were significantly ($p < 0.05$) higher than those without manure in spider plants, amaranth, and African nightshade, but not in slenderleaf and cowpea. The lack of difference in the latter could be due to the nitrogen-fixing ability of these species. This study shows that locally available chicken manure can be an excellent alternative to inorganic fertilizers used in western Kenya in spider plants, amaranth, and African nightshade.

Effect of germination periods on proximate and antinutrient composition of grain amaranth flour. S.O., Owolade[1], O.R. Aderibigbe[1], O.O. Ezekiel[2], and J.K. Korese[3]. [1]National Horticultural Research Institute, Product Development Programme, P.M.B. 5432, Idi- Ishin, Jericho GRA, Ibadan, Oyo State, Nigeria. [2]Department of Food Technology, University of Ibadan, 200132, Ibadan, Nigeria. [3]Department of Agricultural Mechanization and Irrigation Technology, University for Development Studies, PO Box TL 1882, Nyankpala Campus, Ghana. Email: obfem@ yahoo.com

Grain amaranth (*Amaranthus cruentus*), a pseudo cereal, has recently been explored as a good source of quality protein and other essential nutrients. Despite its rich nutritional profile, grain amaranth contains antinutrients that reduce its protein's bioavailability. This study employed germination of grain amaranth at room temperature as a pretreatment method to reduce the antinutrient composition. The grains germinated at different periods (24, 48, and 72 hours, respectively). The germinated grains were washed, dried, and milled into fine powder for analysis. The effects of varying germination periods on grain amaranth flour's proximate and antinutrient properties were evaluated. The results showed that protein content (17.4%) was significantly ($p < 0.05$) higher in amaranth grains germinated after 24 hours as compared to 48 hours (16.0%) and 72 hours (16.7%) germination periods and that of ungerminated grains (16.1%). Germination significantly ($p < 0.05$) reduced the antinutrient contents at varying periods. The contents of phytate were 0.19, 0.22, 0.23 and 0.81 mg/g; oxalate 0.21, 0.22, 0.20 and 0.52 mg/g; saponin 0.09, 0.11, 0.10 and 0.41 mg/g; tannins 0.17, 0.33, 0.14 and 0.93 mg/g; and trypsin inhibitor 0.46, 0.59, 0.44 and 0.86 mg/g for 24, 48, 72 hours, and non-germinated grains, respectively. Over the range of germination periods, it was found that germinating grain for 24 hours provided the highest protein content and lowest saponin and phytate contents.

Effect of moisture on yield and quality of amaranth. Halima Daffa[1], Agnes Nyomora[1], and Fekadu Dinssa[2]. [1]University of Dar es Salaam, 35065 Dar es Salaam, Tanzania. [2]World Vegetable Center, Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. Email: halimawaukweli@gmail.com

Information on the effect of soil moisture on amaranth productivity is limited. To better understand the effect, a study was conducted at the World Vegetable Center-Arusha in 2018 using six amaranth genotypes in RCB design with four replicates. Madiira 2, Madiira 1, and Local cultivar significantly excelled in leaf yield with 19.4, 17.5, and 15.8 g/plant dry weight when irrigated twice weekly, while the lowest yield was

from AH-TL-sel at 4.9 g/plant dry weight for once every two weeks irrigation. AH-TL-sel, 'Mchicha,' and Bresil-sel gave significantly higher grain yield ($p < 0.001$) among the genotypes, with 16.9, 16.66, and 14.16 g/plant at twice-a-week irrigation. When irrigated once every two weeks, the local cultivar gave the lowest grain yield (1.47 g/plant). Bresil-sel, AH-TL-sel grains had significantly higher crude protein ($p < 0.001$) among the genotypes with respectively 26.2 and 24.7% in once every two weeks and twice-a-week irrigation, and the lowest crude protein was from Madiira 2 grains (8.6%) when irrigated once every two weeks. Leaf iron content from local cultivar was significantly higher among the six genotypes (296.7 mg/100g) when irrigated once every week, while the lowest iron content was from AH-TL-sel leaves (114.7 mg/100g) when irrigated once every two weeks (($p < 0.001$). AH-TL-sel, 'Mchicha,' and Bresil-sel were recommended for grain and Madiira1, Madiira 2, and Local cultivar for leaves under a twice-a-week irrigation regime.

Effect of pH and cooking time on shelf life of African nightshade leafy-based sauces. Amina Ahmed, Gudrun Keding, and Elke Pawelzik. Division of Quality of Plant Products, Department of Crop Science, University of Goettingen, 37073 Göttingen, Germany. Email: aahmed1@gwdg.de

African nightshade is among the traditional vegetables of high nutritional potential in West and East Africa. However, high postharvest losses minimize consumption. Therefore, sauces formulations of African nightshade leaves with tomatoes, carrots, baobab fruit powder, and other ingredients were developed. The sauces were cooked at 87±3°C for either 20, 25, or 30 minutes, filled into screw-top glasses, and stored at 22±1°C for 28 weeks. The sauces were analyzed every two weeks to assess the effect of pH and cooking time on the microbiological status. The sauces with a pH of 5.5-5.9 with 20- and 25-minutes cooking times were stable between 6 to 12 weeks, while sauces with a pH of 5.9 with 30 minutes cooking times were stable for 10 to 12 weeks. Formulations with pH below 4 were stable for up to 28 weeks regardless of cooking time. Lowering the pH below four is recommended to achieve minimal processing and long shelf life without adding preservatives.

Effects of cutting height on nutritional components of vegetable amaranth in savannah zone of northern Nigeria. A.M. Aliyu[1], A.A. Manga[2], and A.G. Gaya[2]. [1]Department of Crop Science, Kano University of Science and Technology, Wudil, Kano, Nigeria. [2]Department of Agronomy, Bayero University, Kano, Nigeria. Email: Aliyuaisha02@gmail.com

A field experiment on amaranth (*Amaranthus cruentus*) was conducted during the 2015 rainy season at the National Horticultural Research Institute Bagauda Sub-station, Kano, located in the Sudan savannah ecological zone of Nigeria. The research aims to investigate the effect of cutting height on nutritional components of *A. cruentus* applied with GA3. Three cutting heights (10 cm, 15 cm, and 20 cm) were evaluated on the nutritional components of *A. cruentus*. The results showed a significant increase in percentage fat and crude fiber with an increase in cutting height. Percentage protein, moisture, carbohydrate, nitrogen, phosphorus, and potassium were significantly affected by cutting height, and GA3 applications showed no effects. Based on the results obtained, these findings suggest that cutting amaranth shoots at 20 cm above the ground has an increasingly significant effect on means of percentage fat (3.1) and crude protein (3.8).

Effects of drying technologies on the nutrition and anti-nutritional factors of African nightshade species in Tanzania. Marynurce Kazosi, Frank Sangija, Haikael Martin, and Athanasia Matemu. Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania. Email: kazosim@nm-aist.ac.tz

African nightshades (ANS) (*Solanum nigrum* complex, also known as *Solanum* L. section *Solanum*) is one of the luminary food plants from the Solanaceae family. In Tanzania, ANS is called Mnavu in Swahili. These ANS are cheap and potential dietary sources for micronutrients and bioactive compounds. The study aimed to assess the effects of various drying techniques (open sun, direct and indirect solar drying) on the nutritional and anti-nutritional contents of *S. scabrum* and *S. villosum*. The techniques are expected to reduce post-harvest losses, improve shelf life, and ensure the availability of ANS throughout the year. Non-blanching and blanching at 85°C for 2 minutes with NaCl and without NaCl were conducted. The nutritional content significantly differs ($p < 0.05$) in all the dried samples for the three drying methods. The nutrient retentions were 3.7 to 12.7% for vitamin C, 65.5 to 96.6% for Ca, 35.0 to 77.9% for Fe, 23.8 to 80.7% for Mg, and 38.0 to 97.6% for Zn, respectively, for all methods for the species studied. The removals of anti-nutritional factors were 4.7 to 35.2% for oxalate and 51.7 to 85.4% for phytate, respectively. Open sun and indirect solar drying were the best methods for nutritional retention and removal of the anti-nutritional factors. Likewise, non-blanched samples resulted in significant retention of micronutrients, while blanched samples proved to be the best in reducing anti-nutritional factors. Hence, dried leaves of *S. scabrum* and *S. villosum* can be consumed as side dishes to improve health and suffice for food security.

