Developing African leafy vegetables for improved nutrition

Regional Workshop, 6–9 December 2005

R. Oniang'o, M. Grum and E. Obel-Lawson, *editors*

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Hon. Professor Ruth Oniang'o
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Preface

This special issue of the African Journal of Food, Agriculture, Nutrition and Development is about leafy vegetables in Africa. The contributors were all part of a programme on leafy vegetables coordinated by Bioversity International (then known as the International Plant Genetic Resources Institute) involving more than 40 institutions and organizations spread across 12 countries of sub-Saharan Africa. The programme ran in two phases between 1996 and 2003, and has since developed into a range of other activities, run and coordinated by various stakeholders. These papers were originally prepared for a regional workshop to share knowledge and experiences on developing African leafy vegetables for improved nutrition held at the African Institute for Capacity Development (AICAD) in Juja, Kenya, 6-9 December 2005.

The nutritional health value of the vegetables has been the main message used to promote increased consumption of the vegetables. Nonetheless, despite the evident importance given to a wide range of leafy vegetables across Africa, the message from the scientific community has not always been clearly positive, with critics focusing on the limited bioavailability of the iron and vitamin A present in leafy vegetables. The preface and several papers in this volume weigh into the debate with reviews, opinions and new research. Here we present a few key highlights from each of the papers:

The World Health Organization does not equivocate. Their recommendation of a minimum daily intake of 400g of fruits and vegetables is one of the central tenets of their Global Strategy on Diet, Physical Activity and Health. Smith and Eyzaguirre review the role of African leafy vegetables in this strategy and propose ways forward.

Ndong *et al*. use *in vitro* methods simulating the function of the stomach and conclude that though dried leaves of *Moringa oleifera* are rich in iron, its bioavailability is low when the leaves are used in a variety of traditional Senegalese dishes. However, they emphasise the high protein content, calcium and other nutrients in the leaves, grains and flowers of the plant.

Muchoki *et al*. address the need for out- of- season vegetables by looking at changes in beta-carotene, ascorbic acid and sensory properties in fermented, solar-dried and stored cowpea leaf vegetables. She concludes that fermentation and acidification are both promising storage methods that have acceptable sensory quality for consumers, but they lead to substantial losses in beta-carotene and ascorbic acid. Storage temperature was a key factor in these losses with leaves stored at 18 °C retaining roughly twice the beta-carotene of leaves stored at 32 °C.

Cultural factors have a major impact on consumption and continue to do so even in urban areas where people are far from their traditional production systems, as Kimiywe *et al*. demonstrate with their data from Nairobi. Ethnic origin was found to be by far the dominating determinant of traditional leafy vegetable consumption with income and education levels having no discernable influence. Owuor and Olaimer-Anyara take us through a botanical and cultural exploration of the folklore of the Luo of southwestern Nyanza in Kenya. They find that the rural and the older people tend to have a greater appreciation of the health benefits of bitter leafy vegetables than the young and the urban. Folklore has much to say about bitterness, sliminess, nutrition, vegetables and status, complementarity of foods and much else that is useful to understanding the roles that these vegetables might play in nutrition and society in general.

Nguni and Mwila found that traditional vegetables were more important than exotic vegetables in the three areas of Zambia that they surveyed. Species such as *Amaranthus* spp. and *Cleome gynandra* are still only semi-cultivated or gathered in many situations, whereas others such as *Abelmoschus esculenta* and *Cucurbita* spp. are generally cultivated and have developed local seed markets. With only one rainy season a year, dried vegetables play a more important role in Zambia than in Kenya with its bimodal rainfall pattern where the fresh produce dominates.

Vorster *et al*. looked at the importance of leafy vegetables in seven distinct rural areas of South Africa and found a range of cultivated and uncultivated leafy vegetables that varied by ecological zones, ethnic groups and gender. While the vegetables were important foods at all the sites and generally recognized as nutritious, they were often regarded as backward by the young and educated who also had less exposure to, and knowledge of, the vegetables. Market development, improved access to recipes and improved knowledge of drying techniques were identified as some key components to increasing the contribution of traditional vegetables to diets.

Batawila *et al*. surveyed the gathered vegetables of Togo and identified 105 species that were eaten, two-thirds of which were leafy vegetables. Of these, 47 were only consumed by one ethnic group and 12 were consumed by all the ethnic groups.Most gathered vegetables were found in the northern part of the country, where the Kabye and the Nawdba particularly stood out for their high vegetable consumption.

Research and development in leafy vegetables is often hampered by uncertainty surrounding the correct identification of species. Rarely is this truer than for the African nightshades, *Solanum* section *Solanum*, often lumped under the title of "the *Solanum nigrum* complex" which is generally considered poisonous in Europe and the Americas. Mwai and Abukutsa-Onyango take a much closer look at the morphology and ploidy levels of this group and come up with distinctive traits for nine member species. This will enable future researchers to know and communicate what they are really working on.

Diouf and Mbengue characterized Senegalese leafy vegetables and introduced accessions of *Hibiscus sabdariffa*, *Moringa oleifera*, *Amaranthus* spp. and *Vigna unguiculata*. The hibiscus showed very high variability and clear clustering, while local material of moringa and amaranths showed less diversity, but was clearly distinct from the introduced materials. Local cowpea diversity was high, but did not show clear clustering. The implications for conservation and crop development are discussed.

Among the Luhya, Luo and Kisii of Kenya, Abukutsa-Onyango found nine leafy vegetable species that were more common than kale (*Brassica carinata*) until recently considered by many to be synonymous with Kenya and leafy vegetables.

Van Rensburg *et al*. carried out ecogeographic surveys of *Amaranthus* spp., *Chenopodium album*, *Cleome gynandra*, *Vigna unguiculata* and a number of Cucubitaceae vegetables and mapped their predicted distribution using GIS tools. They also looked at conservation trends across South Africa for these species and recount the specific story of how 'Phara', a local variant of *Cucumis melo* was lost and found.

Diouf *et al*. worked with women farmers from three pilot sites in Senegal, an economic interest group and an NGO to select varieties of *Hibiscus sabdariffa*, *Moringa oleifera*, *Amaranthus* spp. and *Vigna unguiculata* for promotion and distribution. *Hibiscus sabdariffa* was only represented by local varieties, while there were introduced varieties of *Moringa oleifera* and *Amaranthus* spp. from AVRDC that scored alongside the best local varieties. The *Vigna unguiculata* material from AVRDC scored way above the local material with which it was compared. The results will need to be verified in on-farm trials. Overall, there was very large variation among varieties in total scores, demonstrating the strong potential for improvement that generally exists within traditional leafy vegetables across Africa.

Getting improved varieties distributed will require a well organized seed sector. Abukutsa-Onyango studied current seed support and supply systems in three Kenyan communities. She then collected, evaluated and multiplied lines of seven priority species of leafy vegetables at Maseno University and distributed these lines through the Rural Outreach Program (ROP).

Traditional leafy vegetables are generally grown with few external inputs, but as intensification and commercialization of the crops takes place, the use of chemical inputs increases. Assogba and Prudent take a look at the use of nitrates and pesticides in production systems around Cotonou. They found that 83% of *Solanum macrocarpum* producers used more than six times the recommended quantities of nitrate fertilizers but did not find that this resulted in unacceptably high levels of nitrates in the leaves. On the other hand, they found extensive use of insecticides that are prohibited for use on vegetables and found levels of DDT, Endosulfan, Dieldrin and Endrin in sampled leaves that were considerably above the norms established by FAO's Codex Alimentarius. The same chemicals were found in soil samples from the vegetable gardens.

The results of a field trial carried out by Abukutsa-Onyango may explain why other traditional leafy vegetables are often grown with few external inputs. She found no significant effect of nitrogen fertilizer on the leaf or seed yield of slenderleaf (*Crotalaria brevidens*).

In South Africa, like in many other places, the traditional leafy vegetables suffered from neglect as 'poverty foods' and 'weeds'. A concerted effort to raise their standing has begun to change that. Vorster *et al*. organized participatory collecting missions, new germplasm introductions, participatory selection processes, school gardens, and awareness days with cooking competitions, recipe and seed exchanges, school plays and radio shows.

The rapid growth of traditional leafy vegetables marketing and consumption in Nairobi during the first half of this decade is broadly touted as the great traditional leafy vegetable success story. Shiundu and Oniang'o take a critical look at the equity aspects of the story and find that while women and small producers were the foundation on which this expansion was built, they are now losing out. They describe initiatives by the Rural Outreach Program to ensure that women in Western Kenya continue to benefit from the production of these vegetables.

For agricultural research organizations to have an impact on leafy vegetable production and consumption, they need knowledge on the importance of these crops to include in decision-making and priority setting. Venter *et al*. illustrate how the programme on leafy vegetables coordinated by Bioversity International interacted with other projects and institutions to transform the way that the Agricultural Research Council (ARC) of South Africa addressed the research needs of small holder farmers. Important elements of this include: increased participation of communities in the experimental process; social learning and participatory approaches; and engaging all role-players, institutions and projects in an enhanced learning process.

Finally, when time came to publish these papers in a scientific journal, the choice was easy. The Rural Outreach Program that publishes AJFAND has been a partner throughout this initiative, AJFAND is widely and freely accessible over the Internet, it reaches our target audience, and where else will one find a journal that covers such a wide and yet well-linked range of topics as Food, Agriculture, Nutrition and Development, all of which were major themes of the African Leafy Vegetables Programme?

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Foreword

Welcome to a special issue of AJFAND, Volume 7 nos. 3 and 4, 2007. This issue is devoted to African leafy vegetables. The research papers published in this volume were presented at a Bioversity International (formerly International Plant Genetic Resources Institute, IPGRI) regional workshop. The papers are based on research supported by Bioversity International and have been peer reviewed in accordance with AJFAND guidelines and standards.

Remember, African leafy vegetables are good for human health. Remember too, orange, yellow-fleshed foods are good for you. For many of our resource-poor consumers, these constitute the main source of vitamin A in form of beta carotene. What is even more encouraging is that these are mostly a women's crop and so the resource-poor women can affordably provide good nutrition to their families, while they generate some income for themselves. I believe you will enjoy this special issue of AJFAND.

Ruth Oniang'o
Editor-in-Chief
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African leafy vegetables: their role in the World Health Organization's global fruit and vegetable initiative

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Abstract

The increased awareness of the health protecting properties of non-nutrient bio-active compounds found in fruits and vegetables, has directed immense attention to vegetables as vital components of daily diets. For sub-Saharan African (SSA) populations, this attention on vegetables as vital dietary components is significant, as leafy vegetables have long been known to be indispensable ingredients in traditional sauces that accompany carbohydrate staples. African indigenous and traditional leafy vegetables thus have a pivotal role in the success of the World Health Organization's (WHO) global initiative on fruit and vegetable consumption in the sub-continent.

The joint WHO/FAO 2004 report on a Global Strategy on Diet, Physical Activity and Health, recommended a minimum daily intake of 400g of fruits and vegetables. Also, at their 2004 joint Kobe workshop, the WHO and FAO developed a framework that proposes ways to promote increased production, availability and access, and adequate consumption of fruits and vegetables. This framework is expected to guide the development of cost-efficient and effective interventions for the promotion of adequate consumption of fruits and vegetables at the national and sub-national level.

This paper explores ways to integrate African indigenous leafy vegetables into the global fruit and vegetable programme initiative, and identifies some existing barriers to their effective mobilization. African leafy vegetables (ALVs) are increasingly recognized as possible contributors of both micronutrients and bio-active compounds to the diets of populations in Africa. Available data on the more commonly consumed varieties point to antioxidants-containing leafy vegetables that can also provide significant amounts of beta carotene, iron, calcium and zinc to daily diets. How can the successful Nairobi leafy vegetables experience, be mainstreamed across the sub-continent to ensure their mobilization and integration in WHO's fruit and vegetable initiative? The Kobe framework recommends that fruit and vegetable promotion interventions should consider the process from production to consumption.

Very little is known about the production and consumption of ALVs. An expert report on patterns of vegetable consumption in the sub-continent lists common vegetables as onions, carrots, tomatoes and cabbage. Clearly, information on production, processing, distribution and marketing, preparation and consumption of vegetable species relevant to SSA, are vital and constitute the prop on which intervention programmes can be developed. Through its long collaboration with national governments, Bioversity International is well placed to catalyze the process of data generation and dissemination by countries in the sub-continent.

Key words: African leafy vegetables, micronutrients, antioxidants

Introduction

The growing awareness in recent years of the health promoting and protecting properties of non-nutrient bioactive compounds found in fruits and vegetables, has directed increased attention to vegetables as vital components of daily diets. For populations in sub-Saharan Africa (SSA), this attention on vegetables as vital dietary components reinforces the significant roles that leafy vegetables have long held as important components in African diets; they are indispensable ingredients of soups or sauces that accompany carbohydrate staples [1].

African indigenous and traditional leafy vegetables (ALVs) thus have a pivotal role in the success within SSA, of the World Health Organization's (WHO) global initiative on increased consumption of fruit and vegetables. The joint FAO/WHO 2003 Consultation on Diet, Nutrition and the Prevention of Chronic Diseases recommended a minimum daily intake of 400 g of fruits and vegetables [2]. WHO in 2004 again drew attention to this recommendation through its Global Strategy on Diet, Physical Activity and Health. At the joint Kobe workshop on fruit and vegetables for health, the WHO and FAO developed a framework that proposes ways to promote increased production, availability and access, and greater consumption of fruits and vegetables [3].

This framework is intended to guide the development of cost-efficient and effective interventions to promote the adequate consumption of fruits and vegetables at national and sub-national levels. This paper explores ways to integrate ALVs into the global fruit and vegetable initiative for improved health by identifying some existing barriers to their increased consumption and their effective mobilization as part of national agriculture, nutrition and health strategies. The authors also aspire to stimulate debate and exchange of ideas on the subject with a view to arriving at a set of recommendations on applicable, relevant and effective ways to mainstream indigenous and traditional leafy vegetables in global food, nutrition and health initiatives.

Which are these leafy vegetables?

The words *indigenous* and *traditional* are used in this paper to describe leafy vegetables that have been part of the food systems in SSA for generations. Indigenous leafy vegetables are those that have their natural habitat in SSA while the traditional leafy vegetables were introduced over a century ago and owing to long use, have become part of the food culture in the sub-continent. The Plant Resources of Tropical Africa – PROTA, reported an estimated 6,376 useful indigenous African plants of which 397 are vegetables. In the same volume, it is indicated that information is available on cultivation practices for 280 indigenous ALVs [4].

There has been a resurgence of interest in the ALVs during the past decade with several studies reporting on their regional availability and use [1, 5-12]. In the April 2005 issue of Spore, the contributor observed that African "leafy vegetables are everywhere and nowhere, in books and on the internet there is a great deal of information on tropical green vegetables, but it is often scattered like leaves in the wind" [13]. Table 1 presents some of these leafy vegetables that are reported to be in current use.

This list is not exhaustive but represents leafy vegetables that have been commonly cited in recent literature reports. The regional availability of the vegetables is presented in Table 2. This table also highlights the vegetables that are more commonly available and consumed in more than one sub-region or all over the subcontinent. The varieties that are found to have more widespread regional usage could be prioritized and targeted for such programmes as the WHO/FAO initiative for the promotion of increased production and consumption of fruit and vegetables.

Role of African leafy vegetables in health promotion and protection

Quite a large number of African indigenous leafy vegetables have long been known and reported to have health protecting properties and uses [5, 14-17]. Reporting on the Moringa plant (*Moringa oleifera*) in 1937, the British botanist Dalziel observed that the roots, leaves and twigs, as well as the bark of the tree are used in traditional medicine. Several of these indigenous leafy vegetables continue to be used for prophylactic and therapeutic purposes by rural communities (14, 17). This indigenous knowledge of the health promoting and protecting attributes of ALVs is clearly linked to their nutritional and non-nutrient bioactive properties. ALVs have long been, and continue to be reported to significantly contribute to the dietary vitamin and mineral intakes of local populations [18-30].

More recent reports have shown that ALVs also contain non-nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases, although Orech and colleagues observed that some of these phytochemicals found in some ALVs consumed in Western Kenya may pose toxicity problems when consumed in large quantities or over a long period of time [10]. In spite of this body of evidence confirming the nutritional contribution of ALVs to local diets, and their health maintenance and protective properties, there has been very little concerted effort towards exploiting this biodiverse nutritional and health resource to address the complex food, nutrition and health problems of SSA.

What do we know about the production of ALVs?

Published information on the production of indigenous and traditional leafy vegetables tends to be anecdotal. There is very little published information or data on either the areas cultivated or the production levels of specific ALVs [5, 9, 13, 32-35]. The Spore 116 feature article quoting reports from the International Institute for Tropical Agriculture (IITA) indicated that the total 1998 production of leafy vegetables in Cameroon was estimated to be 93,600 tonnes of which 21,549 tonnes was of "bitter leaf", Vernonia *amygdalina* [13].

Such valuable production data are often dispersed and difficult to compare, given the gaps in coverage and different methodologies used. Even the FAO database on vegetable production in SSA fails to capture the indigenous and traditional vegetables that are commonly used on the subcontinent. Of the 15 vegetables documented in the FAO database, only tomatoes and mushrooms have some relevance to the diets of the majority of populations on the subcontinent [FAOSTAT 2004]. This is

Table 1: Regionally consumed indigenous and traditional leafy vegetables

West Africa	East and Central Africa	Southern Africa
Abelmoschus esculentus	*Abelmoschus esculentus*	*Abelmoschus esculentus*
Amaranthus caudatus	*Acalypha biparlita*	*Amaranthus caudatus*
Amaranthus cruentus	*Amaranthus cruentus*	*Amaranthus chirotarota*
Amaranthus hybridus	*Amaranthus dubius*	*Amaranthus cruentus*
Basella alba	*Amaranthus lividus*	*Amaranthus hybridus*
Celosia argentea	*Amaranthus spinosus*	*Amaranthus spinosus*
Citrullus lunatus	*Basella alba*	*Amaranthus thunbergii*
Colocasia esculenta	*Bidens pilosa*	*Bidens pilosa*
Corchorus olitorius	*Citrullus lanatus*	*Brassica carinata*
Corchorus olitorius	*Cleome gynandra*	*Brassica juncea*
Crassocephalum biafrae	*Colocasia esculenta*	*Cassia occidentalis*
Crassocephalum crepidioides	*Corchorus olitorius*	*Chenopodium album*
Crassocephalum rubens	*Crotolaria brevidens*	*Cleome gynandra*
Cucurbita maxima	*Cucurbita maxima*	*Cleome momophylla*
Cucurbita pepo	*Cucurbita moschata*	*Corchorius olitorius*
Gnetum africanum	*Hibiscus sabdariffa*	*Corchorius tridens*
Gongronema latifolium	*Ipomea batatas*	*Cucumis angura*
Hibiscus cannabinus	*Lagenaria siceraria*	*Cucurbia maxima*
Hibiscus sabdariffa	*Manihot esculenta*	*Mormodica balsamina*
Ipomea batatas	*Moringa oleifera*	*Physalis viscosa*
Launea taraxacifolia	*Moringa stenopetala*	*Portulaca oleracea*
Manihot esculenta	*Portulaca quadrifida*	*Solanum nigrum*
Moringa oleifera	*Senna occidentalis*	*Taxaxacum officinale*
Occimum basilicum	*Sesamum angustifolium*	*Vigna unguiculata*
Occimum grattissimum	*Sesamum calycimum*	*Wahlenbergia undulata*
Portulaca oleracea	*Sida acuta*	
Pterocarpus mildbreadii	*Solanum aethiopicum*	
Solanum aethiopicum	*Solanum gilo*	
Solanum macrocarpon	*Solanum indicum*	
Solanum melongena	*Solanum nigrum*	
Solanum scarbrum	*Solanum scabrum*	
Struchium sparganophora	*Sonchus carnutus*	
Talinium triangulare	*Sonchus oleraceus*	
Telferia occidentalis	*Talinium triangulare*	
Vernonia amygdalina	*Vernonia amygdalina*	
Vigna unguiculata	*Vigna unguiculata*	

a serious shortcoming because information from this database is used to inform and guide policy initiatives globally and on the subcontinent specifically [34].