Enhancing environmental services and food security through sustainable land management and African traditional vegetables: Lessons from western Kenya. Abednego Kiwia[1], George Ayaga[2], Assan Ngombe[1], John Macharia[1], and Abdi Zeila[3]. [1]Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya. [2]Kenya Agricultural and Livestock Research Organization (KALRO), Nairobi, Kenya. [3]Centre for Sustainable Development Initiatives (CSDI), Kenya. Email: abdizeila@abdizeila.com

Although African traditional vegetables (ATVs) have always been a big part of indigenous food systems on the continent, they have been saddled with the tag of being considered food for rural and poor households only. This has hampered efforts to promote their production and consumption on a broader scale. However, with falling staple food prices and rising urban incomes, there has been a shift towards strategies that enhance agricultural diversification and increase the added value of ATV production. This paper presents a synthesis of the findings and experiences of a consortium of organizations that have partnered under the aegis of the Global Environment Facility (GEF) to promote sustainable land management in western Kenya. Working with local communities, the partners are scaling up integrated soil fertility management activities, characterized by greater nutrient cycling and ATV production's integration and scaling up. The results of a value chain study undertaken jointly by AGRA) and KALRO show the oversize contribution of ATVs to farmers' incomes and the potential for further growth of this cropping system. Revenues from ATVs account for between 45% (Nandi and Vihiga) and 52% (Kakamega) of all incomes registered by the farmers annually. However, generally, farmers only set aside 18% of their land for their tillage. Farmers generally rate ATVs as their second-tier crops, second in importance only to maize. Enhanced production of ATVs has also impacted weaning farmers off from dependence on the extraction of woody resources from the Kakamega Forest ecosystem, contributing to

sustainable forestry management. Farmers in the region noted that ATVs are not only a consistent source of income for families, but they are also very nutritious as they are rich in nutrients, including vitamin A and iron, and can meet nutritional gaps without promoting excess weight gain. ATVs offer unique opportunities to diversify farming systems, ensure food security, and alleviate poverty while increasing income and improving human health. ATVs have appreciated the remarkable tolerance to drought conditions and other natural vagaries. Improved germplasm and production and postharvest handling techniques, as well as culinary development and nutrition education, can improve access, availability, adoption, affordability, and consumption in western Kenya. Given the contribution of ATVs to food security and sustainable land and forest management, it is recommended that their production and marketing should be promoted and scaled up. It is imperative for county governments to consider investing in protected cultivation technology for ATVs, in addition to promoting rainwater harvesting, in order to enhance the production of vegetables during the dry seasons.

Enhancing women economic empowerment through the sustainable scaling of spices and herbs in southwestern Ethiopia. Rahel Heruy. Damascene Essential Oil Processing PLC, Woreda 08, Addis Ababa, Ethiopia. Email: rahelheruy@yahoo.com

Ethiopia is home to many spices and herbs, including black cardamom, basil, long red pepper, black cumin, turmeric, ginger, etc. They are cultivated widely in different agroecological zones of the country and play a significant role in the diet of most Ethiopians. Despite their importance in the agro-food system, their productivity is low due to their limited knowledge of modern production methods. Production is also fragmented, making it challenging to aggregate sufficient quantities for onward supply to processors consistently. Damascene Essential Oil Processing PLC is a women-led company that processes and markets edible spices, high-quality essential oils, and cosmetic products. The company mainly sources raw materials from women farmers in the Kaffa zone in southern Ethiopia. Now it is diversifying its product offering and seeks to expand its raw material base by reaching out to 5,000 women farmers within four years. To achieve this, through a portfolio of public-private-partnerships (PPP) supported by the 2SCALE program, Damascene has supported six women cooperatives with technical assistance to improve their knowledge and skills in agronomy, food safety, and post-harvest management. These women mainly grow approximately 0.125 ha each of spices and herbs on backyard farms. The company is mobilizing about 1700 women farmers organized into ten cooperatives. More than 100,000 seedlings of different herbs and spices, 27,850 kg of turmeric seeds, and 7,000 kg of ginger seeds have been distributed to over 400 women on credit. An additional 440,000 seedlings are also being distributed. Damascene has sourced over 25,000 kg of spices and herbs from women cooperatives. Through this PPP, Damascene can produce, transform and supply quality and nutritious spices and herb products to end-user markets as well as low-income consumers; empower women to engage in production and agribusinesses of species and herbs; improve incomes for smallholder women farmers; and contribute to the protection of the environment and sustainable utilization of natural resources.

Establishing a technical guideline for agroecological production of baobab leaves at seedlings stage in Benin. G. Hounsou-Dindin[1], K. Valère Salako[1], Idohou Rodrigue[1], Sero Nadejda[1], R.L. Glèlè Kakaï[1], A.E. Assogbadjo[1,2]. [1]Laboratoire de Biomathématiques et d'Estimations Forestières, Université d'Abomey-Calavi, 04 BP 1525, Cotonou, Bénin. [2]Laboratoire d'Ecologie Appliquée, Université d'Abomey-Calavi, 01 BP 526 Cotonou, Benin. Email: guillaumehdd@gmail.com

People in the sub-Sahara count leaves of baobab (*Adansonia digitata*) among their most valued vegetables. To establish techniques for high production of leaves of baobab seedlings, this study aimed to assess the growth of leaf number, morphological traits, and dry weight as related to leaf yield of baobab seedlings to variation of dose of chicken manure (0, 10, 20, and 30 t/ha), sowing density (15×15 cm, 20×20 cm, and 30×30 cm) and leaf harvesting frequency (15, 22 and 30 days). The experiment was conducted on-station in the Guineo-Congolese zone using a split-split plot design with three replicates. Data were analyzed using linear, linear mixed effects for longitudinal data with a standard structure for errors and generalized linear mixed effects models for longitudinal data with a Poisson structure for error models. The results showed that more biomass and the most significant number of leaves were obtained when *A. digitata* seedlings were applied with 30 t/ha of chicken manure at 15×15 cm sowing density and monthly harvests after sowing. This combination provided the highest leaf biomass production (41.6±1.2 kg of dry matter per 100 m2, equivalent to 157.3±4.4 kg of fresh leaves per 100 m2), a less tapering leaf, and the lowest specific leaf area and specific leaf dry weight. The optimum growth of leaf number of *A. digitata* seedlings was with a low dose of chicken manure at 10-20 t/ha. Further research is necessary to assess the protection methods against pests and diseases and control of adventitious plants.

How can 'limited-space' growing alleviate food insecurity of displaced people groups in sub-Saharan East Africa. Philip Newcombe. The Royal Horticultural Society. London, UK. Email: phil.newcombe23@gmail.com

The UN's Sustainable Development Goal (SDG) 2, Zero Hunger, targets ending hunger and improving nutrition and has identified challenges of hidden hunger amongst refugees who are denied access to land and rely on limited-space growing for beneficial household food. In response, this study examines limited-space growing techniques, such as utilizing sacks to grow edible plants in sub-Saharan refugee camps and other resource-poor populations. It uses a case-study approach to look at how displaced peoples in various settings apply horticultural techniques and identifies the strengths and nutrition-improving outcomes of these methods, weighing their potential impact on improving local cultivation practices in the fight to alleviate hunger and achieve food security. The outcomes of this study also have implications for other SDGs relating to poverty, health, gender equality, employment, sustainable communities, responsible production, and climate action. The study reflects critically on the data available and recommends further research into technical areas, including growing media, water supply, waste and greywater management, and suitable plant selection and availability. It highlights traditional, though underutilized, African traditional vegetables and discusses their nutrition and health benefits and potential to provide food resilience in a culturally and climactic-appropriate way. In summary, the study suggests that, through the combination of limited-space growing methods and the use of African traditional vegetables, those in desperate situations can be allowed to contribute to their local food security.

Identification of superior brinjal parents based on qualitative and quantitative traits. Md. Faruk Hossain, Kamal Uddin Ahmed, and Md. Golam Azam. Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. Email: farukgolap@gmail.com

Brinjal or eggplant (*Solanum melongena*) is Bangladesh's second most important vegetable. To maintain healthy germplasm and improve brinjal, it is important to document or characterize the existing local

genotypes, landraces, cultivars, or farmers' varieties. Considering the vast opportunity for improvement of brinjal local genotypes, the study was conducted at BARI's Regional Agricultural Research Station, Ishwardi, Pabna, during 2017-18 to identify the important traits of brinjal accessions. The experiment involved 35 brinjal germplasm with BARI Brinjal-6 as check. Variations among brinjal accessions were observed in different qualitative characteristics. Upright, intermediate to prostrate plant growth was observed. Leaf bade lobing was found to be weak, intermediate to strong, and very acute, acute to intermediate in leaf blade tip angle. Variations were found in a number of prickles and leaf hair. Different flower colors were observed among the accessions, like pale violet, light violet, and bluish violet. Plant growth habit was upright for 20 accessions, intermediate for five accessions (17.9%), and strong for 11 accessions (30.6%). Leaf blade lobing was weak for four accessions (11.1%), intermediate for 12 accessions (33.3%) and strong for 17 accessions (47.2%), and very strong for three accessions (8.3%). Fruit curvature was straight for 26 accessions (72.2%), slightly curved for two accessions (5.6%), curved for five accessions (13.9%), and snake-shaped for three accessions (8.3%). Fruit color was green for 13 accessions (36.1%), milk-white for five accessions (13.9%), scarlet red for two accessions (5.6%), lilac grey for three accessions (8.3%), purple for eight accessions (22.2%), purple-black for three accessions (8.3%) and black for two accessions (5.6%). Variations among brinjal accessions were observed regarding days to first flowering, days to first edible fruiting stage, plant height, number of fruits per plant, fruit weight (g), fruit weight per plant (kg), and 100-seed weight. The first flower initiation was noticed in SM Ish-017 (82 days). The highest fruit weight per fruit (266.4 g per fruit) was recorded from SM Ish-001, and the lowest fruit weight (77.6 g/fruit) from SM Ish-014. The highest fruit yield per plant (5.4 kg) was recorded from SM Ish-015 followed by SM Ish-025 (5.1 kg), SM Ish -010 (5.0 kg), SM Ish-027 (4.9 kg), and the lowest fruit yield per plant (2.1 kg) from SM Ish-032. These selected genotypes may be considered promising accessions. Promising genotypes can be used as parents in future hybridization programs to develop superior types with high yields.