Reports on the diversity of traditional leafy vegetables in SSA by Bioversity International show that there are more than 20 leafy vegetable species specific to Africa that are used in daily diets and are of nutritional importance [37]. Mirghani and Mohammed and Okeno *et al*., however, reported that in contrast to cash crops, little attention has been paid to the production of indigenous leafy vegetables and so there is a dearth of data on their production levels [9, 5]. The availability of reliable information on the production of ALVs is crucial for any planned attempts to integrate them into the global fruit and vegetables initiative for improved health.

The Kobe framework recommends that fruit and vegetable promotion interventions should consider the whole process from production to consumption. This recommendation draws attention to the gap in knowledge and information on the production and consumption of ALVs. There is therefore a dire need in the subcontinent to close this knowledge and information gap as increasing global attention is turned towards mobilizing local biodiversity for food security and health.

Table 2: Distribution of some regional commonly found leafy vegetables (From literature reports*)

All over the sub-continent	West/East and Central Africa	West and Southern Africa	East/Central and Southern Africa
Abelmoschus esculentus	*Basella alba*	*Amaranthus caudatus*	*Solanum nigrum*
Amaranthus cruentus	*Citrullus lunatus*	*Amaranthus hybridus*	*Bidens pilosa*
Corchorus olitorius	*Colocasia esculenta*	*Portulaca oleracea*	*Cleome gynandra*
Cucurbita maxima	*Hibiscus sabdariffa*		
Vigna unguiculata	*Ipomea batatas*		
Solanum macrocarpon	*Manihot esculenta*		
	Solanum aethiopicum		
	Solanum scarbrum		
	Talinium triangulare		
	Vernonia amygdalina		
	Moringa oleifera		

*Literature sources from:
West Africa – Nigeria, Ghana, Benin, Senegal
East and Central Africa – Kenya, Uganda, Cameroon, Gabon, Zambia, Tanzania, Ethiopia
Southern Africa – South Africa, Zimbabwe

Patterns of consumption of African leafy vegetables

Information on the *per capita* consumption of ALVs is just as scarce as data on their production levels. It is generally believed that the introduction of exotic vegetable varieties contributed to the decline in the production and consumption of indigenous vegetables. However, literature reports of a steady decline in dietary intakes of these vegetables with the emergence of simplified diets are based on the assumption of declining use as a result of declining availability [5, 7, 38].

Contrary to this view, Maziya-Dixon *et al*. reported that in Nigeria, leafy vegetables are relatively available and affordable particularly during the rainy seasons but were found to be among the least consumed foods [39]. Ruel *et al*. also reported that fruit and vegetable consumption of these vegetables in SSA is low although in this study the reported common vegetables "included onions, carrots, tomatoes and cabbage", vegetables which are really not representative of ALVs [40].

Reports from the literature (Table 3) do not confirm the general belief of declining consumption of ALVs although it is not clear from some of the studies how the consumption data were generated, what period of the year the studies were carried out and what specific vegetables were studied. Earlier reports had estimated *per capita* consumption of ALVs to be 80 g of fresh leaves per day during high season in Senegal and Burkina Faso, while in Mauritania estimates were 65 g/day in urban areas and 16 g/day in rural areas [15, 41].

In Uganda, an average consumption of 160 g/person/day during the rainy season was reported while another study amongst urban dwellers quoted in the same report estimated *per capita* consumption of 12 g/day [8]. Oguntona reported a mean intake of 65 g/day in western Nigeria while in a more recent study in south eastern Nigeria, Hart and colleagues reported adult *per capita* consumption of 59-130 g/day during the months of May-July, the peak season of vegetable production in the study area [42, 43].

There have been other attempts at estimating consumption patterns using household expenditures on ALVs, or general survey of usage, but these estimates indicate only trends in leafy vegetable consumption [13, 44, 45]. Gockowski and colleagues reported that in Cameroon, ALVs remain important dietary components although household expenditure on ALVs declines as total expenditure grew suggesting that consumption decreases with increasing income [44]. A recent IITA report on Senegal indicated that leafy vegetables account for as much as 50-85% of household budget for some farmers [13].

These reports provide at best only a glimpse into the consumption patterns of ALVs on the subcontinent but the information provided is very limited and so should be interpreted with caution and should not be considered as baseline information for the respective countries or regions. Nevertheless, they highlight the immense information gap on ALV consumption in SSA. There is clearly a need for more regionally targeted studies on the *per capita* consumption of ALVs as data from such studies provide valuable baseline information which is vital both in the development of the ongoing WHO/FAO vegetable consumption promotion strategies for SSA as well as in evaluation of the effectiveness of current and future interventions.

Table 3: Some reported patterns of consumption of African leafy vegetables

Country of Study/ Report	Per Capita Consumption	Season	Urban/ Rural	Year of Study/ Report	Reference
Senegal/Burkina Faso	80 g	Rainy season	Rural	1937	Dalziel (15)
Uganda	12 g	Not specified	Urban	1957	Grant, MW quoted by Rubaihayo (8)
Uganda	160 g	Rainy season	Rural	1989	Goode, PM quoted by Rubaihayo (8)
Mauritania	65 g	Not specified	Urban	1989	Frankenberger et al .(41)
Mauritania	16 g	Not specified	Rural	1989	Frankenberger et al .(41)
Nigeria	65 g	Not specified	Rural	1998	Oguntona, T (42)
Nigeria	91-130 g	Rainy season	Urban	2005	Hart et al. (43)
Nigeria	59-64 g	Rainy season	Rural	2005	Hart et al (43)

Some vital pre-promotion activities for greater consumption of African leafy vegetables

Despite the abundance of African indigenous and traditional leafy vegetables, they remain under-exploited and under-utilized due to various listed constraints [5, 6, 33, 37, 46-48]. The resolution of these production and consumption bottlenecks are crucial prerequisites for the integration of ALVs into WHO's global initiative for fruit and vegetable consumption promotion. These constraints relate to production, processing, distribution and marketing, as well as nutrition information on a large number of regionally specific cultivars. However, one of the first items in the priority list of activities needs to be the identification of regionally common species that could constitute the starting material for planned and concerted multi-sectorial research and development activities.

Seed availability, variability in seed quality, lack of seed selection for uniformity of desired traits, plant pests and disease are some of the agronomic constraints that require urgent research inputs. Given the relative lack of research thus far, a small investment in improved seed quality, seed supply, and improved agronomic practices is likely to yield a large return. Taxonomy is another often cited production-related constraint. Farmers and local populations identify the different leafy vegetable species and cultivars by their local names, but quite often the same local generic type name is applied to two or more cultivars. With the increasing interest in cultivar-specific health promoting and protecting traits, and the desire of the health community to increase public awareness of these traits, it is important that the leafy vegetables are correctly identified by both their botanical and local names. This characterization provides the basis for identifying the variation on nutrients and health protecting traits among cultivars within a given vegetable species.

There is need to develop and promote locally appropriate processing techniques to minimize post harvest losses and ensure regular supplies of ALVs from the production areas to consumers in peri-urban and urban centres. The easy perishability of ALVs poses major challenges with their distribution and marketing. Drying has been an African way of processing leafy vegetables to make them available during periods of shortages. Drying is one solution to the problem of perishability but it does not satisfy the needs of a large population of consumers, particularly urban dwellers who prefer freshly harvested vegetables. Furthermore, not enough is known on how drying and reconstitution when cooked affect the nutritional quality of the vegetables. There are also other food safety issues such as toxicity and microbial contamination that require research attention as strategies are put in place for the promotion of increased consumption of these leafy vegetables.

A significant number of these ALVs are not consumed particularly by the younger generation of Africans because of their unfamiliar tastes or ignorance of how to prepare them [10, 5, 7]. Perhaps a crucial component of the leafy vegetable promotion strategy should be their re-introduction into the daily food habits of the peri-urban and urban populations in particular through recipes developed to show traditional and modernized ways of preparing these under-utilized food ingredients. The recipes should encourage the use of the ALVs in preparing foods other than accompanying sauces in order to ensure that the vegetables are used at least twice daily, thus increasing the opportunities for their consumption.

Community women's groups, women's cooperative groups and other women's social groups would be valuable assets in recipe development projects aimed at show-casing ALVs. Bioversity International (former IPGRI), in collaboration with the Kenyan Centre for Indigenous Knowledge/National Museums of Kenya, has taken the lead and is in the process of publishing a compilation of regional leafy vegetable recipes in a cookbook titled "African Leafy Vegetable Cookbook" featuring recipes from several sub-Saharan African countries.

Regionally appropriate measuring tools and standards need to be established to ensure specificity in portion sizes, information that will be required for promotion activities. The WHO recommendation is for a minimum daily intake of 400 g of fruits and vegetables [2]. It is not clear from the report what proportion of this total daily intake should go to vegetables. However according to the Kobe framework document and an FAO report the recommended total daily intake is equivalent to 5 servings of 80 g each of fruits and vegetables [3, 49].

The FAO report goes on to suggest that "a helping of cooked vegetable or raw leafy greens similar to the size of your fist may also be considered one serving"[49]. What constitutes a serving of leafy vegetables in the African context? There are obvious cultural differences in the way vegetables are prepared and consumed. In several parts of SSA, leafy vegetables are for the most part consumed cooked in accompanying sauces to carbohydrate staples or cooked mixed with tubers such as yam, cocoyam, cassava or sweet potato.

Clearly a fistful of fresh green leafy vegetable or five fists depending on the size of the family sharing the sauce pot may not come to much in the pot of sauce. The differences in the way leafy vegetables are prepared and consumed would influence ways of determining portion sizes. The challenge for nutritionists and food science researchers in the subcontinent is to develop regionally appropriate measures of portion size bearing in mind locally and commonly used handy household tools that are used in food preparation, as well as local food preparation techniques.

Conclusion

The experience in Kenya and neighbouring countries shows that a combination of cultural pride, interest in healthy foods, and a growing taste for diversity is creating a favourable opportunity to protect and revitalize ALVs as a nutritious resource derived from Africa's biological and cultural diversity. What Bioversity and its partners can do is to help develop and provide the tools to better classify the diversity within and across species, and foster partnerships that would mobilize this diversity and make the vegetables easier to obtain and more widely consumed. The list of challenges – agronomic, processing, distribution and marketing, cultivar-specific nutritional characterization, establishing portion sizes, is long and daunting but the goal of integrating ALVs into the global nutrition and health initiative has been clearly defined. This workshop provides a singular opportunity for the stakeholders in the agriculture and health communities of the sub-continent to take the necessary first steps and chart the path towards meeting this goal.

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Valeur nutritionnelle du *Moringa oleifera*, étude de la biodisponibilité du fer, effet de l'enrichissement de divers plats traditionnels sénégalais avec la poudre des feuilles

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Résumé

Dans le but d'évaluer la valeur nutritionnelle du *Moringa oleifera*, nous avons effectué l'analyse chimique de ses produits (les gousses fraîches, les feuilles fraîches, les fleurs fraîches, la poudre des feuilles). La biodisponibilité du fer de la poudre des feuilles de *Moringa oleifera* ou Nébéday et de plats traditionnels sénégalais (bouillie de mil, de fonio, Ceere Mbuum) enrichis ou non avec la poudre a été aussi déterminée. L'analyse chimique montre que les produits de *Moringa oleifera* sont riches en protéines (feuilles, fleurs, poudre) et que les gousses sont plus riches en matières grasses et apportent plus d'énergie que les autres produits du *Moringa*. L'analyse des minéraux a montré que les produits de *Moringa oleifera* sont riches en calcium pour les macronutriments et en fer pour les oligoéléments. La détermination de la biodisponibilité du fer de la poudre des feuilles et des plats enrichis avec la poudre montre une faible biodisponibilité. Ceci montre que le fer contenu dans la poudre des feuilles séchées pourrait provenir d'une contamination et/ ou de l'existence d'inhibiteurs de l'absorption du fer. L'enrichissement des plats avec la poudre des feuilles augmente les teneurs en protéines et en fer (sauf pour la bouillie de mil). En conclusion la poudre de *Moringa oleifera* est riche en protéines et en fer qui néanmoins reste peu biodisponible. L'enrichissement des plats avec la poudre des feuilles améliore les teneurs en protéines mais influe peu sur le contenu en fer biodisponible.

Mots-clés: *Moringa oleifera*, biodisponibilité, fer, enrichissement, in vitro

Introduction

Originaire du Nord de l'Inde, le *Moringa oleifera* est d'usage assez courant en médecine populaire et en alimentation dans les sociétés africaines et asiatiques [1]. En effet, ses feuilles sont communément consommées dans toute l'Afrique de l'Ouest. De nombreuses vertus sont conférées à cette plante : médicinales (antidiarrhéique, hypotensive, bactéricide, laxative) et purificatrice d'eau [1, 2].

Au Sénégal, les feuilles sont généralement consommées cuites sous forme d'une sauce appelée *Mbuum* accompagnant le couscous à base de céréales composés de mil, maïs ou riz (cf. recettes du Sénégal du projet IPGRI Légumes feuilles). Les feuilles sont utilisées fraîches ou séchées et réduites en poudre. Des travaux antérieurs ont décrit la composition nutritionnelle de la plante [2]. L'analyse des feuilles fraîches de *Moringa oleifera* de la région de Dakar a donné la composition suivante pour 100g : eau 74,7%, protéines 8,1%, lipides 0,6%, glucides totaux 14,1%, cellulose 2.13%, cendres 2,5%, calcium 531mg, fer 11,7mg, vitamine C 220 mg, thiamine 0,23mg, riboflavine 0,77mg, niacine 2,66 mg et un équivalent vitamine A de 5000 μg/100g [3]. La richesse des feuilles en certains éléments nutritifs, notamment en protéines, en calcium et en fer a conduit à introduire les produits du *Moringa oleifera* dans les programmes de lutte contre la malnutrition.

C'est ainsi qu'en 1997 une ONG américaine en collaboration avec une ONG sénégalaise ont démarré un projet pilote dénommé « Projet de récupération nutritionnelle des enfants, des femmes enceintes et des femmes allaitantes. Une évaluation du projet en 1998, par des témoignages de la population et d'agents de santé, montre une certaine efficacité de la poudre des feuilles de *Moringa* dans la prévention de la malnutrition et dans la récupération des enfants malnutris. Mais aucune étude scientifique n'avait étayé ces faits ; d'où l'intérêt de la présente étude.

La malnutrition et les carences associées en particulier l'anémie constituent l'un des plus grands problèmes de santé publique dans les zones les plus pauvres des pays en développement [4]. Les causes de cette affection sont multiples mais surtout nutritionnelles caractérisées par un faible apport de facteurs hématopoïétiques (fer, vitamine B12, folates).

L'apport en fer des aliments des pays en développement ne permet pas de couvrir les besoins en fer des populations [5]. Le type de régime de ces pays et la faible biodisponibilité du fer dans l'alimentation liée à la présence de facteurs inhibiteurs de l'absorption du fer tels que les polyphénols, les phytates et les fibres constituent la principale entrave à la couverture des besoins en fer des populations [5, 6, 7, 8]. La valorisation de variétés végétales riches en micronutriments est une stratégie pour lutter contre les carences en micronutriments.

L'objectif principal de l'étude est d'évaluer la biodisponibilité du fer dans la poudre des feuilles de *Moringa oleifera* et de plats enrichis avec cette poudre. Les objectifs spécifiques sont :

- Déterminer la composition chimique des feuilles fraîches, des gousses fraîches, des fleurs fraîches et de la poudre des feuilles séchées
- Evaluer l'apport en fer et en protéines de plats enrichis et non enrichis avec la poudre de Moringa oleifera couramment consommés dans le sud du Sénégal
- Mesurer la biodisponibilité en fer de la poudre et des plats.

Matériel et méthodes

1. Les produits

Les différentes parties fraîches (gousses, fleurs, feuilles) de la plante étudiées ont été récoltées dans la région de Dakar sur différents arbres pour avoir des produits frais. Les produits frais ont été conservés à +4°C. Les dosages sont effectués sur la matière encore fraîche. La poudre est celle préparée par les populations de Casamance dans le cadre du projet de l'ONG sénégalaise. Elle est obtenue par pillage des feuilles séchées à l'abri d soleil, la poudre est conservée dans des sachets en plastique.

2. Les plats

Les bouillies

Elles sont préparées avec deux céréales : le mil (*Pennisetum thyphoides)* et le fonio (*Digitaria exilis)*.

- Bouillie de fonio : 200 g de fonio et 100 g de poudre d'arachide sont cuites dans 1L d'eau potable, 60 g de sucre sont ajoutés en fin de la cuisson qui dure 20 mn. Elle est enrichie avec 15g de poudre de feuilles de Moringa oleifera après cuisson.
- Bouillie de mil : c'est une bouillie à base de farine de mil (50 g), de pâte d'arachide « Dégué » (50 g). Elle est cuite pendant 25 mn avec 600 ml d'eau et du sucre (30 g). Elle est enrichie après cuisson avec 10 g de poudre de feuilles de Moringa oleifera.

Le Mbeulekhé

C'est un plat à base de riz et de sauce. La sauce est constituée de pâte d'arachide cuite « Dégué » (340 g), de poisson frais (300 g), de poisson braisé, fumé et séché « *késthiakh* » et de poisson fermenté séché « guedj » (5 g). L'ensemble est cuit avec 1,5 l d'eau additionnée d'oignon (5 g), d'huile de palme (10 cuilléres à soupe, de piment et une pincée de sel. Elle est enrichie avec 30 g de poudre de feuilles de *Moringa oleifera*. Le riz cuit (1kg de cuit dans 1,5 l d'eau) est mélangé à la sauce dans un rapport ¼ (sauce /riz). La cuisson dure 55 minutes.