Impact of storage conditions and packaging materials on seed germination and field emergence of okra at different seasons. Adam Akinloye[1], Sunday Aladele[1], Mayowa Olubiyi[1], Gloria Afolayan[1], Ayoola Kuyebi[1], and Iyanu Aluko[2]. [1]National Centre for Genetic Resources and Biotechnology, Ibadan, Nigeria. [2]Department of Soil Science, Federal University of Oye-Ekiti, Ekiti, Nigeria. Email: olosundam@yahoo.com

The conservation of okra (*Abelmoschus esculentus*) seeds in genebanks is essential for the success of their use in breeding programs. This study investigated the impact of storage conditions and packaging materials on the germination and field emergence of okra seeds. One okra accession (NGB 00372) produced during the late growing season of 2015 was used for the study. The experiments were set up using 3x3 factorial in completely randomized design and randomized complete block design for germination and field emergence experiments, respectively, with three replications. One hundred seeds per replicate were subjected to a standard germination test and immediately followed by field evaluations during four growing seasons. The individual analysis of variance (ANOVA) revealed that most treatments had a significant effect on germination and seedling emergence in all seasons. However, the combined ANOVA across the seasons revealed that storage conditions, packaging materials, and interactive effects were highly significant on seed germination and field emergence. Okra seeds stored in the plastic container had the highest germination value (79.7%) and field emergence value (78.7%) under short-term storage conditions. In comparison, seeds stored in aluminum foil had the highest seed germination value (74.3%)

and field emergence value (75.3%) under medium-term storage conditions. The materials stored in a deep freezer using aluminum cans had the highest percentage values for seed germination (67.0%) and field emergence (77.7%). This study suggests that plastic containers, aluminum foils, and aluminum cans would enhance the viability of okra seeds, in short, medium, and freezer storage conditions, respectively.

Metabolite diversity of fruits of selected African eggplant accessions for improved health and nutrition. Willis O. Owino[1], Elias K. Mibei[1], Grace M. Wacheke[2], Jane Ambuko[3], and James J. Giovannoni[4]. [1]Department of Food Science and Technology; [2]Institute of Biotechnology Research, Jomo Kenyatta University of Agriculture and Technology, PO Box 62000-00200, Nairobi, Kenya. [3]Department of Plant Science and Crop Protection, University of Nairobi, PO Box 29053-00625, Nairobi, Kenya. [4]USDA-ARS Robert W. Holley Center and Boyce Thompson Institute for Plant Research, Cornell University Campus, Ithaca, NY 14853, USA. E-mail: willis@agr.jkuat.ac.ke

African eggplants, the wild relatives of cultivated eggplants, are among the nutritionally important and valuable crops consumed in Africa. They have been reported to thrive well under stress conditions. Therefore, there is a need to identify and characterize those metabolites that may be responsible for stress tolerance. Seeds of the selected accessions of African eggplants were obtained from the World Vegetable Centre, Tanzania, grown in the greenhouse, and subjected to drought stress. The fruits were harvested at three stages of ripening; mature green, breaker, and mature red. Metabolite profiling using a non-targeted GC-MS metabolomic approach was performed, and identification was carried out with the Golm, Germany metabolomics library software. Sixty-eight metabolites were detected in the fruits and distributed into major compound classes comprising amino acids and their derivatives, organic acids, sugars, sugar alcohols, and nitrogen compounds. Significant changes ($p < 0.05$) in metabolite contents were observed, and potentially important metabolites concerning stress responses were characterized. Proline, glutamate, γ-amino butyric acid, 3-chlorogenic acid, glucose, sucrose, myo-inositol, citrate, quinic acid, and ornithine increased with drought stress. Principal component analysis showed clear discrimination between the different accessions, ripening stages, and drought stress. From the study, it appears that some metabolites may play a role in drought stress tolerance. Further studies are required to confirm this observation.

Microscopic observations of Kersting's groundnut flowers. Azon Christel, Akohoué Félicien, Coulibaly Mariam, and Achigan-Dako Enoch. Laboratory of Genetics, Horticulture and Seed Sciences (GBioS), University of Abomey-Calavi, Abomey-Calavi BP 2549, Benin. Email: christelazon@gmail.com

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal and Baudet] belonging to the Fabaceae family is a grain legume widely consumed in west Africa. Its genetic diversity is low and can be broadened through hybridization. Its flowers are chasmogamous (i.e., pollination occurs in a fully opened flower), but its floral biology is not well known. This study aimed to understand the floral development stages of six cultivars of Kersting's groundnut and to analyze anthesis timing with stigma receptivity and pollen dehiscence and viability by utilizing a photonic microscope and eyes observation. To achieve this, seeds were sown on pots on an experimental site of GBioS using a half di-allele design. For visual observation, one flower per plant was marked and observed every morning at 6:30 pm and evening at 5:00 pm for the development stages of the flowers. One flower per cultivar was observed per day for ten days regarding

pollen viability, stigma receptivity, and the number of ovules per ovary through optical microscopic, at a magnification of × 400 and × 1000. The results show five stages of flower development: immature bud stage; bud emergence; partially opened flower; anthesis and wilted flowers. From the stage of bud initiation to bud emergence, 5±2 days were recorded, 3±1 days between bud emergence and partially opened flower, 2±0.5 days between partially opened flower and anthesis; and 7±2 days between anthesis and development of gynophore. Cultivars showed a difference in the numbers of sepals, petals and stamens, and ovules per ovary. The stigma becomes receptive at the step of bud emergence, and pollen viability occurs at the step of a partially opened flower. The color of the anthers is yellow, and the stigma is green at the partially opened flower stage, showing that these organs are already mature at this stage. There is no significant difference between pollen maturity and stigma receptivity time, and stigma becomes receptive before anthesis. This shows that the appropriate time of emasculation for hybridization happens at the stage of bud emergence.

Nutritional quality of African traditional vegetables as affected by drying methods. Ray-Yu Yang[1,2], Ngoni Nenguwo[3], Tsvetelina Stoilova[3], Antonio Acedo Jr.[3], Didit Ledesma[1], and Peter Hanson[3]. [1]World Vegetable Center, PO Box 42, Shanhua, Taiwan. [2]Food and Fertilizer Technology Center for the Asian and Pacific Region, Taipei, Taiwan. [3]Wosrld Vegetable Center-Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. [4]World Vegetable Center, West and Central Africa–Coastal and Humid Regions, 08 BP 0932 Tri Postal Cotonou, Benin Email: ray-yu.yang@fftc.org.tw

African traditional vegetables (ATVs) are inexpensive sources of high-quality nutrients. Nevertheless, the availability of fresh ATVs is seasonal. To secure the availability of nutrients from ATVs, preserving ATVs by drying could be a means. However, the drying method can affect nutrient contents. Our objective was to assess the nutritive value of popular leafy ATVs affected by the drying method. Two related studies were conducted at WorldVeg-Taiwan (Study I) and WorldVeg-Tanzania (Study II). The treatment design was a split plot with varieties and drying method as main plot and subplot factors, respectively. Main plots were arranged in an RCBD with three replications. Two varieties each of five leafy vegetables (amaranth, African nightshade, cowpea, jute mallow, and spider plant) were grown in the field of WorldVeg-Taiwan and WorldVeg-Tanzania. Tested ATVs were harvested, and 3-5 kg samples were subjected to different drying methods. In Study I, samples were assigned to freeze drying or oven drying. In Study II, samples were subjected to solar or direct sun drying. Protein, sugars, fiber, minerals, carotenoids, vitamin C, total phenolics, and oxalates were measured. Results from the freeze-drying method were used as a standard. The five ATVs were high in protein, minerals, carotenoids, and vitamin C, although significant differences were detected among crops for various nutrients. Spider plant was notably high in beta-carotene. All crops contained oxalate, with amaranth as the highest, followed by cowpea leaves. The drying method significantly affected the contents of most macro-and micro-nutrients. Freeze drying is considered the best method to retain high macro- and micronutrients. This was true in this study except for beta-carotene, which was sensitive to longer drying even at low temperatures. Solar drying and direct sun drying allowed retention of the heat-stable constituents (protein, fiber, sugars, minerals, and oxalate). However, they caused a 100% loss of vitamin C and a 50-90% loss of carotenoids. The solar dryer used in this study did not improve nutritional quality compared with the direct sun drying in sunny weather.

Nutritional variations and economics of jute mallow when intercropped with commonly grown cereal crops in Tanzania. Margareth Makauki, Patrick Ndakidemi, and Ernest Mbega. Department of Sustainable Agriculture and Biodiversity Ecosystem Management, Nelson Mandela African Institution of Science and Technology (NM-AIST), PO Box 447, Arusha, Tanzania. Email: maggiemakauki222@gmail.com

In Tanzania, farmers grow and harvest jute mallow with minimum management, limiting the crop's potential for marketing to exploit its nutritional value fully. This study was conducted to find a better intercropping combination of jute mallow with economically viable cereals with a higher yield in Tanzania. The field experiment was conducted at Hombolo Agricultural Research Centre in Dodoma and NM-AIST farm in Arusha to assess the growth and yield performance of jute mallow when intercropped with either maize or sorghum, or finger millet. The experiment was set in a randomized complete block design with three replications. Results showed that intercropping with sorghum or finger millet did not affect plant height, number of branches, and number of jute mallow leaves. Jute mallow intercropped with maize suppressed the growth and yield performance of jute mallow. Among intercropped stands, jute mallow intercropped with sorghum and finger millet was not affected by intercropping on fresh leaf yield. However, all intercropped stands had yield advantages over mono-cropped stands. Jute mallow-sorghum intercrop had the highest yield advantage with equivalent land ratios of 1.7 in Dodoma and 1.53 in Arusha, respectively. If farmers opt for intercropping and maximizing land use, this study recommends that jute mallow be intercropped with sorghum and finger millet for better yields and sustainable growth.

Overview of African traditional vegetables germplasm collection, characterization and conservation in Tanzania. Alice Makala-Kavishe and N. Merinyo. Tanzania Agricultural Research Institute, Tengeru, PO Box 1253, Arusha, Tanzania. Email: amdkavishe@yahoo.com

African traditional vegetables (ATVs) are important in the food system, given their role in nutritional, medicinal, and economic values and the diversification of the agricultural environment. In this context, a study on ATV germplasm collection, characterization, and conservation was carried out in Tanzania at TARI-Tengeru from April 1999 to 2003 to broaden the genetic base from which plant breeders can obtain desirable genotypes found among landraces and wild plants. The study's objectives were: 1) Collection and characterization; 2) Conservation of the collected germplasm; 3) Promotion of the use of the collected germplasm; and 4) Documentation of the collected germplasm. The collection mission targeted the highly potential ATVs. So far, 350 seed, leafy, and fruit ATVs of 15 species have been assembled. Seeds collected were multiplied and characterized using a standard set of descriptors developed by the World Vegetable Center. Accessions with potential for promotion and domestication were identified. A high level of variability was observed among the accessions collected. This study showed that *Amaranthus blitum*, *Cleome gynandra* (purple and green), *Corchorus olitorius*, and *Solanum scabrum* (52) were recommended for domestication. We recommend that a concerted effort toward domesticating ATVs should be emphasized, given their role in the food system in Tanzania's rural and urban communities.

Overviews of functional properties and folk medicinal use of indigenous vegetables in Taiwan. Ray-Yu Yang[1,2], Hsin-I Wang[1], and Wan-Jen Wu[1]. [1]World Vegetable Center, PO Box 42, Shanhua, Taiwan. [2]Food and Fertilizer Technology Center for the Asian and Pacific Region, Taipei, Taiwan. Email: ray-yu.yang@fftc.org.tw

Evidence for associations between disease prevention and increased vegetable consumption is generally positive. However, studies report weak causal linkages and inconsistent results that vary among different populations with different dietary patterns. Many traditional vegetables highly consumed in the past are neglected in current food systems. The health benefits of phytonutrient intake from plant foods may have been underestimated because modern diets include fewer crop types and lower varietal diversity. We conducted literature reviews on reported functional properties (anti-carcinogenic, anti-microbial, antioxidative, anti-diabetic, and anti-inflammatory activities and others) for 150 Taiwan indigenous vegetables using keywords of their scientific names and terms related to functional properties and medicinal uses. Information on folk medicinal uses or herbal remedies was retrieved from the open-access "Database of Common Medicinal Plants in Taiwan." The latest review papers and original research articles on the functional properties of one or group of vegetables evaluated them using various methods, including in vitro, cell, animal, and human models. About 90% of the listed 150 species were mentioned in one or more studies reporting either one or several functional properties. The anti-oxidant activity was mainly mentioned, followed by anti-inflammatory, anti-diabetic, anti-carcinogenic, and anti-microbial properties using in vitro and cell models. Functional properties of about 15% of species (e.g., *Amaranthus, Talinum paniculatum*, *Oenanthe javanica*, *Perilla frutescens*) have been studied using animal models. Investigations involving human subjects were conducted with a few vegetable species such as bitter gourd (*Momordica charantia*) for anti-hyperglycemia (anti-diabetes) and purple yam (*Dioscorea alata*) for reduced risks of breast cancer and cardiovascular diseases. According to Traditional Chinese Medicine, about 50% of the listed species were used as both food and herbal remedies. Our review summarizes studies on Taiwan indigenous vegetables for functional properties from current research and folk uses that will help to prioritize plant species for further research and future applications.

Pathways to improved food and nutrition security of the poor: the promise of African indigenous foods and technologies. Francesco Rampa, Ellen Lammers, Anita Linneman, Sijmen Schoustra, and Danielle de Winter. European Centre for Development Policy Management, Maastricht, The Netherlands. Email: fr@ecdpm.org

This paper presents a synthesis study of 7 multi-stakeholder research projects funded by the Dutch Research Council (NWO-WOTRO Science for Global Development) Food & Business Research program. The projects focused on the role indigenous foods and technologies can play in contributing to improved food and nutrition security for the poor and diversification of food systems. The projects were set in sub-Saharan Africa, focusing on the challenges and opportunities of production, processing, and marketing of various traditional crops and foods (e.g., African indigenous vegetables, moringa, spider plants, fermented foods, and infant foods based on local resources). The paper analyzes the new knowledge, insights, and innovations that these projects generated, showing that the promotion of indigenous foods can deliver positive and sustainable impacts in the social, economic, and environmental domains, thus contributing to the people, profit, and planet dimensions of the Sustainable Development Goals agenda. Barriers to, as well as drivers for, maximizing the impact of indigenous foods on food and nutrition security are identified, revealing that – depending on the country's context – these include technical, logistical, policy, and economic issues and interests. The unique set-up of the projects, which were all run by a consortium of academic, private sector, and non-governmental organization partners, proved an important factor in promoting research uptake by relevant local and national stakeholders.

Perception of youths on consumption of African indigenous vegetables in western Kenya. E. Minyatta[1], J. Ombati[2], M. Mutuku[2], N. Makete[1], and C. Ndinya[1]. [1]Kenya Agricultural and Livestock Research Organization, PO Box 169-50100, Kakamega, Kenya. [2]Faculty of Education and Community Studies, Egerton University, PO Box 536, Egerton 20115, Kenya. Email: minyattah@gmail.com

To explore the potential of African indigenous vegetables (AIVs), foster nutritional awareness, and creation of AIV market, the perception of young people towards AIVs is important. However, there is limited evidence of youths' perception and preference for AIVs. Understanding the youths' perception of AIVs will provide a way forward in building capacity among the youths on the potential of AIVs. Towards this end, the study was conducted. Eighty-six (50 male, 36 female) youths were interviewed. Results indicate that the youths know most of the common AIVs grown in Kenya, with nightshade being the most known and preferred (60.7%) for consumption. The reasons for preference included taste (40%), medicinal value (35%), and nutritious value (47%). The youths ate AIVs more at home than when they were in college. The reasons for the low consumption were the tedious preparation process (69%), lack of skills in preparation (56%), and high costs (49%), among others. Fifty percent of the males said they would buy dried and packed AIV, while 28% of the female said they would buy. Some reasons for not buying dried vegetables included loss of taste (48%) and loss of nutrients 42%. This result shows that youths know the importance of AIVs in their diets. Capacity building on preparation methods and improving access to AIVs at a cheaper cost throughout the year would improve consumption of AIVs among the youths.

Performance and release of two African nightshade lines from the World Vegetable Center in Tanzania. O. Mbwambo, F.F. Dinssa, R. Mallogo, M. Matovolwa, and S. Mushi. World Vegetable Center-Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. Email: omary.mbwambo@worldveg.org

The genus *Solanum* is the largest and most diverse genus in the family of Solanaceae. African nightshades comprise several species of the genus *Solanum* in the section *Solanum*. African nightshade is particularly rich in vitamin A, iron, and calcium. It is a popular traditional leafy vegetable in many African countries, and leaf yield is the prominent trait farmers look for in an ideal cultivar. Despite the potential of this vegetable crop, most species remain at the level of landraces, with only a few improved cultivars released for commercial production. Ten advanced lines, including three checks, were evaluated in three locations (Moshi, Mbuguni, and World Vegetable Center Eastern and Southern Africa (WorldVeg-ESA) to bring more improved cultivars in northern Tanzania in 2015 and 2016. The objective of the evaluation was to identify fine lines for release and registration. The lines were developed by single plant selection with a cycle of selfing from the germplasm collections kept at WorldVeg-ESA. Significant differences among entries in all three locations in both years were found for yield, leaf length, leaf width, and number of branches per plant. Line RC10-ES13-3 (*S. scabrum*) gave the highest fresh vegetable yield in most locations in both years. Line RC18-ES13-3 (*S. villosum*) gave a high vegetable yield at Mbuguni and WorldVeg-ESA in 2016. It has narrow leaves and bitter taste, traits most liked by farmers. The two lines were released in 2018 after passing the Distinctiveness, Uniformity, and Stability test conducted by the Tanzania Official Seed Certification Institute.