Couscous de mil ou Ceere Mbuum en Ouolof

Le couscous (Thiéré Mboum en Ouolof) est à base de mil (*Pennisetum typhoides*) souvent vendu dans les marchés sénégalais. La sauce Mbuum est constituée de feuilles fraîches de *Moringa oleifera* (300 g) cuites pendant 65mn avec de la poudre de poisson fumé Kéthiakh (200g) et de poudre d'arachide (300 g) dans 2,5 l d'eau. Un cube bouillon et une pincée de sel sont ajoutés à la sauce.

3. Composition chimique des produits de Moringa oleifera

Les dosages ont été effectués selon les méthodes AOAC [9]. Les échantillons analysés en trois répétitions pour les minéraux (calcium, fer, sodium, magnésium, zinc, potassium) et en deux répétitions pour l'humidité, les protéines, les matières grasses, les cendres et la cellulose.

- L'humidité: l'échantillon subit une dessiccation à l'étuve à 105°C pendant 4 heures et la différence de poids donne le taux d'humidité
- Les protéines: elles sont dosées par la méthode de Kjeldahl
- Les lipides: ils sont extraits par un solvant non miscible (n-hexane) dans un extracteur de type Soxhlet (Unid Tecator, System HT2 1045, Suède). Après évaporation du solvant et pesage de la capsule

à l'étuve à 105°C pendant 30mn ; la différence de poids donne la teneur en lipides de l'échantillon

- Les cendres: l'échantillon est carbonisé sur un bec bunsen puis incinéré dans un four à 600°C pendant 6 heures
- La cellulose: l'échantillon bien broyé est mis dans un ballon et on y ajoute 50 ml d'acide sulfurique (H_2SO_4 0.3N). Chauffer pendant 30mn puis ajouter 25ml de soude (NaOH 1,5N) ; chauffer pendant 25mn et ajouter 0,5 g d'EDTA (Ethylène Diamine Tétra acétique), et maintenir l'ébullition pendant 5 mn. A la fin du chauffage, filtrer le mélange à travers un creuset filtrant de porosité 2, laver avec 3 portions de 50 ml d'eau distillée, 25ml d'éthanol et 25ml d'acétone. Le creuset est ensuite séché à l'étuve à 130°C pendant 2 heures et refroidi au dessiccateur puis pesé. Il est enfin porté au four à 400°C pendant 2 heures pour incinération, puis pesé après refroidissement
- Les minéraux: minéralisation par voie sèche, les cendres obtenues contiennent les éléments majeurs (Na, Ca, Mg, K, etc.) et les oligo éléments (Fe, Zn, etc.). Ces minéraux ont été dosés par Spectrophotométrie d'Absorption Atomique avec un appareil de type Pelkin Elmer (PE 3110, Norwalk USA)
- Les glucides sont calculés par différence
- La valeur énergétique correspondant à l'énergie disponible est calculée à l'aide des coefficients spécifiques d'Atwater pour les protéines, les lipides et les glucides.

4. Biodisponibilité du fer

Elle a été déterminée par la méthode *in vitro* de Miller et al. [10], modifiée selon Kane et Miller [11]. Elle consiste à simuler les conditions gastro- intestinales pour avoir des indications de l'absorption du fer au niveau intestinal. La mastication est remplacée par une homogénéisation. Il y a une double digestion pepsique et pancréatique. Les pH stomacal et intestinal sont respectés par ajustement progressif du pH pour avoir un pH 2 pour la digestion pepsique et un pH 6,7 - 7,2 pour la digestion pancréatique. L'utilisation du bain-marie agitant à 37°C permet à la fois de simuler les mouvements intestinaux et de respecter la température corporelle. La surface d'absorption intestinale est remplacée par des sacs à dialyse de diamètre 6000-8000 Á (Spectra /Por membrane MWCO, California, USA).

Préparation des réactifs

Les réactifs utilisés sont:

- une solution d'hydrogénocarbonate de Sodium ($NaHCO_3$) 0,1N ;
- une solution de hydroxyde de potassium (KOH) 0,5M ;
- une solution de chromagène obtenue par dissolution de bathophénanthroline dans une solution d'acétate de sodium 2M ;
- un précipitant protéique préparé avec du TCA (acide trichloroacétique) et de l'hydrochlorure d'hydroxylamine; hog stomach mucosa, Sigma, St Louis, Mo USA) et de l'acide chlorhydrique (HCL) 0,1N ;
- une suspension pancréatine-bile (rapport 0,16). Les solutions d'étalonnage sont préparées à partir de la solution mère de fer (1g/L)

Prise d'essai et digestion pepsique

Après homogénéisation, une quantité suffisante est pesée pour obtenir 4 aliquotes de 20g à la fin de la digestion pepsique. Pour le blanc réactif, l'échantillon est remplacé par de l'eau déminéralisée. Une solution d'HCl 6N est ajoutée à l'aliment jusqu'à l'obtention du pH 2. Pour la digestion pepsique un volume de la solution de pepsine respectant le rapport 0,5 g de pepsine pour 100 g d'aliment est ajouté dans l'Erlenmeyer contenant l'aliment à pH 2 puis incubé au Bain-marie agitant à 37°C pendant 2 heures. Après la digestion pepsine, 4 aliquotes de 20 g sont prélevés dont 3 sont congelés pour la détermination du fer dialysable et le 4ème utilisé pour celle de l'acidité titrable obtenue par la mesure du volume de KOH nécessaire pour mener le pH du produit de digestion pepsique à 7,5.

Digestion pancréatique

Dans chaque sac à dialyse, on a introduit un volume d'hydrogénocarbonate de sodium 0,1N égal au volume de KOH utilisé pour l'acidité titrable de l'échantillon correspondant puis on ajuste à 20ml avec de l'eau déminéralisée. Les sacs ont une longueur de 22 cm avec un nœud à chaque extrémité. Pendant la préparation de ces sacs, les 3 aliquotes sont décongelés dans un bain-marie à agitation à 37°C. Les sacs à dialyse sont placés chacun dans les Erlenmeyer et mis au bain-marie. A la 30ème minute, 5ml de la suspension pancréatine-bile sont ajoutés à chaque Erlenmeyer. Après 2 heures, les sacs à dialyse sont retirés à l'aide d'une baguette de verre, rincés et essuyés. Le volume de dialysat de chaque sac est mesuré à l'aide d'une éprouvette de 25ml.

Le traitement pour le développement de la couleur et la lecture : 2ml de chaque dialysat, 2ml d'eau déminéralisée (blanc étalon) et 2 ml de chaque étalon sont mis dans des tubes corex de 30ml dans lequel on ajoute 1ml de précipitant protéique. L'ensemble est mélangé au vortex et chauffé pendant 10mn dans un bain d'eau bouillante, puis refroidi. Le mélange est ensuite centrifugé (4000xg pendant 5mn à température ambiante), 2 ml de surnageant sont ensuite mélangés à 1ml de solution de chromagène. Après 10 mn, faire la lecture de la densité optique au Spectrophotomètre à 535 nm.

De chaque absorbance de dialysat et à celle des étalons, il faut soustraire l'absorbance du blanc réactif. Le fer héminique contenu dans la sauce et le *Mbuum* provenant du poisson est calculé à partir des tables de composition alimentaire et soustrait du fer total. La formule suivante donne la biodisponibilité du fer dans l'aliment considéré.

Biodisponibilité (%) = (quantité de fer dialysable / quantité totale de fer héminique) x100

Fer susceptible d'être absorbé = quantité de fer non héminique x biodisponibilité

Résultats

1. Composition des produits de Moringa oleifera

Les teneurs en macronutriments et en minéraux des produits de *Moringa oleifera* sont indiqués dans les tableaux 1, 2, 3 et 4. Les produits frais de *Moringa oleifera* (feuilles, fleurs, gousses) sont très riches en eau avec des taux d'humidité supérieurs à 73%. La concentration de nutriments est faible dans les feuilles, les fleurs et les gousses fraîches. La transformation des feuilles fraîches en poudre diminue l'humidité et augmente la teneur en protéines. Ainsi la comparaison des teneurs en macronutriments de 100 g de poudre et de 100 g de feuilles fraîches montre 2 fois plus de protéines, 5 fois plus de lipides, 2 fois plus de cellulose et 5 fois plus de glucides (Tableau 1).

L'analyse des teneurs en nutriments de ces produits par rapport à la matière sèche montre que les macronutriments dominants sont les protéines pour les feuilles, les fleurs et la poudre des feuilles et les lipides pour les gousses. Les teneurs en protéines pour les gousses sont multipliées par 3 par rapport aux feuilles et par 2 par rapport aux fleurs. Les gousses sont très riches en matières grasses et en cellulose. La poudre est très riche en cendres, les taux de cendres des feuilles et celui des fleurs et gousses sont respectivement multipliés par 5 et 10 dans la poudre (Tableau 2).

Les teneurs en minéraux sont plus importantes dans la poudre des feuilles. Les produits frais n'ont pas de concentrations élevées en minéraux. La transformation des feuilles en poudre permet une concentration en minéraux. En effet, les teneurs en Ca, Na, K, Mg, Fe et Zn dans 100 g de feuilles sont ainsi multipliées respectivement par 13, 3, 12, 13, 3, 6 (Tableau 3).

La poudre est riche en minéraux notamment en calcium, en potassium et en magnésium. La teneur en fer des gousses est très faible par rapport à celle des autres produits. Les teneurs en zinc des différentes parties de *Moringa oleifera* sont faibles (Tableau 4).

La poudre de *Moringa oleifera* est riche en protéines avec une digestibilité de 56% et malgré sa teneur en fer assez importante, la biodisponibilité en fer est faible (2,2%) (Tableau 5)

2. Composition des plats

Les résultats des analyses sont indiqués dans les tableaux 6 et 7 suivants. La teneur en fer et la quantité de fer biodisponible de la bouillie de fonio enrichie sont 2 fois plus élevées que celles de la bouillie non enrichie. La biodisponibilité du fer ne diffère pas entre les bouillies enrichies et non enrichies. Les teneurs en protéines des bouillies enrichies sont 2 fois plus élevées que celles de bouillies non enrichies. Les bouillies de fonio sont 5 fois plus riches en protéines que celles de mil (Tableau 6).

Les teneurs en fer de la sauce sont 4 fois et 2 fois plus élevées que celles du riz et du *Mbeulekhé*. La biodisponibilité du *Mbeulekhé* est plus élevée même si la plus grande quantité de fer biodisponible est trouvée dans la sauce (Tableau 7).

Les teneurs en fer ne varient pas dans le mélange du couscous avec la sauce *Mbuum*. Cependant, on note une amélioration de la teneur en fer, de la biodigestibilité du fer et des quantités de fer biodisponible avec ce mélange (Tableau 8).

Ces feuilles sont caractérisées par des teneurs élevées en calcium et faibles en fer. Les feuilles de Moringa oleifera sont plus riches en protéines que les autres feuilles (Tableau 9).

Tableau 1: Teneurs en g / 100g de produit tel quel (moyenne ±écart-type, n=2)

	Feuilles fraîches	Poudre feuilles	Fleurs fraîches	Gousses fraîches
Humidité	73,57 ± 0,02	4,53 ± 0,25	81,97 ± 0,09	81,98± 0,40
Protéines	15,27± 0,06	35,03± 0,01	8,64± 1,17	3,41± 0,23
Matières grasses	1,31 ± 0,25	7,50 ± 0,27	1,14 ± 0,40	6,05 ± 0,40
Cellulose	1,65± 0,98	4,02± 0,16	0,68± 0,07	4,84± 1,06
Cendres	0,63 ± 0,08	10,68 ± 0,90	0,29 ± 0,02	0,24 ± 0,06
Glucides	7,57	38,24	7,28	3,48

Tableau 2: Teneurs en g/100g de produit séché (moyenne ± écart- type, n=2)

	Feuilles fraîches	Poudre feuilles	Fleurs fraîches	Gousses fraîches
Protéines	57,79 ± 0,24	39,69 ± 0,01	47,979 ± 6,51	18,83 ± 1,29
Matières grasses	4,95± 0,96	7,85± 0,28	6,34± 2,24	33,59± 2,24
Cellulose	6,24± 3,74	4,21± 0,18	3,79,24± 0,43	26,85± 5,89
Cendres	2,42± 0,30	11,39± 0,66	1,61± 0,11	1,34± 0,02
Glucides	28,6	35,33	40,29	19,39
Energie (Kcal)	390,11	358,73	410,1	455,19

Tableau 3: Teneurs en mg/100g de produit tel quel (moyenne ± écart type, n=3)

	Feuilles fraîches	Poudre des feuilles	Fleurs fraîches	Gousses fraîches
Ca	111,89 ± 6,91	1457,58 ± 47,77	15,76 ± 1,46	13,08 ± 0,62
Na	18,82 ± 0,12	73,68 ±1,74	10,14 ± 0,09	5,91 ± 0,17
K	67,24 ± 2,04	848,26 ± 36,57	57,70 ± 1,53	50,84 ± 0,11
Mg	25,70 ± 0,85	359,45 ± 11,35	8,55 ± 0,41	6,51 ± 0,10
Fe	5,73 ± 0,16	18,39 ± 0,60	4,20 ± 0,02	0,47 ± 0,14
Zn	0,30 ± 0,04	2,04 ± 0,07	0,15 ± 0,05	0,13 ± 0,01

Tableau 4: Teneurs en mg/100g de produit séché (moyenne ± écart-type, n=3)

	Feuilles fraîches	Poudre de feuilles	Fleurs fraîches	Gousses fraîches
Ca	423,19 ± 25,90	1526,74 ± 50,03	87,47 ± 8,12	72,61 ± 3,48
Na	70,87 ± 0,48	77,17 ± 1,83	55,98 ± 0,50	32,86 ± 0,97
K	254,44 ± 7,74	888,50 ± 38,30	320,04 ± 8,12	251,72 ± 2,04
Mg	97,27 ± 3, 25	428,87 ± 85,96	47,47 ± 2,26	36,17 ± 0,60
Fe	21,72 ± 0,61	18,86 ± 1,20	23,34 ± 0,12	2,63 ± 0,79
Zn	1,13 ± 0,14	2,13 ± 0,07	0,86 ± 0,28	0,73 ± 0,09

Tableau 5: Caractéristiques de la poudre des feuilles séchées

	Poudre de feuilles de Moringa oleifera
Protéines (g / 100g)	35,03 ± 0,01
Fer (mg / 100g)	18,39 ± 0, 60
Biodisponibilité du fer (%)	2,24 ± 0,65
µg de Fe biodisponible / 100g	411,93

Tableau 6: Caractéristiques des bouillies (moyenne ± écart-type, n=3)

	Bouillie de fonio	Bouillie de fonio	Bouillie de mil	Bouillie de mil
	Non enrichie	Enrichie	Non enrichie	Enrichie
Protéines (g/100g)	5,02 ± 0,49	11,89 ± 0,68	1,93 ± 0,21	2,11 ± 0,60
Fer (mg / 100g)	1,42 ± 0, 18	2,86 ± 0,05	10,60 ± 0,96	10,64 ± 1,04
Biodisponibilité (%)	0,20 ± 0,02	0,19 ± 0,08	0,43 ± 0,01	0,40 ± 0,02
µg Fe biodisponible / 100g	2,84	5,43	45,58	42,56

Tableau 7: Caractéristiques du Mbeulekhé (moyenne ± écart type, n=3)

	Riz	Sauce	Mbeulekhé
Protéines (g / 100g)	5,08 ± 0,49	15,26 ± 1,70	9,80 ± 0,24
Fer (mg / 100g)	1,18 ± 0, 22	5,13 ± 0,48	2,25± 0,18
Biodisponibilité (%)	0,18 ± 0,10	2,40 ± 0,005	4,24 ± 0,20
µg Fe biodisponible / 100g	2,12	123,12	95,4

Tableau 8: Caractéristiques du Thiéré Mbuum (moyenne ± écart type, n=3)

	Thiéré	Mbuum	Thiéré Mbuum
Protéines (g/100g)	6,98 ± 0,44	11,54 ± 0,86	9,58 ± 0,59
Fer (mg/100g)	7,79 ± 1, 09	8,42 ±1,07	8,52 ± 0,57
Biodisponibilité (%)	0,26 ± 0, 04	0,27 ± 0,02	0,82 ± 0,03
µg Fe biodisponible / 100g	20,25	22,84	69,86

Tableau 9: Composition de feuilles fraîches consommées en Afrique

	A	B	C	D	E	F	G	H	H'
Humidité (%)	77	79	84,8	71,7	81	81	8303	75	73,6
Protéines (g/100g)	3,8	5,6	3,5	7	5	6,1	4,8	8,1	15,3
Lipides (g / 100g)	0,3	0,1	0,2	1	0,1	0,2	0,1	0,6	1,3
Glucides (g / 100g)	16,1	12,6	10,3	18,3	12	11	9,8	14	7,6
Cellulose (g / 100g)	2,8	2,3	1,8	4	4,3	2,4	2,3	2,1	1,6
Cendres (g / 100g)	2,8	2,1	1,2	2	2,6	1,9	2	2,5	0,6
Ca (mg / 100g)	402	608	214	303	398	74	168	531	111,9
Fer (mg/100g)	-	6	4,9	7,6	4,8	16	4	12	5,7

A = Baobab, B = *Casia tora*, C = Oseille de Guinée, D = Manioc, E = Leptadenia sp, F = *Ficus gnaphalocarpa*, = Patate douce, H = *Moringa oleifera* (Toury et al), H' = *Moringa oleifera* (notre étude).

Discussion

Le taux d'humidité des feuilles est comparable à celui trouvé par d'autres auteurs [2], il est de 74,70%. Les teneurs en protéines des produits de *Moringa oleifera* trouvées dans l'étude sont le plus souvent supérieures à celles de plusieurs légumes et feuilles consommées en Afrique [3] et fait de *Moringa oleifera* une véritable source de protéines végétales. Le fer oligoélément important est présent cependant la teneur en fer est faible mais n'est pas différente de celle d'autres légumes consommés en Afrique. Les quantités de fer trouvées dans les feuilles fraîches sont inférieures à celles trouvées par Toury et al. [3]; ce qui est peut être dû à une différence de méthodologie de dosage. Les quantités de calcium trouvées dans notre étude sont inférieures à celles décrites par Toury et al. [3] ; ceci peut être dû à une différence de sol de culture de la plante. La poudre est plus concentrée en nutriments que les autres produits de *Moringa oleifera*. Cependant le séchage entraîne souvent une perte importante d'éléments nutritifs comme les vitamines A et C, et de plus, de mauvaises conditions de séchage peuvent provoquer une contamination du produit.