Phenotyping African eggplant growth and nutritional quality under abiotic stresses. Noémie David-Rogeat[1], Eleftheria Stavridou[2], and Martin Broadley[1]. [1]Division of Plant and Crop Sciences, University of Nottingham, Leicestershire, LE12 5RD, UK. [2]NIAB EMR, East Malling, West Malling, ME19 6BJ, UK. Email: noemie.david-rogeat@nottingham.ac.uk

Malnutrition affects approximately one in three people worldwide and is particularly prevalent in Africa, where more than 40% of all children are affected by one form of malnutrition. Vegetables have great potential to help reduce this burden due to their current position in the food system and multiple dietetic and nutritive values related to their nutrient content. While climate change is negatively affecting crop production worldwide and increasing abiotic stress prevalence, indigenous vegetables constitute an untapped reservoir of biodiverse and highly nutritional plants adapted to local climates that offer opportunities to improve the nutritional status of the local population and the resilience of agricultural systems. The African eggplant, *Solanum aethiopicum*, is one such vegetable, widely consumed within sub-Saharan Africa but only sparsely researched and promoted, thus not used to its full potential. The objectives of this research were to assess the tolerance of the African eggplant under high temperature and/or drought stress conditions. As a preliminary step, a description of the African eggplant developmental stages was performed by assessing nutrient dynamics uptake, plant growth, and nutritional quality of fruits during ripening. Then, high temperature and drought stress were imposed individually and in combination on plants in a controlled environment. Shoot and fruit nutrients, phytonutrient levels, physiological responses, marketable yield, and fruit quality were measured. Results will increase our current understanding of the African eggplant's responses to climate change and its potential role in future food systems. They will be the starting point for studying agronomic management changes to improve tolerance.

Phytochemistry and biological activities of secondary metabolites from the leaves of *Vitex grandifolia*. Oluwasesan M. Bello[1,2.3], Pius S. Fasinu[4], Zulfiqar Ali[3], Ahmed A. Zaki[3], Ikhlas A. Khan[3,5], Usman L. Ajao[2], and Oguntoye S. Olubunmi[2]. [1]Department of Applied Chemistry, Federal University, Dutsin-Ma, Katsina State, Nigeria. [2]Department of Chemistry, University of Ilorin, Kwara State, Nigeria. [3]National Center for Natural Products Research, University, MS 38677, USA. [4]College of Pharmacy & Health Sciences, Campbell University, Buies Creek, NC 27506, USA. [5]Division of Pharmacognosy, Department of BioMolecular Sciences, School of Pharmacy, University of Mississippi, University, MS 38677, USA. Email: obello@fudutsinma.edu.ng

Vitex grandifolia of the Lamiaceae family is indigenous to West Africa as an underutilized vegetable. Fruits are eaten and used to make alcoholic drinks. *V. grandifolia* is also used as a folk medicine to treat various ailments. Its bark has been used to relieve stomach aches and to manage diarrhea, bronchial symptoms, rickets, soreness, and fever. However, little is known about its phytochemistry or its biological evaluations. Methanolic extracts of dried leaves of the plant were subjected to fractionation and isolation using vacuum layer and column chromatography techniques. The structures of the isolated compounds were elucidated using spectroscopic techniques including IR, 1D-, 2D-NMR and high-resolution electrospray ionization mass spectrometry by docking with Schrodinger software. They were then evaluated in vitro for the inhibition of monoamine oxidase (MOA) A and B and antioxidant activities. Inhibition of MAO-B by vitexoside one was 11-fold more potent (1C50 (μg/mL) of 9.04 and 9.08) compared to the inhibition of MAO-A (1C50 (μg/mL) of >100). Vitexoside 1 exhibited the highest activity

against skin melanoma cell line with IC50 (µg/mL) of 6.0. Isoorientin and orientin gave good antioxidant activity with IC50 (µg/mL) of 33 and 41, which were better than the control. This study provided insight into the phytochemical profiles and pharmacological importance of *V. grandifolia* beyond basic nutritional values. It is recommended that this vegetable could play a protective role against diseases after a thorough clinical examination of the isolates from the plant.

Postharvest quality characteristics of fruit derived from intra and intergeneric grafted tomato. Dianah Walubengo, Willis Owino, and Irene Orina. Department of Food Science and Technology, Jomo Kenyatta University of Agriculture and Technology (JKUAT), PO Box 62000-00200, Nairobi, Kenya. Email: willis@agr.jkuat.ac.ke

Tomato is the second most important vegetable in terms of value in Kenya. However, its production is plagued by disease complexes that lead to low yield, poor quality fruit, and significant postharvest losses. While grafting is a popular technique for combating soil-borne diseases in other parts of the world, it is almost non-existent in Kenya. Grafting is an ideal vegetable production technique because scions susceptible to soil-borne diseases can be grafted onto rootstock that is more resistant to these diseases. Tomato grafting studies focus on yields and disease resistance, with limited studies on the quality characteristics of the fruit. The objective of this study was to compare postharvest quality characteristics of bacterial wilt susceptible tomato (Anna F1) grafted on African eggplant (intergeneric) rootstocks and bacterial wilt resistant hybrid tomato (intrageneric) rootstocks. The grafted tomato was grown under greenhouse conditions in JKUAT, and the fruit was harvested at mature green, turning, and red ripe stages. The fruits were analyzed for physical and physiological characteristics. At mature green stage, the intergeneric grafted fruits had higher firmness (6.3 N mm1) compared to control (4.69 N mm1). The respiration rate of intrageneric grafts were (7.12 ml/kg/h) lower than the controls (36.9 to 0.1 ml/kg/h) while the ethylene production rate of the intragenic grafted fruit was lower (0.16 µl/kg/h) at ripe stage compared to control (0.41 µl/kg/h). Generally, fruits derived from intergeneric and intrageneric grafts displayed desirable, superior, and better postharvest qualities with prolonged shelf life than the non-grafted controls.

Processing methods and nutritional quality of dried amaranth (*Amaranthus* spp.) leaves: A review. M. Osei-Kwarteng[1], D.M. Brenner[2], and G.K. Mahunu[3]. [1]Department of Horticulture, University for Development Studies, PO Box TL 1882, Tamale, Ghana. [2]Department of Agronomy, Plant Introduction Station, Iowa State University, Ames, IA 5001, USA. [3]Department of Food Science, University for Development Studies, PO Box TL 1882, Tamale, Ghana. Email: misokwart@yahoo.com

Leafy amaranths are popular in African and Asian countries. They have excellent nutritional value because of their high essential micronutrients such as beta-carotene, iron, calcium, vitamin C and folic acid. They also have lysine, an essential amino acid in the range of 6% dry weight protein, which is similar to the recommended FAO/WHO standards and is often lacking in human diets. Amaranth leaves are mostly bundled fresh for marketing, which leads to postharvest losses as high as 20-50% of production. The use of drying is encouraged as an alternative to prolong the shelf life of harvested leaves but under studied. This review highlights drying methods for leafy amaranths and their effect on nutritional quality. Literature was sourced from journal articles, reports, books, online libraries, and website extension fact sheets. Dried leaves are preserved to prevent microorganism infestations and to concentrate nutrients for

later use. Based on the literature, amaranth leaves can be dried by the following methods: 1) open sun drying; 2) air drying in the shade; 3) solar drying under a glass-surfaced structure; 4) cabinet drying with air circulation; 5) drying in a hot-air oven; 6) freeze-drying; 7) infra-red drying with thermal radiation: and 8) vacuum drying. Nutrient retention in solar-dried leaves is higher than in open sun and oven-dried leaves. We recommend using solar and shade drying for a longer and shorter storage period of amaranth leaves. However, cabinet drying should be employed for higher retention of beta-carotene and ascorbic acid. Drying is advocated for a year-round supply of nutrient-rich amaranth leaves in developing countries.

Research and development of traditional vegetables in Zimbabwe: A review. Dorah Mwenye[1] and Linda Muusha[2]. [1]Department of Research and Specialist Services (DR&SS), Ministry of Agriculture, Box CY594, Causeway, Harare, Zimbabwe. [2]Horticulture Research Institute, DR&SS, PO Box 810 Marondera, Zimbabwe. Email: dmwenye6@gmail.com

The role of traditional vegetables in the food and nutrition security of rural and urban populations has gained significant prominence in the last two decades. In response, interest has grown for research and development to promote production and utilization among various players, including national research and extension services, non-governmental organizations, and tertiary institutions. Uncoordinated and disorganized information on the properties and uses of traditional vegetables in Zimbabwe exists in various forms. Horticulture Research Institute researched *Cleome gynandra*, *Amaranthus* spp. and *Brassica carinata*, and *Brassica juncea*, focusing on fertilizer requirements and harvesting techniques to improve productivity. Unfortunately, this work and similar research from other institutions have been challenging to access. With this in mind, this paper reviews research work and related documentation on traditional vegetables to promote their value chain. A desk study will be commissioned, which will be supported by interviews of key informants who will be identified through snowballing. Data will be analyzed, guided by the principles of thematic analysis. This review is of significance as it will inform policy on the role of traditional varieties and identify gaps for future research.