Les bouillies (qui sont très diluées) ont de faibles teneurs en protéines qui augmentent avec l'addition de la poudre. Le *Mbeulekhé* et le *Thiéré Mbuum* ont des teneurs protéiques plus élevées que celles des bouillies du fait de l'existence de sources de protéines animales (poisson) dans ces plats.

La biodisponibilité du fer a *été* déterminée *in vitro* et la méthode utilisée peut permettre la comparaison de la biodisponibilité de divers repas composés. C'est une amélioration des premières méthodes *in vitro* basées sur l'extraction du fer ionisable et cette amélioration se traduit par un ajustement graduel, progressif et reproductible du pH et une double digestion pepsique et pancréatique dans des conditions de pH correspondantes à celles de l'organisme où seul le fer soluble est pris en compte. La biodisponibilité du fer des plats étudiés est faible (souvent inférieure à 1%) malgré certaines teneurs relativement importantes de fer (bouillies de mil, couscous, poudre). Ceci peut s'expliquer par l'existence du fer dit de contamination qui n'est pas biodisponible et qui est fréquent dans les repas des pays en développement [12], la contamination est liée aux conditions de préparation des aliments et peut aussi provenir de la poussière et du sol. Elle peut aussi résulter de longues préparations du couscous traditionnel mais aussi des ustensiles de cuisine [13]. La faible biodisponibilité du fer peut aussi être due à l'action d'inhibiteurs de l'absorption du fer (polyphénols). La meilleure digestibilité du fer trouvée avec le *Mbeulekhé* et le *Thiéré Mbuum* peut être expliquée par la présence de protéines animales activatrices de l'absorption du fer.

Il a été montré que le poisson est un activateur de l'absorption du fer [14]. Les quantités de fer susceptibles d'être absorbées sont faibles mais augmentent avec l'apport de produits de *Moringa*. L'addition d'une grande quantité de *Moringa* pourrait augmenter cette valeur mais changerait aussi les caractères organoleptiques des plats (couleur, goût) ce qui peut influer sur l'acceptabilité.

Conclusion

L'analyse de la composition chimique des différentes parties consommables de *Moringa oleifera* fait apparaître des particularités d'un grand intérêt sur le plan nutritionnel. Cette plante est une importante ressource alimentaire pour les populations, notamment rurales. Les gousses quant à elles sont riches en lipides. Les teneurs en minéraux de *Moringa oleifera* sont importantes, surtout en calcium et en fer et sa richesse en potassium, en sodium et en magnésium augmente ses qualités nutritionnelles.

La transformation des feuilles en poudre reste une bonne pratique pour une meilleure conservation du produit mais aussi pour une bonne concentration des nutriments. La biodisponibilité du fer dans la poudre et dans les plats enrichis ou non avec la poudre est très faible. Les quantités de fer susceptibles d'être absorbées des repas sont aussi faibles et ne peuvent pas couvrir les besoins des populations même si elles augmentent avec l'apport de *Moringa oleifera*. Nous avons noté un bon apport protéique et une bonne digestibilité des protéines avec l'adjonction de *Moringa oleifera*. L'enrichissement des bouillies par de faibles quantités de poudre de *Moringa oleifera* n'a pas d'influence notable sur la biodisponibilité du fer.

En somme, l'apport de *Moringa oleifera* dans les repas se manifeste par une augmentation des teneurs en fer et en protéines. Pour faire de *Moringa oleifera* un moyen d'enrichissement d'aliments dans la lutte contre la malnutrition et l'anémie par carence en fer, il faut nécessairement améliorer la biodisponibilité de son fer (par un apport d'activateurs de l'absorption du fer tels que l'acide ascorbique, les produits animaux par exemple). Il faut aussi améliorer la qualité nutritionnelle des céréales utilisées (par torréfaction, cuisson, extrusion, fermentation notamment). Une revalorisation des produits de *Moringa oleifera* passera nécessairement par une bonne sensibilisation des populations sur l'intérêt de la plante et l'exploitation des potentiels nutritionnels des gousses et des fleurs qui sont là peu consommés. Il faut aussi former les populations en vue d'une bonne transformation et une meilleure conservation des produits de *Moringa oleifera*.

La comparaison de l'état nutritionnel entre deux cohortes d'enfants ne différant que par la consommation de *Moringa oleifera* est nécessaire pour confirmer les qualités nutritionnelles de cette plante. Il est aussi important de déterminer la composition en acides aminés des protéines du Nébéday et les teneurs en caroténoïdes.

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Changes in beta-carotene, ascorbic acid and sensory properties in fermented, solar-dried and stored Cowpea leaf vegetables

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Abstract

This study was conducted to determine the effects of fermentation, solar drying and packaging on the nutritional, sensory and keeping properties of Cowpea leaf vegetables. The Cowpea leaves were purchased from the local markets, sorted to remove the blemished leaves and foreign materials, washed in running tap water, then drained. The vegetables were divided into three batches of 16 kg. One batch was heat-treated in hot water for three minutes, then cooled to ambient temperatures, drained and solar-dried. The second portion was acidified to a pH of 3.8, heat-treated, and then solar dried. The third portion was fermented for 21 days, heat-treated, and then solar dried. The three batches of vegetables were spread at different times on drying trays at the rate of 4kg/m2 and dried in a solar drier to approximate moisture content of 10%. The dried vegetables were packaged in either polyethylene bags or Kraft company paper bags and stored for three months at 18ºC, 22ºC –26ºC or 32ºC.

Fermentation, heat-treating and drying of vegetables retained substantial levels of the vitamins: beta-carotene, 91% and ascorbic acid, 15%. Storage of the dried vegetables led to loss in both vitamins. The retention of beta-carotene and ascorbic acid at the end of storage were 23%–52% and 4%–7% respectively, depending on storage conditions. Samples stored at 32 ºChad the highest losses, while those stored at 18 ºChad the lowest in both vitamins. Samples stored in Kraft paper bags had the highest losses in both vitamins. The duration and temperature of storage and the packaging material did not have significant effect on the sensory attributes of the dried vegetables. Increased acceptability of the fermented-dried vegetables in rural communities would assist in alleviating micronutrient malnutrition, help in dealing with the issue of seasonality and increase food security, especially during the dry season.

Key words: Fermentation, solar-drying, leafy vegetables, beta-carotene

Introduction

Malnutrition due to nutritionally inadequate diets is one of the major concerns in Kenya and many other developing countries [1]. The prevalence rates of micronutrient malnutrition remain high, with devastating consequences for health and productivity [2]. In Africa, people have always depended on traditional leafy vegetables to meet their nutritional needs. The vegetables represent cheap but quality nutrition for large segments of the populations in both urban and rural areas. The vegetables are rich in vitamins especially A, B, and C, and minerals such as iron, zinc, calcium and phosphorus [3].

The Cowpea (*Vigna unguiculata* syn *Vigna sinensis*) is one of the most important legumes in Kenya. It is cultivated all over Kenya mainly for seeds but the leaves are a popular local vegetable. The main problem with traditional vegetables is the non-availability due to seasonality. However, in areas where seasonality is a critical factor in limiting availability, promotion of home gardening and appropriate local preservation technology can improve availability [4].

Fermentation of indigenous foods is considered to be an effective, inexpensive and nutritionally beneficial household technology, especially in the developing world. Likewise, sun drying has been a means of preserving food from earliest times [5]. The main problem with the conventional solar-drying is huge nutritional losses. This study aimed at reducing these nutritional losses by incorporating fermentation into solar-drying. The study also considered the problem of food security, which is devastating during the dry season. The beta-carotene, ascorbic acid and sensory properties of fermented solar-dried cowpea leaf vegetables were assessed.

Materials and methods

Cowpea leaves

The fresh cowpea leaves were purchased from the local markets in the morning and transported quickly to the laboratory of the University of Nairobi's Department of Food Technology and Nutrition. The vegetables were prepared for moisture content, beta-carotene and ascorbic acid analyses. For the fermentation trials, the stalks, withered and dried leaves, weeds, stones and other foreign materials were sorted out from the rest of the vegetables. The vegetables were then thoroughly washed and well drained. They were cut manually with a kitchen knife into slices approximately 5mm thick.

Determination of optimal levels of salt and sugar for fermentation

To determine the optimal level for salt, the sorted cowpea leaves were divided into seven equal portions and were fermented in lots of 500 g. Each lot was mixed thoroughly with 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5% or 5.0% concentration respectively of table salt, followed by tight packing in 4-litre plastic beakers. Fermentation was carried out at ambient temperatures (22 ºC–26 ºC). To determine the optimal level for sugar, each sample was mixed with 3% salt (determined as the optimal level of salt for fermentation) and varying percentages of glucose and sugar i.e. 2.5%, 3.0% and 3.5%.

The fermentation was carried out for 16 days and replicated two times. Sensory analyses were performed on the fermented vegetables to determine the effect of added sugar on acceptability of the fermented vegetables.

Product manufacture

The fermented-dried vegetables were prepared in comparative trials with control and acidified samples as follows: Procurement and preparation of the raw materials was similar to that carried out during the determination of optimal levels of salt and sugar for fermentation. The amount of cowpea leaves used was larger. The vegetables were sliced then divided into three equal portions each of 16 kg.

One portion was thoroughly mixed with 3% salt and allowed to stand for two hours, then heat-treated. This was treated as the control sample. The second portion was thoroughly mixed with 3% salt and citric acid (EFF Chemicals Ltd, Kenya) to a final pH of 3.8 and allowed to stand overnight, then heat-treated. This was treated as an acidified sample. The third portion was thoroughly mixed with 3% salt and 3% sucrose, and then tightly packed well in a 60-litre plastic bucket. The salted and sugared vegetable sample was allowed to stand for 10 minutes before a polyethylene bag full of water was placed inside the bucket as a weight to ensure that the vegetables were immersed under the brine and fermented for 21 days. After fermentation, the sample was heat-treated.

Dehydration and storage

The fermented, acidified and control vegetable samples were heat-treated by boiling in their own liquor at 90 ºC–95 ºCfor three minutes. Each vegetable sample was cooled and drained immediately after heat-treating and loaded onto a solar drier with shade provision [6]. The vegetables were spread on trays at the rate of 4kg/m^2 and the trays inserted into the drier. They were then dried until the weight was constant, which took on average five days. Samples were taken for beta-carotene, ascorbic acid and sensory analyses.

The fermented-dried vegetables were packaged in either Kraft or polyethylene paper. Each package contained 50g of the fermented-dried vegetables. The packaged products were stored at: 32 ºC, ambient temperatures (22 ºC–26 ºC) and 18 ºC in enclosed dry places for three months.

From each batch, one polyethylene and one Kraft paper bag were opened each month and the vegetables analyzed for ascorbic acid and beta-carotene. Two bags were used every month for sensory evaluation. The fermented-dried vegetables were prepared in comparative trials with control and acidified samples as shown in Figure 1. The experiments were replicated twice.

Vitamin analyses

Moisture content of fresh vegetables was determined by accurately weighing 5 g of the sample and drying in an air oven at 105 ºC to constant weight [7]. The loss in weight of the sample was calculated as moisture content. Vitamin A was determined as beta-carotene by the following method:

One gram of the sample was ground in a mortar and pestle in admixture with some acid-washed sand and then extracted completely with acetone. The volume of the combined extracts was raised to 50 ml by adding acetone, then dewatered with anhydrous sodium sulphate. Twenty five millilitres of this extract were evaporated to near dryness in a rotary vacuum evaporator. The separation was carried out in a chromatographic column packed with silica gel. The evaporated sample was dissolved in 2 mls of petroleum spirit (40 ºC–60 ºC), then quantitatively spotted into the column, and eluted with petroleum spirit. The first yellow eluate was collected in a 25 ml flask and made to the mark with the petroleum spirit.

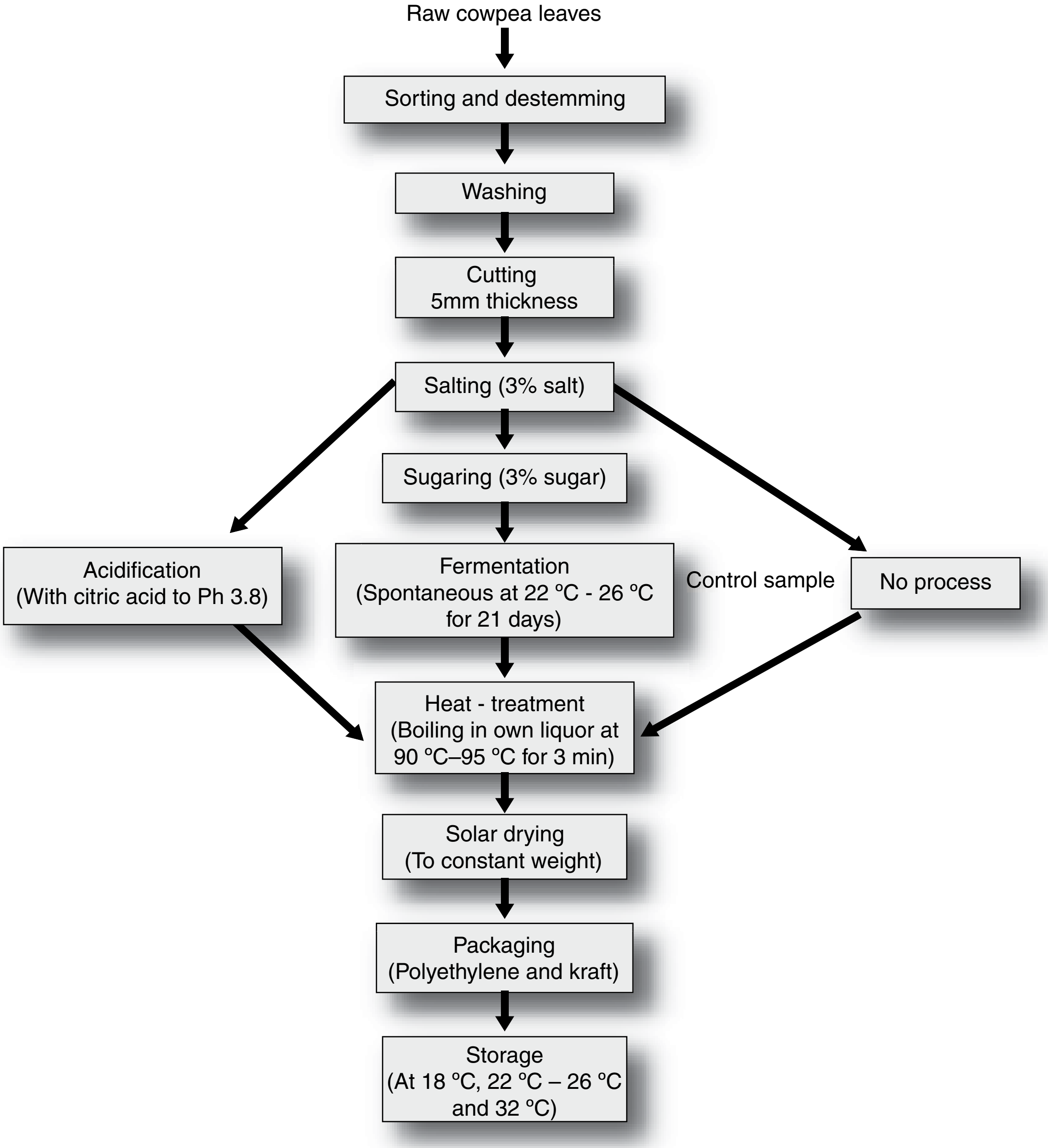

Figure 1. Product manufacture flow diagram

The optical densities of the beta-carotene fraction was measured at 450 nm using a CE 440 UV/Vis Double Beam Scanning Spectrophotometer, that had been calibrated with standard solutions of pure beta-carotene in petroleum spirit. The results were calculated as beta-carotene equivalents [9]. Ascorbic acid was determined by titration with 2, 6-dichlorophenolindophenol dye [7]. Ten grams of the sample were extracted in 30 ml of 5% oxalic acid in a mortar and pestle, and then filtered. Standard indophenol solution was prepared by dissolving 0.05 g of 2, 6-dichlorophenolindophenol in distilled water, diluted to 100 ml and filtered.

Ascorbic acid standard solution was prepared by dissolving 0.05 g of pure ascorbic acid in a small volume of 5% oxalic acid solution and then diluted to 250 ml with the same oxalic acid solution. Ten millilitres of the ascorbic acid standard solution was titrated with the Indophenol solution to a slight pink end point. Ten millilitres of oxalic acid was titrated as a blank. The amount of ascorbic acid corresponding to 1 ml of Indophenol solution was then calculated. Ten millilitres of the filtered sample extract was pipetted into a 50 ml flask and made to the mark with the 5% oxalic acid solution. It was filtered quickly through glasswool after the first few millilitres of the filtrate were discarded. The standard Indophenol solution was used to titrate 10 ml of the filtrate. The vitamin C content was calculated as mg/100 g sample.

Sensory evaluation

Sensory evaluation was performed on the fermented vegetables during the second preliminaries; and on dried fermented vegetable samples. Taste panelists, familiar with the taste of cooked cowpea leaves, assessed organoleptic quality characteristics such as appearance, colour, flavour, texture and overall acceptability. The test compared dried cooked, acidified-dried cooked and fermented-dried cooked vegetables. For presentation to panel members the dried vegetables were prepared as follows: Ten grams of finely chopped onions were weighed into an aluminium pot with 10 g shortening.

The container was then heated on an electric plate at medium heat setting until the onions turned golden brown in colour. One hundred grams of the fermented-drained (for the preliminaries testing) or rehydrated leaves (for the dried samples) and 1 g salt were added. The ingredients were thoroughly mixed and 150 ml of water added. The pot was covered and heating continued for 10 minutes with occasional mixing of the vegetables. The heating setting was changed to low, and vegetables simmered for another 10 minutes. The vegetables were then presented to the panelists as an accompaniment for *ugali* (a maize meal paste) and as coded randomized duplicates such that each taster had six samples of three products for testing. The panelists were asked to score the sensory attributes of the samples on a seven point hedonic rating scale with 1 = dislike very much and 7 = like very much.

Data analysis

All the experiments were arranged in a completely randomized factorial design with three main treatments of fermented vegetables, acidified vegetables and control vegetables. The sub-treatments were: two types of packaging material: Kraft paper and polyethylene, three different storage temperatures, i.e. 18 ºC, 22 ºC–26 ºCand 32 ºCand three different lengths of storage, for one month, two months and three months. The experiments were replicated twice. All data were then subjected to analysis of variance (ANOVA) and means were separated by Duncan Multiple Range Test using Genstat 6th Edition and Costat Statistical Software Programmes.