Role and responsibility of international development agencies to promote and incorporate consumption of indigenous vegetation in nutrition programs throughout Africa. Bryan Pride[1] and Chelsie Kolberg[2]. [1]Rise Against Hunger, USA. [2]Global Health. Email: bpride@riseagainsthunger.org

Africa is losing indigenous vegetables. Research demonstrates that indigenous crops are highly nutritious. However, the consumption and cultivation of leafy green African vegetables are dwindling. Multiple factors have caused the loss of indigenous crops. The research presented will address how the loss of indigenous crops results from the stigmatization of indigenous crops, and the acceptance of "The West Knows Best" development practices. Through documented interviews, the primary response is that Africans are not consuming indigenous crops because traditional vegetables are viewed as "poor man's food." In order to eradicate the negative stigma against indigenous crops, there is a need for policies and educational platforms to support the cultivation and consumption of indigenous crops. Additionally, international development agencies need to support African governmental institutions in the promotion of indigenous crops in order to de-stigmatize traditional vegetables. The present research analyzes how indigenous crops and traditional African diets help build proper gut health, thus leading to a healthy gut microbiome. Many indigenous vegetables provide essential micronutrients that allow Africans to maintain proper nutrition. When Africans cannot eat traditional diets, essential nutrients that maintain a healthy gut

microbiome and proper nutrition are lost, thus leading to malnutrition and increased instances of overall poor health among Africans. Establishing policies that mandate international development agencies to promote and utilize indigenous crops in agriculture and nutrition-sensitive programming will de-stigmatize indigenous vegetables. Additionally, when international development agencies incorporate indigenous crops in development programs, the nutritional value of indigenous crops is shared with host country nationals, increasing the understood value of indigenous crops. Increasing knowledge will increase the desire to consume indigenous vegetables, positively impacting Africans' overall health.

Seed yield and quality of jute mallow as affected by cutting frequency and salicylic acid foliar application. Hamdino M.I. Ahmed[1] and Jean Jacques Muhinda[2]. [1]Horticulture Research Institute, Giza, Egypt. [2]Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Plot 5 Mpigi Road, Entebbe, Uganda. E-mail: hamdino.ahmed@gmail.com

Jute mallow (*Corchorus olitorius*) is an important leafy vegetable found in the wild and cultivated in many countries of Africa. To improve its seed yield and quality, two field experiments were conducted to investigate the effect of cutting frequency (no cut, one cut, and two cuts) and salicylic acid (SA) foliar application at (0, 25, 50, and 100 ppm) on growth, seed yield and its quality. Cutting frequency caused a significant increase in the number of branches per plant and a reduction in plant height. Cutting once was the most effective treatment in increasing seed yield by increasing pod number/plant, seed number/pod, and 1000-seed weight. All cutting frequency treatments had no significant effects on germination percentage. Spraying jute mallow plants with SA enhanced the vegetative growth of plants and increased seed yield and its components. Different SA treatments did not significantly affect germination percentage and rate (i.e., germination percentage/time). However, salicylic acid at 100 ppm gave the highest values. Generally, cutting plants once and spraying them with 100 ppm of SA was the best treatment for high seed yield and quality.

Taiwan indigenous vegetables in current agri-food systems. Hsin-I Wang[1], Wan-Jen Wu[1], and Ray-Yu Yang[1,2]. [1]World Vegetable Center, PO Box 42, Shanhua, Taiwan. [2]Food and Fertilizer Technology Center for the Asian and Pacific Region, Taipei, Taiwan. Email: ray-yu.yang@fftc.org.tw

About 150 Taiwan indigenous vegetables (TIVs) were summarized from our previous reviews of ethnobotanical studies. We further investigated TIV production over the past 20 years and searched where and how the TIVs are currently produced, utilized, and promoted. Production data and market prices were retrieved from monthly, and annual Taiwan Agriculture Statistics Reports; information on TIV farms, local markets, and restaurants was searched on the internet with keywords. Among the 150 TIVs, only 14 were included in the wholesale market database. Amaranth had the highest annual production in 2017 (8,566 t), followed by chayote vines (2,549 t), okra (2,545 t), and vegetable fern (247 t). Six types of trends of TIV production and price changes over time were classified. Many TIVs were produced by small farms and sold in local markets; production data were not recorded. About 39 TIV organic farms were searched on the internet, 70% of the farms are open to visitors and provide farming courses for education purposes. The learning program and topics generally include DIY (do-it-yourself), indigenous people's culture, and food and agricultural education. Farm locations were scattered around Taiwan. Three common channels of purchasing TIVs include local markets, online shopping, and wholesale markets. About 44 local markets selling TIV and 73 restaurants with TIV on menus were found from an internet search. About

85% of the restaurants were tribal, 46 TIVs were mentioned in the 73 menus, and mountain pepper (*Litsea cubeba*) was mentioned the most. Google Maps for TIV farms, restaurants, and local markets were developed using Google My Map for future promotion. Those farms, markets, and restaurants not searchable on the internet were not included in this study.

The contribution of less documented indigenous leafy vegetables to total micronutrient intake of children below five years in a rural semi-arid area in Tanzania. Hadijah A. Mbwana[1] and Stephen Ruvuga[2]. [1]Department of Food Technology, Nutrition and Consumer Sciences, Sokoine University of Agriculture, PO Box 3006, Morogoro-Tanzania. [2]National Network of Farmers Groups in Tanzania, Morogoro, Tanzania. Email: hadija27@yahoo.com

In semi-arid regions of Tanzania, indigenous vegetables, although less documented, are part of the culture and have the potential for a high nutrition impact on the communities. This study ascertained the contribution of some of the undocumented indigenous vegetables to the total micronutrient intake of children below five years of age in two rural villages in the semi-arid region of Dodoma, where the production, preservation, and consumption of these vegetables were promoted. An exploratory cross-sectional study with a longitudinal 24-hour dietary recall (four repeated one month apart) assessment factor was employed. Household surveys were conducted to elicit information on socio-economic and demographic profiles and food consumption patterns at the household level. An intervention combined with nutrition education and promotion of production, preservation, and consumption was conducted. The study employed stepped-up advocacy, information, and community education to change people's attitudes by mobilizing champions and role models farmers and demonstrating kitchen gardening and nutrient-sensitive cooking demonstrations. Food intake reported in household measures was converted into weight, and nutrient contents were computed using various food composition tables and literature. The SAS software package converts food intake to macro and micronutrients. For the vegetables commonly consumed, intake was calculated and expressed as a percentage of total intake. *Ipomoea pandurate* (chiwandagulu), *Corchorus trilocularis* (ilende), *Ipomoea obscura* (chipali), and *Amaranthus graecizans* (fwene) were tested. Households (n=350) with at least one child below five years and a woman caregiver in Mzula and Chinoje villages in Chamwino District, Dodoma Region. Regarding production, reported constraints were inappropriate crop varieties and infestation by major pests and diseases, leading to low-quality produce. An impact assessment study showed that nearly 40% of households growing vegetables increased their income, while almost half had increased their consumption of indigenous vegetables. Total dietary intake of nutrients was significantly improved for children who consumed indigenous vegetables. For most vegetables, leaves and stems were common parts consumed. The proportion of children who consumed indigenous leafy vegetables during the 4-day recall period ranged from 28% (first survey) to 89% (last survey). After four weeks of promotion, the average number of times children consumed vegetables ranged from 1.2 (first survey) to 3.1 (last survey). Dietary recalls revealed low intake quantities of these vegetables. The average portion consumed was approximately one-fourth of a cup (78 ± 42 g) for *I. pandurate* and 78 ± 37 g for *C. trilocularis*. Children who consumed these vegetables significantly improved their total dietary intake of nutrients. These included calcium (18 to 35% of total intake), iron (21 to 38%), vitamin A (39 to 61%), and riboflavin (7 to 24%) of total intake. This positive impact can conceivably be augmented if these vegetables are consumed more frequently and in a larger quantity and a larger children population. Policies and interventions must be devised to achieve wider consumption through production, conservation, processing, promotion, documentation, and adequate nutrition

education. This can significantly impact increased micronutrient intake among children in this community through readily available indigenous vegetables.

The contribution of neglected oyster nuts to biodiversity conservation and improved community livelihoods in northern Tanzania. Philipina F. Shayo, Emmanuel F. Mwakasege, and Anna C. Treydte. Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania. Email: shayop@nm-aist.ac.tz

Oyster nut (*Telfairia mbuia* (Sims) Hook) of the Cucurbitaceae family is a vine usually growing on tall hardwood tree species and native only to northern Tanzania, Mozambique, and Uganda. The northern Tanzanian natives value its nuts because of their important nutritional and healthy-oil seeds, which are in great demand by pregnant and lactating women (due to lactogenic properties). The socio-economic importance, conservation strategies, and prospects for improved production and utilization of oyster nuts would provide more diversified food and oil sources necessary for addressing food and nutritional security in Tanzania. Here, we present a few potentials of the neglected oyster nut which could be helpful for agriculturists, researchers, conservators, and nutritionists to enhance their utilization.

The participatory evaluation of amaranth germplasm for leaf yield in South Africa. W.S. Jansen van Rensburg[1], L.N. Khoza[1], A.S. Gerrano[1], M.W. Bairu[1], and K. Denby[2]. [1]Agricultural Research Council (ARC), Vegetable Ornamental Plants, Private Bag X293. Pretoria, 0001, South Africa. [2]Department of Biology, University of York, Wentworth Way, York YO10 5DD, UK. Email: WjvRensburg@arc.agric.za

Amaranth, better known as “thepe” in Sesotho or “51mbuia” in isiZulu, is a very popular leafy vegetable in South Africa. Amaranth is very nutritious, and 100 g of cooked amaranth can contribute up to 70% of the daily beta-carotene and 30% of the daily iron needs of growing toddlers. Traditionally, amaranth is harvested from the wild, but it can be cultivated with great success. However, no genetically improved material is available in South Africa. The Agricultural Research Council (ARC), in collaboration with the University of York and the Department of Agriculture, Forestry, and Fisheries, has embarked on a project to evaluate amaranth germplasm. Eleven promising amaranth lines were selected based on phenotypic traits. A formal yield trial was planted at ARC-Vegetable and Ornamental Plants, Roodeplaat research farm, Gauteng. The yield trial was planted in a randomized complete block design with three replicates during the 2018/19 and 2019/20 cropping seasons. The young growth shoots and leaves were harvested three times, and the fresh and dry weights of the three harvests were determined. Participatory demonstration trials were planted during 2019/20 with two farmers in their field in Gauteng, one farmer in Mpumalanga, and a farmers group in KwaZulu Natal. These farmers were visited during the season, and group discussions were held. The result showed that the amaranth lines differ significantly for all yield attributes. Different farmers’ evaluations were very similar. They all prefer green-leaved amaranth. All of them have been harvested for their consumption. The farmers in Mpumalanga and KwaZulu Natal sold their produce to the local community for home consumption. Three amaranth lines, namely, Anna, ACAT Seedfair, and Arusha, can be recommended for cultivation by smallholder farmers in the country. These lines will also be included in the amaranth breeding program at ARC.

Traditional African vegetables strengthen food and nutrition security in Madagascar. Bodovololona Rabary[1], Tatiana L. Rakotoson[1], Marteen van Zonneveld[2], Lalaina B. Ranaivoson[3], Justus Ochieng[4,5], Herimiamina Andriamazaoro[3], Juvet Razanameharizaka[6], Tendro Radanielina[6], Denis Randriamampionona[6], Isabelle Rahetsivololona[7], Sognigbe N'Danikou[4]. [1]Centre Régional de Recherche FOFIFA (National Center for Applied Research on Rural Development), BP 230, 110 Antsirabe, Madagascar. [2]World Vegetable Center, PO Box 42, Shanhua, Tainan 74199 Taiwan. [3]FOFIFA, BP 1690, Antananarivo 101, Madagascar. [4]World Vegetable Center-East and Southern Africa. PO Box 10 Duluti, Arusha, Tanzania. [5]Bayesian Consulting Group, PO Box 44817, 00100, Nairobi, Kenya. [6]AT2D, Université d'Antananarivo, BP-175, Antananarivo 101, Madagascar. [7]SEMANA, Antananarivo, Madagascar. Email: bodo.rabary@gmail.com

Malagasy farmers maintain a high diversity of traditional vegetables, but their production and consumption are low. Low usage makes traditional vegetables vulnerable to local or national extirpation under the pressure of land-use change and crop replacement. Within the framework of the 3-year Darwin Initiative-funded project, the World Vegetable Center, FOFIFA, Université d'Antananarivo, and SEMANA Seed Company are working with small-scale farmer families in Itasy and Antsirabe regions to improve the production of traditional vegetables for income generation and dietary diversification to reduce hidden hunger. The approaches integrate a good understanding of the status of agro-biodiversity in Malagasy food systems; germplasm collection to rescue landraces of both popular and threatened traditional vegetables in ex-situ; capacity building of 25 Malagasy extension workers, 200 women farmers, and five primary schools on seed saving and production of traditional vegetables; and seed business capacity development of 10 progressive women farmers on promising varieties of traditional vegetables. The women farmers receive seed kits for on-farm evaluation. These actions will enhance and protect vegetable genetic resources through increased utilization. The project strengthens existing school garden initiatives with training on seed saving and providing good quality seeds of traditional vegetables to raise awareness for local food plants. An agro-biodiversity catalog about Malagasy food plant diversity will be developed and promote the relevance of agro-biodiversity as a biocultural heritage, a source for human diets, and the importance of this diversity for nutrition.

Understanding molecular mechanisms of seed dormancy for improved germination in traditional leafy vegetables. Silvère Fernand Sohindji. Laboratory of Genetics, Horticulture and Seed Science, University of Abomey-Calavi, 01 BP 526 Tri Postal, Cotonou, Benin. Email: sohindjisilverfer@gmail.com

Loss of seed viability, poor and delayed germination and inaccessibility to high-quality seeds are key bottlenecks limiting all-year-round production of African traditional leafy vegetables (TLVs). Poor quality seeds result from several factors, including harvest time, storage, conservation conditions, and seed dormancy. While other factors can be easily controlled, breaking seed dormancy requires a thorough knowledge of the seed's intrinsic nature and physiology. Here, we synthesized the scattered knowledge on seed dormancy constraints in TLVs, highlighted seed dormancy regulation factors, and developed a conceptual approach for molecular genetic analysis of seed dormancy. Several hormones, proteins, changes in chromatin structures, ribosomes, and quantitative trait loci are involved in seed dormancy regulation. However, most knowledge was based on cereals and *Arabidopsis*, and there is little awareness about seed dormancy and mechanisms in TLVs. To successfully decipher seed dormancy in TLVs, we

used *Cleome gynandra* to illustrate possible research avenues. We highlighted the potential of this species as a model plant for seed dormancy analysis. This will serve as a guideline to provide prospective producers with high-quality seeds.

Use of lusala, a wild yam, in southern Zambia. Donald Zulu, Richard Ellis, and Alastair Culham. School of Agriculture, Policy and Development, University of Reading, Earley Gate, PO Box 237, Reading RG6 6AR, UK. Email: donald.zulu@gmail.com

Lusala (*Dioscorea hirtiflora* Benth. subsp. *pedicellata* Milne-Redh.) is an important wild edible tuber foraged from the miombo woodland in southern Zambia. This wild yam blends well with groundnuts, eggs, fish, and meat in meals. Its collection, sale, and consumption are widespread in southern Zambia. Of rural households interviewed, 83, 96, and 59% collected, consumed, and sold lusala during the dry season from March to September. In the peak month for foraging (April), each rural household that reported lusala use within the respective groups collected 27.9 kg (n=129), consumed 12 kg (n=108), and sold 35.7 kg (n=69). Among the latter group, the reported household annual income from lusala sales was about 44% of that from their maize crop and, therefore, crucial to household income in the dry season. Lusala also supported market traders' businesses, each purchasing at an average of 899 kg valued at USD 383 during one month (August) for resale. Lusala populations in the wild are at risk from overharvesting and deforestation. It was propagated successfully from tubers, mini-tubers, minisetts, and vine cuttings, but high dormancy often delayed stem emergence. Considerable genetic diversity was detected amongst 185 lusala samples collected across Zambia. Analysis of molecular variance showed 65% variation between populations and only 35% within populations, with five clusters of samples nationally. Genetic resource conservation combined with more sustainable foraging and/or possible domestication will be needed to sustain livelihoods and reduce the decline of lusala in the wild.

World Vegetable Center's genebank of African traditional vegetables in Tanzania supports better income and healthier diets for smallholders. Sognigbe N'Danikou, Jeremiah Sigalla, Omary Mbwambo, and Martha Munisi. World Vegetable Center-East and Southern Africa. PO Box 10 Duluti, Arusha, Tanzania. Email: sognigbe.ndanikou@worldveg.org

African traditional vegetables are valuable assets to support nutrition-sensitive agriculture under climate change because they are generally more nutrient dense than most global vegetables. They have lower water requirements, can do better on poor-quality soils, and have higher resistance to pests and diseases. However, the biodiversity of African traditional vegetables is endangered by displacement in favor of high-energy staple crops with largely informal seed systems. The World Vegetable Center-East and Southern Africa genebank maintains about 2,700 accessions of African traditional vegetables, with okra, African eggplant, roselle, amaranth, and cowpea being the most represented crops. About 500 accessions (over 10,000 seed samples) are distributed annually to farmers, universities, seed companies, and national research institutes. About 45,000 seed kits containing about 189,000 vegetable seed samples were distributed to smallholder farmers in Tanzania, Kenya, Uganda, and Madagascar from 2013 to 2019. To optimize the supply of vegetable diversity, the WorldVeg genebank of African traditional vegetables continues working with partners in the formal and local seed systems.