Results

The levels of beta-carotene and ascorbic acid for raw, fermented-, acidified- and control-dried cowpea leaves are given in Table 1. The levels of ascorbic acid in the fermented, acidified and control-dried samples were significantly different (P<0.05) from those of the raw cowpea leaves. There was no significant difference between the raw, the fermented-, the acidified- and the control-dried samples in beta-carotene content, though the raw sample levels were slightly higher.

The retention of beta-carotene during storage of fermented-, acidified- and control-dried cowpea leaves is presented in Figure 2. For the fermented-dried sample [Fig. 2 (a)], 100% represents 29.5 mg of beta-carotene, the quantity present in 100 g (dry weight basis) of fermented-dried cowpea leaves before storage. Loss during the first and second months of storage was higher than in the third month for samples stored in Kraft paper bags, whilst for samples stored in polyethylene bags, the loss was higher during the first month and slight during the second and third months.

The loss in beta-carotene was highest for the samples stored at 32 ºC and decreased with decrease in storage temperature. The higher the temperature of storage, the higher was the loss in beta-carotene. At the end of three months storage, the retention ranged between 7.6 mg (sample stored at 32 ºC and packaged in Kraft paper bag [32CK]) and 17.4 mg/100 g on dry weight basis (sample stored at 18 ºC and packaged in polythene bag [18CP]). At each storage temperature, the retention of beta-carotene was higher for samples stored in polyethylene bags than in samples stored in Kraft paper bags.

For acidified-dried samples, 100% represents 19.7 mg/100 g (dry weight basis) of beta-carotene [Fig. 2 (b)]. Loss of beta-carotene during the first month of storage was higher than in the second and third months. The loss in beta-carotene was highest for samples stored at 32 ºC and the losses decreased with decrease in storage temperature. At the end of the three months, the retention ranged between 0.5 for samples stored at 32 ºC and packaged in polyethylene bags and 1.4 mg/100 g (dry weight basis) for samples stored at 18 ºC and packaged in polyethylene bag. For the control-dried samples, 100% represents 18.9 mg/100 g (dry weight basis) beta-carotene [Fig. 2 (c)]. Percent loss of beta-carotene was highest during the first month of storage but decreased as storage period increased for all the samples. At each temperature of storage, the loss was higher for samples packaged in polyethylene bags than for those packaged in Kraft paper bags. At the end of the three months of storage, the retentions ranged between 1.5 mg for samples stored at 32 ºC and packaged in polythene bags and 6.8 mg/100 g (dry weight basis) for samples stored at 18 ºC and packaged in Kraft paper bags.

Table 1: Beta-carotene and ascorbic acid contents of raw, fermented-acidified- and control-dried Cowpea leaves expressed in mg/100 g edible portion on dry matter basis

Sample	Ascorbic acid	Beta-carotene
Raw	308 ± 14^{a}	33 ± 12^{a}
Fermented-dried	45 ± 9^{b}	30 ± 4.5^{a}
Acidified-dried	52 ± 6.8^{b}	20 ± 1.5^{a}
Control-dried	42 ± 7.6^{b}	19 ± 1.5^{a}
L. s. d.	163.3	17.12

Mean ± Standard Deviation (n =4)

Means within columns superscripted by the same letter are not significantly different at (P<0.05).

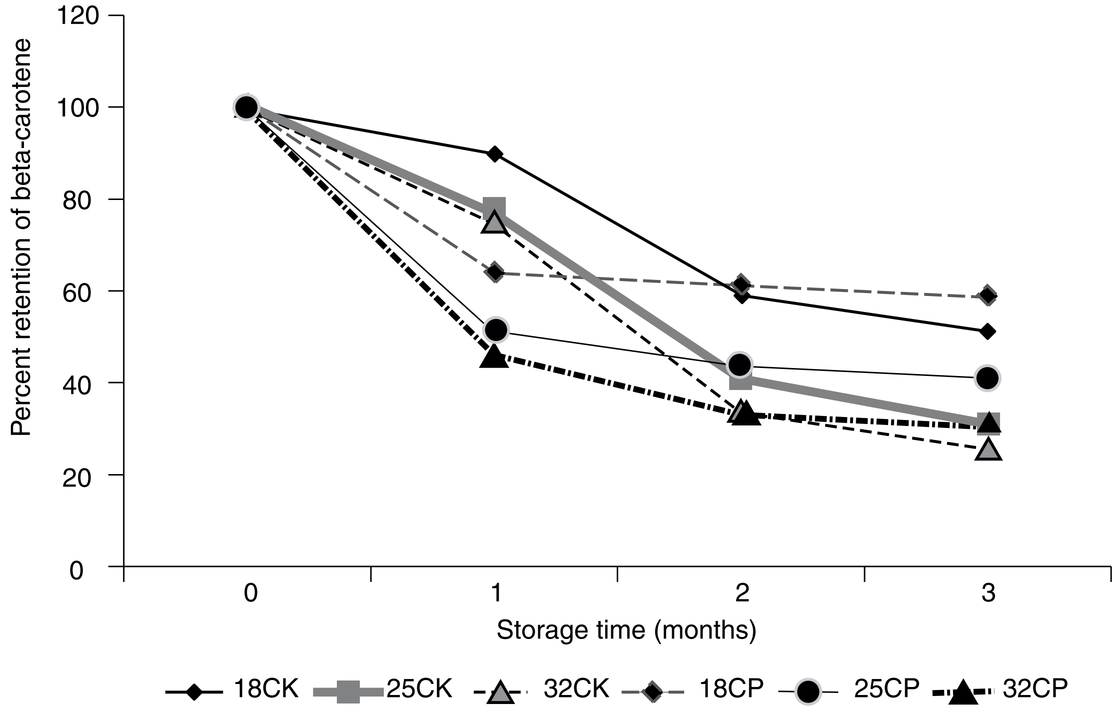

Fig.2 (a): Retention of beta-carotene in fermented-dried cowpea leaves during storage for three months

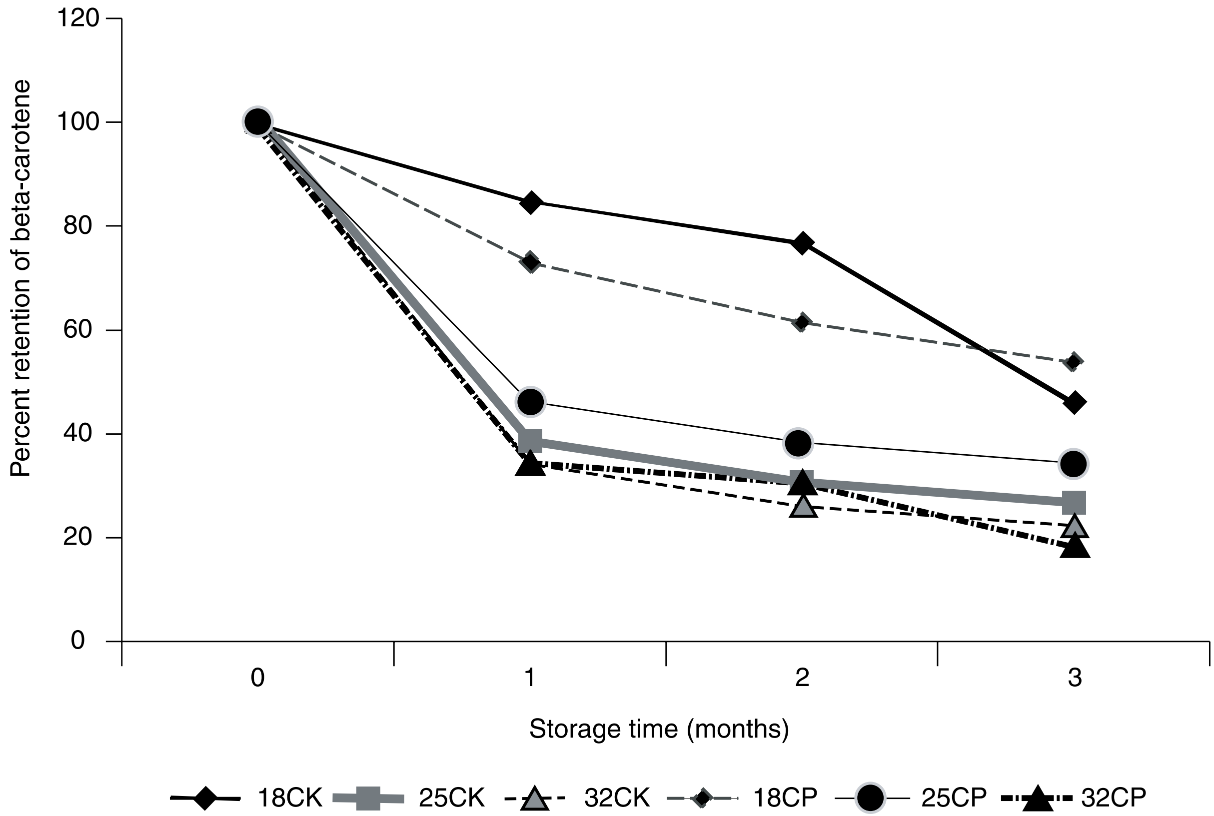

Fig 2 (b) Retention of beta-carotene in acidified-dried cowpea leaves during storage for three months

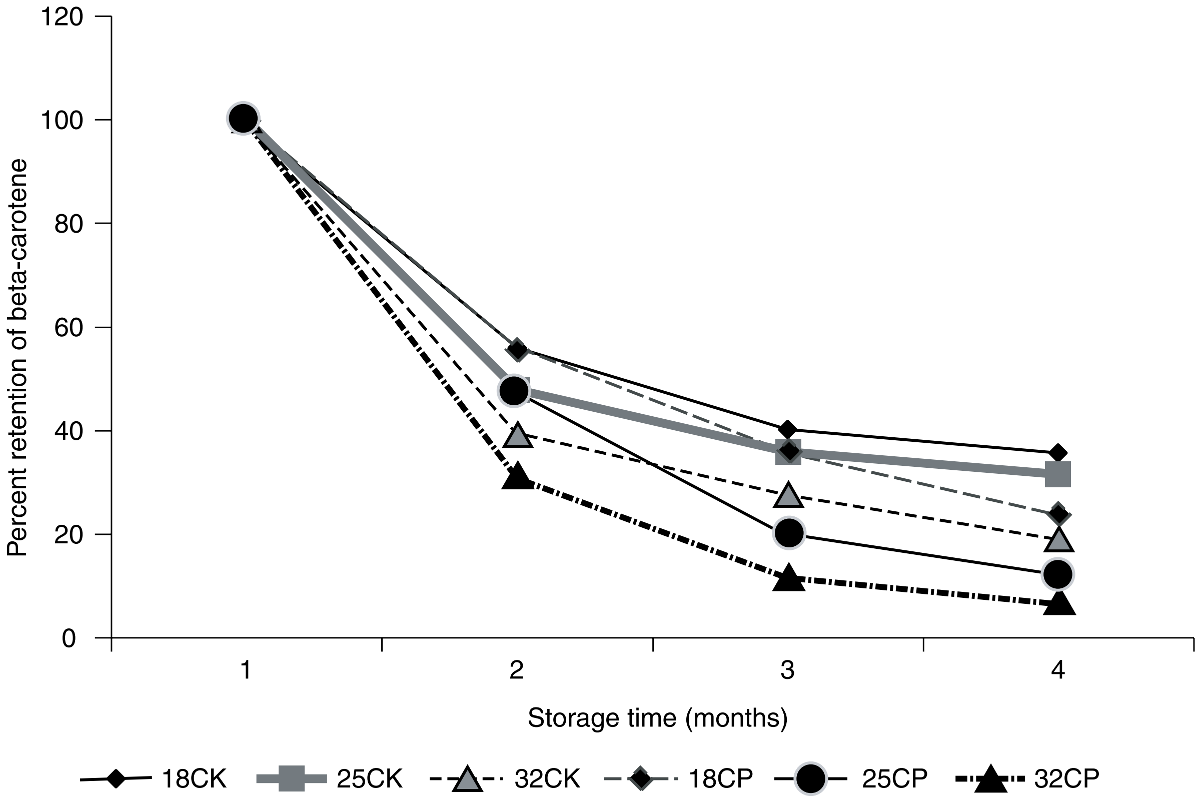

Fig. 2 (c): Retention of beta-carotene in control-dried cowpea leaves during storage for three months.

The retention of ascorbic acid during storage of fermented-, acidified- and control-dried cowpea leaves is presented in Figure 3. For fermented-dried samples, [Fig. 3 (a)] 100% represents 44.7 mg ascorbic acid per 100 g (dry weight basis) of fermented-dried cowpea leaves before storage. The percent loss was highest during the first month of storage, and was least during the third month for the samples. The total loss in ascorbic acid was highest for samples stored at 32 ºC and decreased with decrease in storage temperature. The samples stored in Kraft paper bags had higher loss compared to those stored in polyethylene bags at each storage temperature. At the end of three months, the retentions ranged between 11.4 mg for sample stored at 32 ºC and packaged in Kraft paper bags and 22 mg/100 g (dry weight basis) for sample stored at 18 ºC and packaged in polyethylene bags.

For acidified-dried sample [Fig. 3 (b)] 100% represents 52.3 mg/100 g (dry weight basis) ascorbic acid before storage. The highest percent loss was in the first month of storage for all the samples. The total loss in ascorbic acid was highest for the samples stored at 32 ºC and decreased with decrease in storage temperature. At the end of the storage period, the retentions ranged between 12.1 mg for sample stored at 32 ºC and packaged in Kraft paper bags and 22.7 mg/100 g (dry weight basis) for samples stored at 18 ºC and packaged in polyethylene bags.

For control-dried samples [Fig. 3 (c)] 100% represents 42.4 mg/100 g (dry weight basis) ascorbic acid before storage. The control-dried samples had the highest per cent loss in ascorbic acid. Hence we can conclude that fermentation and acidification resulted in better retention of ascorbic acid. In the first month of storage the samples experienced the highest loss in ascorbic acid, and the third month showed least loss. The loss in ascorbic acid was highest for samples stored at 32º C and decreased with decrease in storage temperature. At the end of the third month, the retention ranged between 13.6 mg for samples stored at 32 ºC and packaged in Kraft paper bags and 18.2 mg/100 g (dry weight basis) for samples stored at 18º C and packaged in polyethylene bags.

Sensory evaluation was carried out immediately after drying and after the third month of storage. The panelists' mean scores for appearance, colour, flavour, texture and overall acceptability of the fermented, acidified and control samples immediately after drying are presented in Table 2. The acidified-dried sample had significantly higher ($P<0.05$) scores for appearance, flavour and colour than the fermented-dried samples. The scores for texture and overall acceptability were not significantly different. However, all the scores were above neither like nor dislike category. Table 3 gives a summary of sensory evaluation mean scores at the end of storage. The results showed that packaging in either Kraft paper bags or polyethylene bags does not have

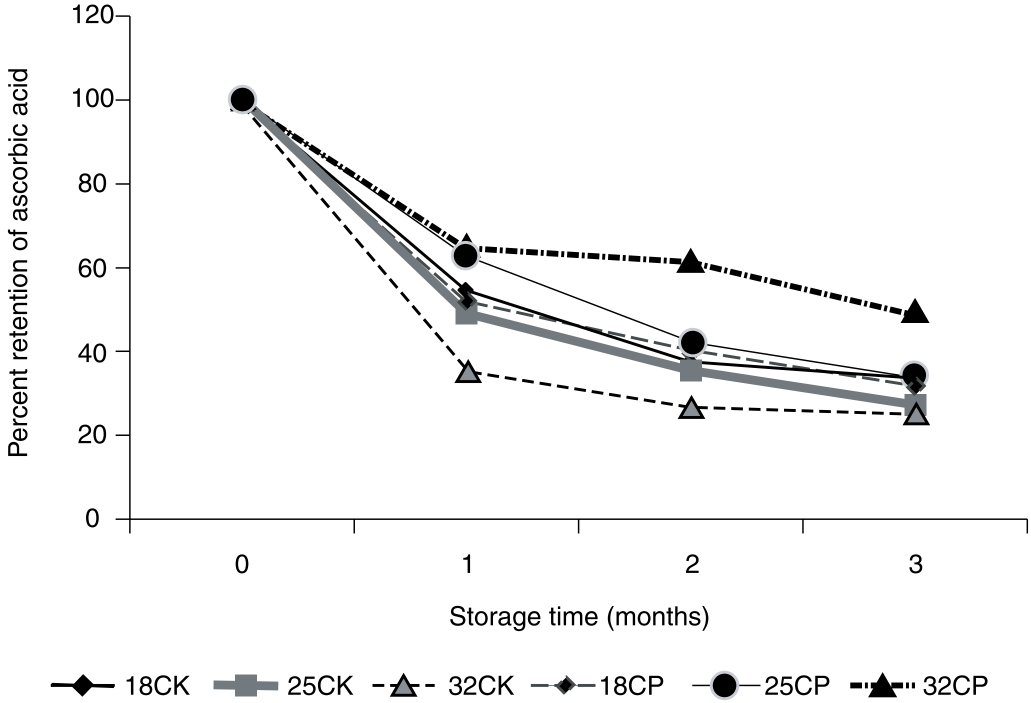

Fig 3 (a): Retention of ascorbic acid in fermented-dried cowpea leaves during storage for 3 months

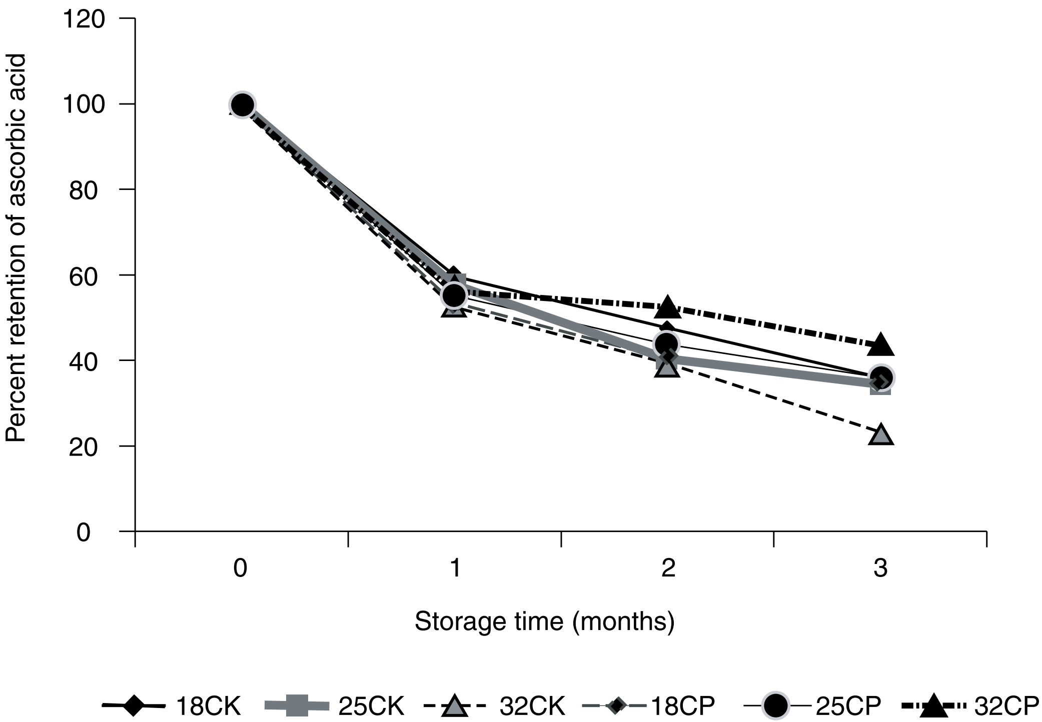

Fig 3 (b): Retention of ascorbic acid in acidified-dried cowpea leaves during storage for 3 months

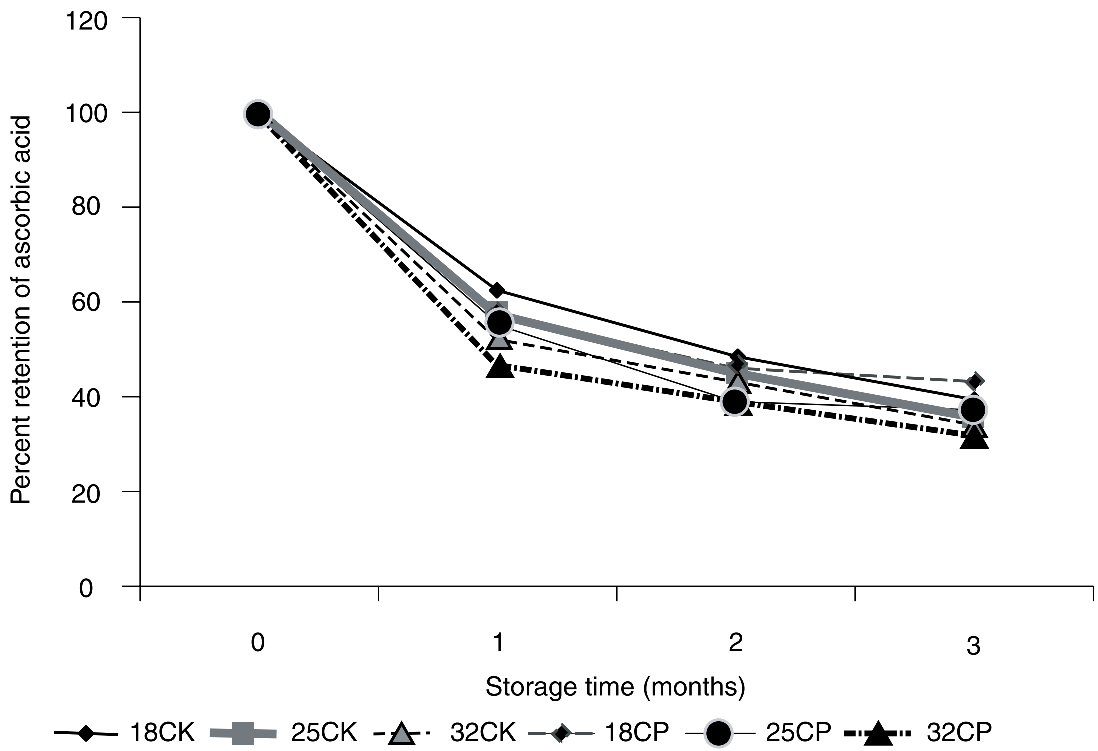

Fig 3 (c): Retention of ascorbic acid in control-dried cowpea leaves during storage for 3 months

Table 2: Mean scores for sensory attributes for freshly processed cowpea leaves

Sensory attributes	Fermented-dried sample	Acidified-dried sample	Fresh-dried sample	L. s.d
Appearance	4.7[b]	5.3[a]	5.2[ab]	0.54
Colour	4.7[b]	5.3[a]	5.3[a]	0.49
Flavour	4.3[b]	5.2[a]	5.1[ab]	0.74
Texture (Mouth feel)	4.6[a]	4.4[a]	4.7[a]	0.80
Acceptability	4.8[a]	5.3[a]	5.3[a]	0.58

Means within rows superscripted by the same letter are not significantly different at ($P<0.05$)

significant effect on the sensory attributes. The temperature of storage also had no significant effect on the sensory attributes. Fermentation or acidification did not significantly affect the sensory attributes of the samples.

Discussion

The levels of beta-carotene and ascorbic acid for raw cowpea leaves in this study were comparable to values reported by other researchers [10-12]. These results indicate that heat-treating and sun drying of cowpea leaves under shade provision can result in significant reduction in levels of ascorbic acid. Such losses in ascorbic acid during drying have been reported for other vegetables [13]. It is generally recognized that dehydration of leafy vegetables results in losses of vitamins, the extent of loss depending on the type of vegetable [14-15]. There was significant destruction of both beta-carotene and ascorbic acid during heat-treatment and drying. The loss in beta-carotene, during processing, could have resulted from the heat treatment. It has been reported that at high temperatures, the long chain polyunsaturated carbons undergo isomerization from the trans to the cis form, leading to loss of the vitamin activity [19]. The loss in ascorbic acid could have resulted from leaching during heat-treatment, effects of the processing temperatures or due to enzymatic and chemical degradation especially in the presence of traces of heavy metal ions [20- 22, 14]. Nevertheless, the destruction would have been more pronounced if the drying were done without shade provision [16-18].

The recommended dietary allowance (RDA) of ascorbic acid for adults is 30 mg/day and 20 mg/day for children. Therefore, consumption of 10 g of fermented-dried cowpea per day can provide approximately 15% and 22.5% of RDA of ascorbic acid for adult and children respectively. Consumption of 10 g of

Table 3. Mean scores for sensory attributes after three months of storage

Attribute	Storage condition	Fermented-dried sample	Acidified-dried sample	Control-dried sample
Appearance (L.s.d. 0.92)	18 °C (Kr)	4.3[d]	4.8[bcd]	5.8[ab]
	18 °C (Po)	4.8[bcd]	5.3[abcd]	6.1[a]
	25 °C (Kr)	4.6[cd]	5.0[abcd]	5.8[ab]
	25 °C (Po)	5.3[abcd]	5.1[abcd]	5.3[abcd]
	32 °C (Kr)	5.5[abc]	5.6[abc]	5.3[abcd]
	32 °C (Po)	4.9[bcd]	5.6[abc]	5.8[ab]
Flavour (L.s.d. 1.06)	18 °C (Kr)	3.6[e]	3.7[de]	5.0[abc]
	18 °C (Po)	4.5[abcde]	4.3[cde]	4.8[abcd]
	25 °C (Kr)	5.1[abc]	4.6[abcde]	5.6[ab]
	25 °C (Po)	5.3[abc]	5.2[abc]	4.3[bcde]
	32 °C (Kr)	5.5[abc]	5.5[abc]	4.9[abc]
	32 °C (Po)	5.1[abc]	5.3[abc]	5.7[a]
Texture (Mouth feel) (L.s.d. 1.04)	18 °C (Kr)	4.7[abc]	3.9[bc]	5.0[ab]
	18 °C (Po)	4.3[abc]	3.5[c]	4.5[abc]
	25 °C (Kr)	4.8[ab]	4.3[abc]	4.7[abc]
	25 °C (Po)	4.9[ab]	4.8[ab]	3.9[bc]
	32 °C (Kr)	5.5[a]	4.9[ab]	4.3[abc]
	32 °C (Po)	5.0[ab]	4.1[bc]	5.3[ab]
Overall Acceptability (L.s.d. 0.82)	18 °C (Kr)	4.6[cde]	4.2[e]	5.3[ab]
	18 °C (Po)	4.7[cde]	4.8[cde]	5.5[abc]
	25 °C (Kr)	5.2[abcd]	5.9[a]	4.9[bcde]
	25 °C (Po)	5.4[abc]	5.3[abc]	4.3[de]
	32 °C (Kr)	5.8[ab]	5.4[abc]	4.9[bcde]
	32 °C (Po)	5.1[abcde]	5.3[abc]	5.9[a]

Means for an attribute superscripted by the same letter are not significantly different at $P<0.05$

Key: Kr : Kraft paper bags Po: Polyethylene bags

Abbreviations

In all the graphs the following abbreviations apply:

18CK - Sample stored at 18 °C and packaged in Kraft paper bag
25CK - Sample stored at 25 °C and packaged in Kraft paper bag
32CK - Sample stored at 32 °C and packaged in Kraft paper bag
18CP - Sample stored at 18 °C and packaged in polyethylene bag
25CP - Sample stored at 25 °C and packaged in polyethylene bag
32CP - Sample stored at 32 °C and packaged in polyethylene bag

fermented-dried cowpea leaves per day would also provide more than 100% of RDA of beta-carotene for adults and children, as the group needing the highest levels require 750 μg/day.

The high levels of beta-carotene loss during the first month of storage could have resulted from oxidation by the oxygen retained in the package which was obviously more during the first month than in the other months. Losses of beta-carotene in stored dehydrated vegetables are usually due to oxidation mainly by the oxygen retained in the package and catalyzed by light [15]. It has been reported that losses of beta-carotene in stored dehydrated vegetables are usually caused by oxidation. Hence, Kraft paper being permeable to air, could have contributed to the higher losses in samples stored in Kraft paper compared to those packaged in polyethylene paper which is impermeable.

The loss of beta-carotene during storage in the acidified sample was higher than that of the fermented sample. We can conclude that fermentation had a positive effect on the retention of the beta-carotene. Among the three samples, the control sample had the greatest loss in beta-carotene during storage. It can be concluded that both acidification and fermentation had a positive effect on the retention of beta-carotene. It has been reported that light and oxidants catalyze the oxidation of beta-carotene in stored dehydrated vegetables causing great losses [15]. This fact could have contributed to the higher losses in polyethylene paper-packaged samples compared to the Kraft paper-packaged samples. Kraft paper being opaque, whereas polyethylene paper is transparent, could have contributed to these differences. Similar losses of beta-carotene in dried leafy vegetables have been reported by other researchers [17]. It is therefore recommended that dehydrated vegetables be stored away from direct sunlight.

The high rate of ascorbic acid loss during the first month of storage as compared to the second and third months was probably due to the effect of the residual oxygen retained in the packaging material during the initial packaging [13]. As storage progressed, the residual oxygen in the package decreased and therefore the rate of oxidation of ascorbic acid also decreased. Such trends in the loss of ascorbic acid during storage of fruits and vegetables have been reported by other researchers [23; 24]. One researcher observed that the ascorbic acid content of stored products generally decreases more rapidly at higher storage temperatures [25]. He concluded that conservative processing and low storage temperature are critical for ascorbic acid retention. The fact that samples stored in Kraft paper bags had higher loss compared to those stored in polyethylene bags at each storage temperature, was probably due to gas permeability of the Kraft paper, leading to more oxidation of the ascorbic acid compared to the polyethylene bags. These results lead to the conclusion that, fermentation and acidification resulted in better retention of ascorbic acid because the control-dried samples had the highest percent loss in ascorbic acid. Also that, acidification led to better retention of ascorbic acid than fermentation.

The sensory evaluation scores indicated that the consumers could easily accept the fermented product, as its sensory attributes do not significantly differ from those of the control sample. The storage of the dried cowpea leaves did not significantly affect their sensory attributes either, considering the results obtained for freshly dried cowpea leaves (Table 2). Thus, storage for three or so months would not lower the sensory attributes of the dried vegetables, but would ensure they are available for consumption for longer periods. This could help in reducing seasonality of the vegetables and increasing food security. It is recommended that:

1. A microbiological study should be carried out to ascertain which specific species of microorganisms are involved in fermentation of Cowpea leaf vegetables to give a uniform product and for large-scale production.
2. A study should be carried out on the storage of the dried vegetables in other types of packaging material, especially those that are conventionally used by communities to store dry foods and on other popular traditional vegetables.
3. Storage of the dried vegetables should be carried out for longer periods than the three months in this study.
4. Lastly, this technology being cheap and effective should be transferred to the local communities and women groups for preservation of seasonal vegetables like cowpeas. Together with it, the promotion for increased acceptability and consumption of the fermented and dehydrated vegetables should be done among the rural communities, where the deficiency of vitamin A and iron is likely to be rampant during the period of drought.

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Utilization and medicinal value of indigenous leafy vegetables consumed in urban and peri-urban Nairobi

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Abstract
Indigenous African leafy vegetables (ALVs) have recently been attracting research attention not only in terms of their inherent nutrition quality but also because of the healing power of some of these plants. Diversification of diets through increased utilization and consumption of these vegetables would go a long way in alleviating hidden hunger and malnutrition. The main objective of this survey was to determine the consumption patterns and medicinal uses of indigenous ALVs by the residents of urban and peri-urban Nairobi. A descriptive cross-sectional survey was conducted and the survey subjects included populations from all socio-economic strata and income levels. Probability proportional to size stratified sampling was used to select a representative sample of 800 households (600 urban and 200 peri-urban). Data were collected through structured questionnaires, focus group discussions and an observation checklist guide. A picture guide consisting of all foods available in the Nairobi markets was prepared, and used by the researchers to help the respondents identify the vegetables they consumed. Ethnic origin was found to greatly influence consumption of indigenous ALVs. There was no significant relationship between household income and education level and choice or use of indigenous leafy vegetables. Some of the reasons for not consuming the vegetables included prohibitive costs and not knowing how to cook them, especially those from other tribes. More than 60 % of the respondents reported that the vegetables had a medicinal value attached to them and some were said to cure more than one disease. About half of those who used them also said the vegetables were healthy. It was concluded that dietary diversity of indigenous ALVs in addition to providing essential nutrients presumably offers broad benefits to health. The findings support interventions to promote use of indigenous ALVs as a food-based initiative towards alleviation of micronutrient deficiencies and poverty through premium value addition incentive strategies.

Key words: Indigenous leafy vegetables, nutritional, medicinal

Introduction
Nutrition plays a central role in alleviating food insecurity and ill health in developing countries. Studies have also shown the potential synergetic effect of indigenous ALVs as nutraceuticals (micro-nutrient dense and medicinal) [1]. Kenya is experiencing a decline in the consumption of indigenous ALVs, the main reason for such a trend being lack of knowledge of the correct choice of foods and hence reduced dietary diversity [2]. Studies have shown that indigenous vegetables apart from their inherent nutritional quality also have healing power [3, 4]. Considering the difficulty in precisely identifying optimal diets, a diverse and balanced diet, including a variety of indigenous ALVs provides an intrinsic buffer against the uncertainties of change and remains the preferred choice for human health [5]. Diversification of diets through increased utilization and consumption of indigenous ALVs was the main focus of the survey. The main objectives of the survey were to establish

the food consumption patterns, practices and medicinal use of indigenous ALVs by the residents of urban and peri-urban Nairobi, Kenya. Ethnicity was found to strongly influence choice and consumption of indigenous ALVs. This was evident from families with all members originating from one tribe and those households that had members from different tribes. Occupation was also found to strongly influence choice and consumption of indigenous ALVs. This was brought forth depending on the time one has for buying, preparing and cooking these vegetables. Availability of these vegetables was another main factor of their choice and consumption by the respondents. Generally the respondents reported that the indigenous vegetables they consumed were medicinal. Some vegetables were reported to cure more than one illness. Other studies have also found out that consumption of indigenous vegetables can cure and/or manage diseases [6].

Materials and methods

A descriptive cross sectional research design was adopted for this survey to cover urban and peri-urban populations in Nairobi. The survey took place between February and May 2005. A total of 32 enumeration areas, 24 of which were in urban and 8 in the peri-urban Nairobi were visited and a sample of 791 households, 592 in urban and 199 in peri-urban areas interviewed. The urban and peri-urban households were disproportionately allocated to the two types of areas of survey. This was necessitated by the small size of the peri-urban areas. There were two stages of sample selection in this survey. These were the Primary Sampling Units (PSUs) and the households. The primary sampling unit for the survey was the enumeration areas (EAs) created for the Population and Housing Census of 1999. The allocated EAs were selected independently in the two areas of the survey using the Probability Proportional to Size (PPS) method. The selection of the households was done using the random walk method. The enumeration areas were drawn across the socio-economic classes of the upper, the lower upper, middle, lower middle and lower groups. This was for purposes of monitoring variations in consumption of indigenous leafy vegetables.

The data collection instruments were pre-tested in February 2005 and they included interview schedules, which were complemented by a picture book [7], Focus Group Discussion guides and an observation checklist guide. The collected data were analyzed both quantitatively and qualitatively using the statistical package for social sciences (SPSS). Descriptive summary statistical data were used to describe the demographic profiles of the study population. In addition, descriptive summary statistics were used to establish the commonly consumed indigenous leafy vegetables, frequency of their consumption and their medicinal value. Chi-square tests were used to obtain p-values. Analysis of variance (ANOVA) was also used to compare means in consumption among the urban and peri-urban Nairobi residents. A p-value of <0.05 was considered as significant.

Results

Household consumption patterns of indigenous leafy vegetables

Households reported consumption of different types of indigenous leafy vegetables. Table 1 shows a summary of consumption patterns of indigenous ALVs at the time of the survey and others usually consumed.

Analysis of variance (ANOVA) showed no significant group differences ($p>0.05$) in mean monthly consumption of indigenous ALVs between urban and peri-urban residents. Results from the 24-hour recall and 7-day food frequency showed that only a few varieties of the indigenous vegetables were consumed at the time of the survey; and where they were consumed, they were eaten as relish accompanying staples such as 'ugali' (maize meal), rice, maize and legumes or chapati. The following indigenous vegetables were consumed during lunch and dinner: Cowpea leaves ('kunde') (4.1%), Jute ('mrenda') (2.8%), pumpkin leaves ('seveve', 'malenge' leaves) (2%), Amaranthus ('terere') (5.4%), Bacella alba ('nderema') (2%), spider plant ('saget', 'saga'), Black night shade ('managu', 'osuga') (2%), *Crotalaria* ('mitoo') (3.9%). Botanical names were obtained for eight vegetables. However, as indicated in Table 1, a wide variety of indigenous vegetables were consumed at other times, once a month or rarely. About half of those who consumed these vegetables also reported that the vegetables were bought and not adequate.

Food consumption patterns among children 12-36 months

Results from the 24-hour recall showed that only a few children (23.2%) consumed traditional plant vegetables. Consumption of leafy vegetables for lunch was as follows: Cowpea leaves, pumpkin leaves, and Nightshade with 7.8%, 7.6% and 1.3%, respectively while pumpkin leaves were the most consumed for dinner at 15.3% followed by Nightshade and Amaranth at 2.5% and 0.6%, respectively. Most of the children were consuming vegetables from the family pot.