Yield, nutrient content and release of improved amaranth varieties in northern Tanzania. E. Laswai[1], F.F. Dinssa[2], and O. Mbwambo[2]. [1]Tanzania Agricultural Research Institute, Tengeru, PO Box 1253, Arusha, Tanzania. [2]World Vegetable Center, Eastern and Southern Africa, Duluti, PO Box 10, Arusha, Tanzania. Email: fekadu.dinssa@worldveg.org

Amaranth (*Amaranthus* spp.) is one of the African continent's most commonly produced and consumed traditional vegetables. It is a nutritious crop with high protein, minerals, and vitamins. However, Tanzania still lacks improved varieties of amaranth despite the importance of the crop for human health. The current study's objective was to develop improved lines for release as commercial varieties. Sixteen amaranth entries (13 test entries plus three check varieties) retained from breeding nurseries of the World Vegetable Center Eastern and Southern Africa (WorldVeg-ESA) were evaluated in replicated trials in three different locations: WorldVeg-ESA, Moshi, and Mbuguni, in northern Tanzania in 2015 and 2016. Data collected included vegetative yield and agronomic traits. Farmers' participatory selection was also conducted in all locations. Significant differences among entries in all locations were found for yield, plant height, leaf sizes, and branch numbers per plant. Three lines, AH-TL-Sel (*A. hypochondriacus*), UG-AM-9- ES13-2 (*A. dubius*), and Paris (A)-Sel (*A. cruentus*), were released as vegetables or dual-type varieties in Tanzania in 2018/19 under commercial variety name 'Poli,' 'Nguruma' and 'Akeri,' respectively. This paper presents the performances of these varieties in yield and nutrient contents.

HIGHLIGHTS OF YOUTH PANEL DISCUSSION

YOUTH FOR ENTHUSIASM AND ENTERPRISE: GREEN SHOOTS TO BIG BUSINESSES

Moderator: Ronald Diang'a, Kenavara Group, Kenya
Panelists:
Kenneth Chepkwony, Kenavara Group, Kenya
Kinshaga Elias, Kishaga Foods, Tanzania
Rogers Kirwa, iAgribiz Africa, Kenya
Sandra Nabasirya, tomato farmer, Uganda
Erick Ochonga, Irri-Hub, Kenya
Jannette Toroitch, integrated farmer, Uganda

Recommendations from the panelists:

- Promoting the consumption of ATVs among youth through awareness and campaigns that include repeated exposure, school curriculum, ATV availability at home, public food services, mobile phones, internet, radio, television, etc.
- Improving youth mentoring programs, especially for young rural women, to partake in the green economy with ATVs, which is labor intensive and value adding.
- Engaging youth to leverage social media for food system transformation with ATVs and innovations in digital technologies in the ATV value chain.
- Providing loans to assist youth in acquiring land and financial products catered to youth and start-up funding opportunities for developing entrepreneurial ventures with ATVs.

HIGHLIGHTS OF HIGH-LEVEL PANEL DISCUSSION

ADVANCING THE CONTINENTAL AGENDA ON AFRICAN TRADITIONAL VEGETABLES

Moderator: Susan Mugwe, Africa Region M&E Expert at FAO
Panelists:

Laurence Haddad, Global Alliance for Improved Nutrition (GAIN)
Judy Matu (Association of Women in Agriculture Kenya (AWAK)
James Mwangi, Equity Bank, Kenya
Mboka Mwanitu, Tanzania Agricultural Development Bank (TADB)
Munguatosha Ngomuo, Tanzania Official Seed Certification Institute (TOSCI)
Eltruda Temba, East-West Seed Tanzania

Major issues raised from the floor:

- Do financial institutions view African traditional vegetables (ATVs) as an important and viable investment opportunity? If so, are there successful stories on investments in ATV value chains?
- Why have ATVs not been fully part of the mainstream agriculture and food policy? What should be done to elevate the status of these critical food crops?
    - What are available pathways for the scaling-up process of integrating ATVs in the sustainable food system to achieve larger-scale impacts from ATVs?
    - What are the constraints and challenges for smallholder farmers in the sub-Saharan continent, especially women farmers, as the primary actors in the food system for the adoption of ATVs?

Responses and recommendations from the panelists and participants:

- Demand creation is imperative for ATVs. Thus, there is a need for sound policies that scale-up promotion and create demand for ATVs by re-creating awareness of ATVs; and encouraging smallholder farmers to grow, traders to market, and consumers to eat more ATVs. This would be important in increasing balanced diets for the micronutrient-deficient population. Furthermore, it calls for policymakers to provide the right incentives to take action.
- Facilitate the establishment of communication networks to link different stakeholders of the vegetable value chain (policymakers, financial institutions, private sector, researchers, farmers, input suppliers, buyers, processors, and consumers); provide extension opportunities for further development and exchange of information on ATVs. This is to lead and strengthen collaboration among different stakeholders.
- Establishment of ATV seed systems that deliver sufficient, affordable, climate resilient, quality seeds by combining the best of formal and informal seed systems.
- Postharvest value additions of ATVs through appropriate packaging and home-scale drying, preservation (fermentation), and bottling/canning; menu planning and recipe development to enhance the presentation of appealing and delicious dishes with nutritious ATVs; and create value from edible ATV wastes.
- Food relief efforts by the humanitarian agencies need to include ATVs and other common vegetables to balance the nutrition in the diet, subsequently creating demands for ATVs and other vegetables.

- Encourage public-private partnerships in research and innovation to maximize outputs of ATVs in terms of productivity and profitability in different farming systems with an inclusive, gender-responsive approach.
- Apart from achieving high yields, the breeding of ATVs should also reflect consumer taste preferences and nutritional values.
- The transformation to sustainable and resilient food systems with ATVs requires an effective mobilization of public and private finance. Apart from public funding as a push mechanism to initiate the transformation, there is also a need for early-stage business models and bankable projects, mainly within the smallholder farmer context, that attracts the private sector's interest in opportunities with ATVs.

THE 10 TAKEWAYS FROM THE 'POWER ON YOUR PLATE' SUMMIT

The 'Power on Your Plate Summit' dedicated to African traditional vegetables (ATVs) was held on 25-29 January 2021 in Arusha, Tanzania. The event highlighted 64 scientific presentations covering six subject areas. There were about 175 in-person participants in Arusha, 312 registered ZOOM participants, and another 200 people following activities through the WHOVA conference app. More than 10,000 people viewed the summit during the live Facebook feed.

The followings are the main ten takeaways from the Summit:

1. Consumption of ATVs is declining on the African continent because of changing diets towards more processed and westernized foods.
2. ATV diversity is threatened because of diet homogenization, food production homogenization, and urban migration. There is an urgent need to conserve and document vegetable landraces, their wild relatives, and traditional knowledge of these vegetables before they are lost.
3. ATVs are generally very rich in micronutrients and sturdier than global 'exotic' vegetables and are an affordable way to meet the micronutrient needs of a rapidly growing African population.
4. ATVs can provide significant opportunities to create employment and income, particularly for women and youth, diversify diets, and diversify farming systems, thereby contributing to increased resilience to climate change.
5. To realize the potential of ATVs in Africa, there is a need to work simultaneously on the '3 Ps' of ATVs: **pulling** demand for ATVs, **pushing** the supply of ATVs, and providing enabling **policy** and governance for ATVs.
6. On the push (or supply) side, innovative approaches are needed to expand the availability and affordability of ATVs. This will involve strengthening formal and informal seed systems and introducing 'green' agricultural practices to guarantee food safety, diversify the ATV species grown and marketed, raise yields, and sustainably extend growing seasons. There is also scope to reduce post-harvest losses by introducing processing technology, shorter supply chains, and appropriate market storage space for vegetable vendors.
7. On the pull (or demand) side, innovative approaches are needed to stimulate the acceptability and accessibility of ATVs as part of healthy foods. Establishing trust and traceability relationships and short connection lines between producers and consumers can address food safety concerns. Information campaigns can raise interest in traditional vegetables. Such campaigns must emphasize

taste, cultural value, and ease of preparation besides nutritional, health, and environmental benefits.

8. On the policy (or governance) side, the promotion of ATVs must occur within local, national and regional initiatives to reduce malnutrition, create employment opportunities, and ensure crucial buy-in from policy- and decision-makers. Government policies supporting public procurement of ATVs for school feeding and other public food programs are expected to raise demand and address several of the Sustainable Development Goals (SDGs) at once, including SGDs 1, 2, 3, 13, and 15, among others.
9. The enormous diversity of ATVs offers farmers and processors great market opportunities. There is a need to identify 'local favorites' that best fit local agroecosystems and diets.
10. A far more significant proportion of national, regional, and global R&D efforts must be dedicated to nutritious food, particularly ATVs.