Factors influencing consumption of traditional foods

Ethnicity was found to strongly influence choice and consumption of these vegetables. There was a significant difference ($p<0.05$) in type and consumption of these vegetables between households with members originating from different tribes and those households with members originating from the same tribe (Table 2).

While 41.3% of the respondents indicated that they did not have problems in choice, preparation and consumption of foods, 7.5% of them reported that the foods were expensive. Further, 21.1% of the respondents reported that they lacked time to shop and prepare the indigenous leafy vegetables, while 1.1% indicated lacking knowledge on how to prepare them.

Table 1: Distribution of indigenous vegetables consumed, by frequency and source

Name	Consumed %	*Frequency %				*Sources %		
		1	2	3	4	Own produce	Bought	Donation
Ethiopian/African kale	0.1	0.1	0	0	0	0	0.1	0
Crotalaria sp./'mitoo'	2.4	0.3	0.9	0.6	0.6	0	2.4	0
Cowpea leaves	8.2	0.5	1.2	6.5	0	0.1	8.0	0.5
Stinging nettles	0.6	0	0	0.6	0	0	0.6	0
Amaranths	8.1	0.4	0.6	4.9	2.2	0.3	7.6	0.2
Spider plant ('saget')	4.3	0.4	0.4	0.8	2.7	0.3	4.0	0
Pumpkin leaves	4.2	0.1	0.3	1.3	1.5	0.6	3.4	0.1
Night shade	5.4	0.3	0.8	0.9	3.4	0.8	4.6	0
Jute ('mrenda')	3.4	0.4	1.3	1.1	0.6	0	3.4	0
Arrowroot leaves	1.1	0.4	0.5	0.1	0.1	0	0.9	0.2
Comfrey	0.6	0	0.1	0.4	0.1	0	0.6	0
Bean leaves	0.4	0	0.2	0.1	0.1	0	0.4	0
'Nderema' *(Basella alba)*	0.2	0	0.1	0.1	0.0	0	0.2	0
Sweet potato leaves	0.1	0.1	0	0	0	0	0.1	0

Frequency codes: 1=2 times a week 2=once a week 3= Once a month 4=rarely

Table 2: Consumption of indigenous leafy vegetables by ethnicity

Indigenous vegetables	Embu (0.9%)	Meru (2.3%)	Kamba (11.3%)	Kikuyu (42.5%)	Kisii (4.6%)	Luo (13.3%)	Luyha (17.6%)	*Others (3.4%)	**X2 Sign.gn
Crotalaria sp./'mitoo'				0.4		1.3	2.0		0.01
Amaranth	0.3	0.6	1.9	9.4	0.5	2.5	2.7		
Cowpea leaves	0.4	0.5	3.7	7.7	1.4	5.6	10.0	0.3	0.02
Spider plant ('saget')					1.9	3.7	2.9	0.3	0.01
Pumpkin leaves			1.4	3.7		0.3	0.9		
Night shade	0.6	1.9	1.4	10.0	3.7	2.9	3.4	0.6	
Jute ('mrenda')					0.9	3.9	3.7		0.03

Note: Only consumption by more than one respondent (0.1%) indicated.
Figures in parenthesis represent percentages of respondent's ethnic group.
** Chi-square tests. Significance at $p<0.05$

Results from the focus group discussions (FGD) and observation guides indicated that traditional foods were readily available in urban and peri-urban Nairobi. The availability of traditional foods varied from estate to estate with Eastlands registering high accessibility to traditional foods. These foods were mainly sold in kiosks, open markets and supermarkets. Most of these vegetables sold in open markets appeared fresh but were sold from poor environmental conditions. At times because of poor handling, their qualities were perceived to be poor, an issue that discouraged many potential buyers from consuming these products. The most commonly sold traditional leafy vegetables in Nairobi were Jute ('mrenda'), Crotalaria ('mito'), Solanum ('osuga'/'managu'), Spider plant ('saget'), Amaranth, pumpkin leaves, and African kale. The survey was conducted during the hot months (February/March) and therefore most of the vegetables were not available in large quantities.

The survey also sought to find out the methods used for preparation and cooking of the leafy vegetables. While most traditional leafy vegetables are nutritious if well cooked, findings from this survey indicated that respondents used preparation and cooking procedures which could lead to a decrease of the nutritive value of cooked food. Some of the procedures used in preparing leafy vegetables, that need to be discouraged are described as follows:

(a) Chopping before washing

Nearly half of the respondents (43.1%) reported chopping their vegetables before washing. It is noted that water-soluble vitamins, namely vitamins B complex and C are lost during the washing stage if the vegetables are chopped before they are washed. Actually the colour of the washing water is green indicating presence of the nutrients. Some respondents repeated washing which further led to further loss of the water-soluble vitamins. However, a few households (11.9%) reported cooking some of their vegetables whole such as 'mrenda', Cowpea leaves, Black nightshade and amaranths. This is encouraged since nutrients are not lost due to chopping.

(b) Repeated boiling

Many respondents (79.1%) reported boiling the vegetables for a long time before frying. The boiling water, which could be containing nutrients, was also discarded. High temperatures such as those for boiling and cooking vegetables for more than 40 minutes as in the case of boiling and then frying also destroys vitamin C which is the most unstable vitamin.

(c) Addition of *sodium bicarbonate ('magadi')*

Over three quarters of the respondents (77.1%) reported adding sodium bicarbonate to vegetables, especially cowpeas during boiling. While sodium bicarbonate helps the vegetables tenderize and retain their bright green colour, vitamin B complex namely vitamin B1, B2 and niacin are lost. This could thus indicate that most of the vegetables consumed might have lost these particular nutrients.

Other factors influencing the choice and consumption of indigenous vegetables included: occupation, sex, income and education levels. Occupation was found to influence choice and consumption of indigenous vegetables. There was a significant difference ($P<0.05$) between consumption of indigenous vegetables and occupation, with more casual labourers and/or non-employed respondents (79%) than those in full time employment and business (21%) consuming indigenous vegetables (Table 3). This was brought forth depending on the time one has for buying, preparing and cooking indigenous vegetables. There was no significant difference ($p>0.05$) between men and women with regard to perceptions on consumption of indigenous vegetables. However, men were reported to have less preference for vegetable consumption compared to women. The survey also showed no direct relationship between households' incomes except for Cowpea leaves with significantly ($P<0.05$) more households with total household income of less than Ksh. 3,000 consuming these vegetables (Table 3). There were also no relationships between education and consumption of indigenous vegetables except for Spider plant ('saget') and pumpkin leaves, with significantly more respondents with informal education and secondary education consuming these foods ($P<0.05$), respectively.

Medicinal value of indigenous vegetables

Generally, the respondents reported that the indigenous vegetables they consumed had a medicinal value attached to them. Some vegetables were reported to cure more than one illness. A wide range of illnesses was cited as being treated or managed by consumption of leafy vegetables. Table 4 presents results on what respondents felt about the medicinal roles of indigenous leafy vegetables. However, there is need for further investigations to establish the basis of these perceptions.

Table 3: Household food consumption of traditional foods and total monthly income

Indigenous Vegetables	Household Monthly Income Levels (Ksh.)							
	3000 & below (30.6%)	3001-5000 (21%)	5001-10000 (25.7%)	10001-20000 (8.2%)	20001-30000 (5.3%)	30001-40000 (1.3%)	40001& above (8.0%)	X^2 Sign.
Crotalaria sp./ 'mitoo'	1.0	1.1	1.1	0.3	0.1	0.1	0.4	
Amaranth	5.2	4.0	4.3	1.9	1.3	0.4	1.6	
Cowpea leaves	8.0	7.1	8.0	3.3	1.9	0.3	2.3	0.03
Spider plant ('saget')	2.8	1.9	2.4	0.9	0.3	0.3	0.9	
Pumpkin leaves	2.8	1.1	1.0	1.3	0.5	0.3	0.9	
Night shade	7.1	5.8	6.6	2.3	1.9	0.1	2.1	
Jute/'mrenda'	2.1	1.5	3.3	0.6	0.4	0.1	0.6	

X2 - Chi-square tests. Significance at $p<0.05$ *Figures represent percentages

Table 4: The attached and medicinal value of indigenous leafy vegetables as reported by respondents

Indigenous vegetable	Attached value	Medicinal value	% N = 791
Mukimo (with pumpkin leaves)	Delicacy	Treats diabetes, high blood pressure, backache	6.2
Ethiopian kale	Cleanses blood		0.5
Pumpkin leaves		Improves eye sight	4.1
Garlic	Boosts appetite, revitalizes the body	Colds and coughs, high blood pressure, stomach ache, cancer, asthma, TB	5.8
Ginger	Nourishing and revitalizing	Colds and coughs, high blood pressure	2.3
Stinging nettle	Boosts appetite Cleanses blood	Anaemia, fainting, colds and coughs, backache	1.3
Black night shade	Boosts appetite, general comfort, cleanses blood	Malaria, stomach ache, colds and coughs, high blood pressure, diabetes, chest pains	10.0
Crotalaria sp./ 'mitoo'/ 'miroo'	Cleanses blood	Stomach ache	3.9
Cowpea leaves	Boosts appetite	Digestive problems	3.9
Amaranth	Boosts appetite	Malaria, colds and coughs, AIDs, stomach ache, diarrhoea, skin rashes, diabetes, back ache	2.3
Spider plant ('saget')	Cleanses blood	Stomach ache	6.9
Pumpkin leaves	Boosts appetite	Malaria, typhoid, high blood pressure, stomach ache, oedema, constipation, general health	4.0
'Nderema' (*Basella alba*)	General good health		0.5
Jute ('mrenda') (Bush okra)	Boosts appetite	Stomach ache, anaemia	7.7
'Muthunga' or 'mchunga'	-	Backache	0.6
Arrowroot leaves ('matekyo')	Boosts appetite	Diarrhoea	3.1

The most common illnesses cited were malaria, diarrhoea, anaemia, colds and coughs, skin infections, malnutrition, HIV/AIDS, diabetes and high blood pressure, among others. In addition to determining the medicinal value attached to indigenous vegetables by respondents, the survey also sought other values attached to these vegetables. The most common values attached were that the vegetables were: satisfying, a delicacy, appetite booster, and able to make one live long. Other values included improved blood flow, ability to cleanse blood and so on (Table 4).

Discussion

Food consumption patterns

Recently there has been a trend in the production and consumption of indigenous leafy vegetables as these have been found to be both nutritive and therapeutic. Indigenous leafy vegetables play a significant role in the nutrition and health status of the under privileged in both urban and rural settings [9]. Findings from the survey showed that ethnicity, occupation, sex, income and education levels are among some of the major factors affecting consumption and utilization of these vegetables. In a similar study, Maxwell and Frankenberger also found accessibility to be a limiting factor [10].

Overall, consumption of indigenous leafy vegetables was low (34%). These findings concur with those of Waudo et al. who reported low intakes of traditional vegetables by women and children in the wetlands of Lake Victoria region [11]. Consumption and utilization of indigenous leafy vegetables was highest when the vegetables were in season and prices were lower. Familiarity among adults with these vegetables accounted for their popularity in consumption and utilization.

Medicinal value

The diversity of indigenous and wild plants available in most tropical countries, in addition to providing essential nutrients, presumably offer broad benefits to health [12]. Studies have further shown that countries that retain indigenous vegetable diets and had high consumption of these vegetables are much less likely to be affected by cardiovascular diseases, diabetes and other adverse consequences of nutrition in transition [6]. These findings concur with those of Johns and Musinguzi et al., which found out that there was a potential relationship of indigenous vegetables and the ability to treat diabetes, gout, hyperlipidemia, gastro-intestinal tract infections, and protozoan parasites, amongst others in Kenya and Tanzania [5, 13]. Olembo et al. also state that traditional vegetables have medicinal properties for the management of HIV/AIDS, stomach-related ailments and other diseases [14]. This is encouraging for interventions geared towards motivating individuals to increase the consumption and utilization of indigenous leafy vegetables. There is need for further investigation to establish the basis of the above-mentioned perceptions.

Conclusion

It is evident from these findings that only a small proportion (34%) of the people living in urban and peri-urban Nairobi consume indigenous leafy vegetables. Consumption was based on ethnicity among other factors. The most consumed indigenous leafy vegetables by children were pumpkin leaves and cowpea leaves. Children were consuming the indigenous leafy vegetables from the family pot. The major constraint to consumption and utilization of indigenous leafy vegetables were the cost, lack of time and lack of knowledge in food preparation and cooking. Generally, indigenous leafy vegetables were liked because they were nutritious and had a medicinal value attached. The respondents indicated a willingness to consume indigenous leafy vegetables if they were sensitized about their value and shown how to prepare them. This poses a challenge to relevant stakeholders to promote production, utilization (preparation and processing) and commercialization of indigenous leafy vegetables.

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The value of leafy vegetables: an exploration of African folklore

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Abstract

Indigenous leafy vegetables foods have an exceptional place in African cuisine. It is commonly argued that vegetable consumption reflects cultural backgrounds and their value transcends a biological one, as food, to symbolism enhancing the functioning of society and promoting social order. This study set out to determine species use, folkloric dimensions and taste preferences in a rural East African setting. A bio-cultural approach reinforced by ethno-botanical tools conducted over a three-year period and recourse to a corpus of Luo ethnic food plant literature and gathering of folklore elements from a conversational context was used to study socio-cultural elements of vegetable foods of people of Migori and Suba districts of Kenya.

Seventy four respondents, 56 female and 18 males, of mean age 43 years and ranging between 16 and 84 years participated in focus group discussions and research interviews. Herbarium specimens of 34 leafy edible plant species in 17 plant families are deposited at the University of Nairobi and the Catholic University of Eastern Africa herbaria. This study documents 17 sayings (folkloristic products) of different genre: mantras, traditional beliefs, customs, practices, folk stories/ tales, songs, jokes and lexical phrases.

Their sociolinguistic analysis reveals they address issues appropriate to Luo ritual, social status, nutrition, taste preferences, cooking habits and conflict resolution. Though Luo folklore indicates aversion for bitter vegetables, the body of folkloric wisdom sustains vegetable dish consumption. The preference and craving for bitter tasting herbs by elder women was because of an understanding of both food and medicinal values. This paper concludes that vegetable consumption reflects cultural backgrounds and experiences. Folklore defines how Africans perceive, define, and value indigenous leafy vegetables in their own terms and presents a stable platform for cultural analysis of oral food culture. Indigenous leafy vegetables are symbolic "sources of illumination" that orient African people persistently with the system of meaning in their culture.

Key words: Indigenous leafy vegetables, culture, folklore

Introduction

Culture is an organization of things, the meaning given by people to objects, places and activities [1]. Cultural diversity is as necessary to human beings as biodiversity is to life [2]. Every human society is culturally situated and at the core of every culture are issues of food resource availability. Indigenous leafy vegetables (ILVs) have an exceptional place in African cuisine. They differ to some degree across African cultures and regions on the basis of the amount of value and meaning being communicated in the symbol of food and the social class of the persons being served. It is these latter factors that account for differences in the styles of food preparation, recipes and tastes across African cultures. Some vegetable taste preferences seem to be entrenched and are unusually tenacious within specific cultural groupings.

Dietary change taking place among both the rich and poor peoples as well as in urban and rural populations of the developing world has been documented [3, 4]. During the last millennium many African cuisines experienced dynamic changes induced by socioeconomic, colonial and political impacts. Many cultures conformed to or adopted dominant modern cuisines. In recent times, increased global contact has made exotic foods readily available to Africans. In Kenya, *Brassica oleracea* var. *acephala* otherwise known as *"*Sukuma wiki*"* has now become the main type of leafy vegetables in both rural and urban areas, yet its value and symbolic meaning is lacking in indigenous folklore. Dietary changes among some African peoples have led to the neglect of the symbolic meaning of food and consequently broken the link between culture and cuisine. Little has been said about cultural lore underpinnings of food. Further, efforts to sustain traditions have been little investigated.

Most scientific studies have focused widely on edible plant species diversity; little attention has been given to the social cultural value of edible plants. The need for symbolic "sources of illumination" to orient people persistently with the system of meaning in their culture has been recognized [5]. In general, the symbolic meaning of food, including ILVs serves the purpose of enhancing the functioning of society and promoting social cohesion and order. As far as ILVs are concerned, these meanings have scarcely been studied. This paper presents a botanical and cultural exploration of indigenous vegetable use. It identifies folkloric dimensions and taste preferences of ILV dishes consumed in rural southwestern Kenya.

Study site

The study was carried out in the southwestern Nyanza Province of the Republic of Kenya. The area lies within the Lake Victoria Basin. The study focuses on the Luo people, who are an agropastoral group of the Nilotic cluster of societies [6]. The Luo speak *'DhoLuo'* language, which has a Nilo-Saharan and eastern Sudanic accent and affiliation.

The selection of the Luo as the focus of this study was motivated by their habitat which is uniquely fed by the rich ecosystem of the lake basin and labour-migrant economy. In addition the Luo have an up-to-date demonstrated knowledge and use of local flora.

Methodology

Two districts namely Migori and Suba in Nyanza Province were sub-sampled for the study. Standard focus group discussions with participants of age 45 years on average were conducted in Uriri, Karungu, Nyatike and Rongo divisions of Migori District and in Mbita Division of Suba District between 1999 and 2003. Selected homesteads and surrounding ecosystems were observed with the assistance of a key local informant. A database of 34 edible plant specimens deposited at the University of Nairobi and the Catholic University of Eastern Africa herbaria was also utilized. The study also utilized available corpus of literature on ethno-botany and recipes for over 70 indigenous ILVs used by the Luo [7-10]. Data analysis is based on the bio-cultural approach reinforced by ethno-botanical and nutritional tools of analysis.

Results

The findings presented in this paper are based on responses from a total of 74 participants which divide into 56 females and 18 males. In general, the Luo cultivate vegetables in home gardens called "ogundu". They also gather wild edible plants from the diverse ecosystems of the Lake Victoria Basin for their nutritional requirements. A strict societal gender separation in food preparation, processing and marketing prevails within the Luo community. The rural women are directly responsible for conserving and preserving ILVs by virtue of their reproductive and feeding roles in the family. Among the Luo of Nyanza, food has both biological and social value. The biological value hinges on the nutritional importance of food while the social value embodies a patterning of social status based on age and gender. The biological value of food is automatically understood without conscious reference to science. From a biological perspective, food is viewed as a body building and body tissue repairing agent.

The social meaning and the message to be communicated to the social environment and to persons being served is reflected in who gathers, purchases, prepares and serves the food as well as in the type of food in question. The social ranking of the food is reflected by the age and sex involved in its gathering, purchase, preparation, serving and consumption. The elaborateness of the technique of food preparation is determined by the occasion and the social status of the persons to be served. The significance of the social activity determines the type, kind, and amount of food to be procured for preparation for the event. In general, the procurement of beef is the domain of men mainly, because they are the herdsmen.

The women gather leafy vegetables mainly because they are versed with the corpus of edible flora in the immediate environment. In most of the African communities, visitors are highly regarded. Food for guests is procured and prepared with a lot of caution. Persons of high social status are usually served highly valued food. They are served by women of high social ranking in the community. Traditional vegetables are generously used to supplement food for guests. The vegetables are usually prepared using fermentation techniques. Energetic elderly women are in most cases consulted whenever customary dishes are being prepared. The collection of vegetables for common household consumption is more often than not left to young girls. The complexity of vegetable preparation and the number of complementary food items served depend on whether a meal is to be eaten as a snack or as the main meal of the day. The taste and amount of food invariably reflects the worthiness, reliability, and honour of both the host and the guest. Generally, food must be enough for everyone. Food shortage at social gatherings means neglect or outright insult to guests and consequent diminutive perception of the host.

The food and the social environment of consumption promote and sustain social status, respect, cohesion and responsibility. During mealtimes, persons being served take positions at table that say something about their social ranking. The Luo proverb *"chiem gi wadu"* literally meaning eat with your neighbour reinforces a communal sense of responsibility and togetherness. Food resources are largely considered communal and individualistic forms of behaviour are generally shunned. Stingy persons are commonly described by disparaging expressions like *"ng'at ma iye kwar"* or *"ng'at ma iye lit"* which literally describe the stingy person as the one with a red stomach and the one with an aching stomach, respectively. They both describe a bad-hearted person.

Leafy vegetables' tastes and social structuring

The fact that many structurally unrelated compounds (peptides and amino acids, sulfimides, ureas, thioureas, terpenoids, phenols, and polyphenols) give rise to a uniform bitter taste suggests the existence of multiple bitter taste receptors and genes in a person [12]. Taste buds pick up only four sensations (sweet, sour, salty, and bitter), but these are combined with the sense of smell to give various foods their unique tastes. Among the Luo the terms *"kech"* and *"wach"* respectively depict degrees of sweet and bitter taste conceptions. However, five main terms of taste are recognized: *"mili mili"* (astringent), *"wach"* (sour), *"kech"* (bitter/ acidic), *"mit"* (sweet, also meaning delicious), and *"both"* (bland).

A leafy vegetable with a bitter taste was commonly associated with medicine while one with a sour taste was associated with food. Generally, lower social classes are said to have "vulgar" taste while the upper classes are thought to have a refined taste. The taste of the vegetable provides a clue of the social links of the person eating it. Leafy vegetables' tastes tend to provide distinguishing marks for rural and urban influences or attachments. Persons eating vegetables with milder tastes are commonly associated with urban links, while those eating ILVs with a bitter taste tend to have stronger rural attachments. The prejudice against ILVs among urban dwellers and the youth is attributed to the bitterness and hairiness of the ILVs as well as to the tedious cooking methods involved. The urban Luo have in recent times been rediscovering their indigenous foods and have tended to pay more attention to their unique varieties and cooking styles.

Generally, the youth prefer vegetables with milder taste while adults tolerate sour and bitter tasting leafy vegetables. The Luo women who understand both the food and medicinal value of ILVs crave for the bitter tasting ILVs commonly referred to as *"alode makech"* or 'bitter herbs'. Elderly women pride themselves on bitter herbs – a preference that has made them the leading conservators and producers of bitter cultigens including *Crotalaria* spp., *Solanum nigrum* and *Gynandropsis gynandra* which are highly ranked in the category of ILVs with bitter taste and in terms of preference. Bitter tasting cultigens tend to possess biologically active phytochemicals. They have acrid or astringent taste and have health benefits [13]. Preference for a sour or bitter taste develops in the course of early childhood therapeutic and nutritional induction [8, 9, 14-17].

Preference is acquired through both socialization and imitation. In the past, socialization took place in informal structural institutions called *"siwindhe"* for girls and *"duol"* for boys. The subject of discussion at the *"duol"* and *"siwindhe"* included general matters on plants, animals or people. The boys were educated on their role in the procurement of the best foods either as hunters or herders. Girls were informed on matters of nutrition and how to prepare the best dishes. However, the customary educational system among the Luo has almost vanished.

In general, mild flavours are enjoyed by all the segments of the population with variations in the level of enjoyment determined by degree of sourness or vegetable texture. A general observation from folklore indicates that bitter vegetables are loathed, as illustrated in the common saying *"kech ka manyasi"*, meaning bitter as herbal medicine. Almost all the women of age 39-84 had preference for bitter tasting vegetables. In general, women have more taste buds than men [18]. A greater number of taste buds appear to give them greater sensitivity to sweetness, sourness, saltiness and bitterness. Fear of bitter tasting vegetables tends to wane with age [19-20]. However, any dislike for ILVs is moderated by hunger and the Luo have sayings to communicate this message, for example *"ng'ama oyieng' jaro chiemo - to ng'ama odenyo chamo kata a lot makech manadi (osuga kata mitoo)"* meaning the starving person will even eat bitter *"osuga"* or *"mitoo"*. *"Ngima ema ilaro, dek kiyudo to hadh ahadha"* contests pickiness on the relish.

Visual and olfactory considerations in leafy vegetables preparation

The colour of food was not often used in food label and preference ranking. Dark green indigenous vegetables and dark green, brown-green to light green cooked vegetable is preferred and deemed tasty and healthy. Generally, green soups had positive health connotations and were perceived as good weaning preparations. The health value of brown green vegetable seems minimal due to vitamin losses associated with overcooking [21-23].

The type of smell emitted by the food is an indicator of the manner in which it has been prepared. In general, bland foods are acceptable but dishes with strong aromatic and pungent odours (especially of essential oils) are considered repulsive and are shunned. The dearth of aromatic plants, notably the Anthemideae tribe of the sunflower family (one of the largest with ILVs in this study), the mint family (Lamiaceae) and Verbenaceae reinforces this point.

Textural considerations in the procurement and preparation of leafy vegetables

Vegetable dish texture determines its mode of preparation, cooking and suitability for particular occasions. Two vegetable dish textures are identifiable among the Luo. These are slimy "*rudruok*" and coarse non-slimy *"maok rudre"* textures. The textural classifications are based on chewing sound (crunchiness or *"radruok"*). About 37% of the plants consumed by the Luo are slimy and have a 'sharp- bitter taste'. Slimy vegetables are preferred over non-slimy ones because they are believed to ease ingestion of accompanying foods and general digestion.

It is also appropriate for elderly people whose dietary needs are implied in the saying *"ted ne rahuok a lot aruda"* directly translated as simply "cook for the one without teeth slimy foods". Slimy foods demand less effort to masticate. Sex differences in the preference of leafy vegetables dish texture exist among the Luo. Males prefer coarse vegetables to slimy ones partly because the slimy vegetables have a likeness to male seminal fluid. However, this behaviour also tends to reinforce male identity and the social structure. On the other hand, females largely tend not to discriminate vegetable dish textures. Further, several concoctions of ILV species are normally prepared for an array of textural and taste sensations. In general, *Corchorus* spp. and *Sesamum angustifolium* are preferred for dish thickeners. However, other seasonal substitutes like *Portulaca* spp., *Basella alba*, *Asystasia schimperi* and *Commelina* spp. are also utilized.

Ritually marked vegetables

Consumption of food among the Luo is a ritual activity. It is patterned, repetitive and unchanging. Food is a medium of expression in that among the Luo, people converse and exchange views as they eat. Similar observations were made about the Midzichenda [24] whose dishes are used to punctuate activity and ritual cycles as well as to underscore honour. Some ILVs are assigned to special social times and contexts. In southwestern Nyanza, culinary skill competence is associated with the social status of wives and their relationship with their husbands. It creates affective bonds within the family. This is underscored in the Luo saying *"yadh hera en chiemo* "translated as the "medicine of love is food". It implies responsibility on both sides of the married couple. However, the man must be able to provide and sustain the family so as to have "love" in the family. The wife must also know how to prepare the right food for the family. The Luo developed sayings to sustain good cooking habits and reduce social conflicts within the family. For example, *"alot ok bul"* meaning you cannot roast vegetables; *"alotni otwon gi chumbi mojow piny, kwoyo radoree"*, *"Nyodo okonyo omboga"* literally translated as "suckering reproduction saves the parentals".

Highly valued vegetables are prepared during ceremonial occasions. Expensive ingredients such as ghee and milk are added during the preparation of this category of vegetables. Some of the highly valued ILVs are Nightshade S. nigrum and Spider plant G. gynandra. The S. nigrum has a higher ritual value when consumed with millet cake than with maize meal..

The intricate and arduous manner in which *S. nigrum* and *G. gynandra* are prepared makes them very significant in the Luo food system, family roles, family tradition and ethnic identity. In general, cultural constructs influence the blending of vegetable foods as shown in Table 1. However, a functionalist analytical approach can shed light on therapeutic and nutritional value of the blends.

Folkloric aspects

Leafy vegetable foods and dishes are usually complementary but they are also served singly without meat, depending on family finances. They are commonly given as gifts for convalescence when visiting sick relatives and friends, and as atonement during funerals. The ILVs are either grown or gathered in the wild. Some women grow them for commercial purposes while others maintain home gardens in which they grow ILVs for household use. The emergence of a money economy has tended to give financial value to certain activities and commodities which in turn receive high ranking and social value.

High value was accorded to beef because it has financial costs and it is the common dish of upper social class households. However, the long Luo tradition of pastoralism appears to reinforce the belief that plant diets are nutritionally inferior to meat ones. The procurement of ILVs tends to be associated with less financial value and with households of low social-economic status. In general, households with low economic status rarely serve beef on their table and apparently, the decreasing consumption of ILVs may be interpreted as a psychological rejection of the low social class tag. However, this development appears to have been anticipated and checks including communal wisdom on the health and social importance of leafy vegetables was developed and incorporated into the informal socialization curriculum with the objective of encouraging people, especially the Luo to consume these vegetables.

The importance of leafy vegetables is explained and sustained in folklore, sayings, proverbs, tales and lexical phrases. A commonly used phrase stressing the importance of ILVs is *"alot ma ocha ema tieko kuon"* – translated literally as "the despised potherb is what relishes the corn cake"; this saying promotes the value of leafy vegetables relative to other dishes. It is translated as: "a thing that is despised might become respected" [25]. Less common sayings that deride the social class system by reflecting its disadvantages when it comes to

Table 1. Cultural blending of vegetable dishes and the emic explanation

Vegetable combination	Emic explanation
V. unguiculata and *Corchorus* spp.	Improves texture (roughness) and texture
S. nigrum and *V. unguiculata*	Improves texture (roughness)
Amaranthus and *G. gynandra*	Improves taste (bitterness)
Sesamum spp. and *V. unguiculata*	Improves texture (roughness)
Crotalaria spp. and *Corchorus* spp.	Improves flavour (bitterness) and texture

food are *"Ruoth ne ogombo obwanda"* and *"Ruoth rapemo nokecho obwanda wamlare"*. Both sayings simply translate as: "the nobleman yearned for green herbs".

They are drawn from a folktale about a tired and hungry nobleman who, after an unsuccessful hunting trip, longed for something to eat, even a poor dish of herbs, purselane, served by a peasant woman. According to the tale, the peasant woman who received the hunters in her home served them in accordance with the norms of hospitality. However, the nobleman was not served the dish of herbs because the peasant woman felt that his status did not deserve eating leafy vegetables and she had no food suitable for him. The account underpins the significance of hospitality in society and the indictment of social class when it comes to food. However, it also reflects the social stigma associated with purselane and leafy vegetables in general, whereby they are viewed as markers of social class.

The perjoration of vegetables is illustrated in other proverbs such as *"irach ka a lot"* literally meaning "you are disgusting as potherbs". *"Wang'i olil ka alot e agulu"* meaning you are unsightly or poor looking as potherbs", *"Dek ojonyo ng'at ma otede"* alluding to the bitterness of leafy vegetables especially the *G. gynandra* and to the view that what is familiar and cooked regularly is not delightful. This saying is commonly used on a marital relationship which is sometimes defined by a low level of affection between the spouses. One of the soothing sayings for this type of situation is *"mo moleny loso alot marach mondo obed mamit"* meaning "ghee improves vegetable taste". The Luo wisdom on food promotes a balanced diet. This is alluded in the saying *"alot kone ring'o ni kori ema ichwalo e mach kora to mach otho"*. These sayings capture an imaginary discussion where the vegetable fireplace complains of neglect because all attention is directed to the meat fireplace.

Negative attitudes towards some ILVs have also come from an interpretation of Hebrew and Christian teachings by syncretic African religions. For example, adherents of the Legio Maria sect are forbidden from eating vegetables that have been gathered from *"gunda"* (abandoned homesteads) and from *"liete"* (gravesites) because they are likely to be possessed. Cowpea leaves *Vigna unguiculata*, are among the leafy vegetables derided by the Legio Maria sect because of the belief that it resembles the vine that the dishonoured Adam and Eve used to cover themselves with when exiting paradise and also because the creeping stem of this vegetable is specifically used for tying the umbilical cord of a newborn child. However, proverbs such as, *"atipa kaitedo seyo kuon dala mar jolejo donjo e tek"* meaning "atipa" (*Asystasia schimperi*) is so delicious with cornmeal is a miserable fix, have been developed to defy the Legio Maria beliefs about certain sources of leafy vegetables. Regardless of the hint of obscenity constructed by the Legio Maria adherents, cowpea leaves remain popular among other members of the Luo community.

Conclusion

Cultural factors forcefully determine semiotic workings that underlie food consumption and are more imposing, largely determining what is palatable and what is not. The consumption of indigenous leafy plants among the Luo of Nyanza has social, mental, economic, gender, and moral considerations. The ILVs define ceremonies in special ways, they appear to bring distinctions in the social structure, and they promote social order and enhance societal synergy. By virtue of their significance, ILVs enhance human capabilities and widen human nutrition, cultural rituals, environmental adoption and socializing choices. The barriers to eating ILVs include taste, social cues, and religious and cultural symbolism of certain foods. In general, the Luo have a body of wisdom that sustains the consumption of ILVs despite the increasing tendency to like exotic foods.

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Opportunities for increased production, utilization and income generation from African leafy vegetables in Zambia

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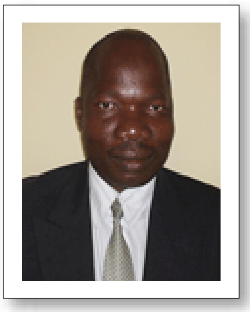

Dickson Nguni

Abstract

To promote the production and marketing of African leafy vegetables (ALVs) and help realize their potential as sources of food and income, a case study was undertaken under the Bioversity International (formerly IPGRI) programme on ALVs. The study was aimed at determining the priority ALVs and assessing their status in terms of genetic diversity, production, processing and marketing through a household survey. Three communities of Hoffmeyer, Subcentre and Chikumbi in Nyimba, Siavonga and Chibombo districts respectively were covered. Information was gathered from 280 households across the communities through participatory rural appraisal using guided household interviews and focus group discussions. Amaranthus spp. Wild spinach (English) 'bboonko' (Tonga), 'libondwe' (Lenje), 'bondwe' (Nyanja); Cleome gynandra (Cat's whiskers), Spiderplant (English), 'shungwa'/ 'luyuni-yuni' (Tonga), 'lubanga' (Lenje), 'suntha' (Nyanja); Abelmoschus esculentus, Okra (English), 'mudelele'/ 'mutezi' (Tonga), 'delele'/ 'mulembwe' (Lenje), 'delele' (Nyanja); Brassica carinata, Ethiopian mustard (English) 'tanta a chulu'/ 'chishu chituba' (Tonga), 'mupilu'/ 'nchembele' (Lenje), 'mupilu' (Nyanja) and Cucurbita spp., Pumpkin (English) 'bboobbo', 'lutanga', 'muchile' (Tonga), 'buchisa bwa nyungu' (Lenje), 'chiwawa', 'mthopo' (Njanja) were identified as priority ALVs.

It was found that within species, variability based on morphological markers of the target ALVs was generally low except for *Abelmoschus esculentus* and *Cucurbita* spp. which had more than three known varieties. Although 63% of households cultivated both ALVs and exotic vegetables, 33% of the households cultivated ALVs while only 4% exclusively grew exotic vegetables. Farm-saved seed for all ALVs except *Abelmoschus esculentus* was used by 81% of households across communities while 10% obtained their seed from neighbours/ relatives within their communities. Direct sowing was the commonest planting method while the application of organic manure to the crop was prominent in Subcentre followed by Chikumbi. Application of mineral fertilizers to ALVs was an uncommon practice except in *Abelmoschus esculentus*. It was revealed that the most preserved ALVs were *Abelmoschus esculentus* and *Cucurbita* spp. Open markets and supermarkets in Lusaka sold ALVs such as *Abelmoschus esculentus*, *Amaranthus* spp. and *Cucurbita* spp. The main sources of these vegetables in Lusaka were local farmers in the peri-urban areas of the town. A total of 33 different recipes and 11 preservation methods for ALVs were documented across communities while seven recipes were documented from commercial restaurants. The ALVs play an increasing role in the diets and as source of income for many households. Efforts required for stimulating production include improvements in access to improved varieties and availability of urban markets.

Key words: Amaranths, *Cleome*, Okra, Cucurbits

Introduction

African Leafy Vegetables (ALVs) are traditionally known plants whose leaves (including immature green pods and flowers) are socially accepted, used and consumed [1]. In Zambia, ALVs occur as cultivated and semi-cultivated crops or weedy and wild plants, with ecological, social and cultural values playing a significant role in the day to day food and nutritional requirements of local people mainly in rural areas, but more increasingly also in urban areas. It is generally accepted that there are cultural differences between rural and urban communities in lifestyles including food habits. In the urban setting the status of ALVs is affected by the changing socio-cultural values and attitudes.

The ALVs in Zambia include major local traditional vegetables such as *Amaranthus* spp., *Cleome gynandra*, *Abelmoschus esculentus*, *Brassica carinata* and *Cucurbita maxima*. There are various other vegetable species occurring locally which are utilized to varying degrees. Most of these species occur either as semi-cultivated or tolerated weeds. The tolerated weeds are those plant species that are frequently and extensively encountered around human dwellings and in farmland as a result of large scale protection because they have been left as volunteer seedlings during cultivation of other crops [2].

The term "local vegetables" can also include leaves of some crop species cultivated widely in Zambia and elsewhere for their pods, roots, or tubers. Leaves from beans and cowpeas are important vegetables [3]. Vegetables are a basic component of the Zambian diet that accompanies the starch staple, 'nshima', which is a thick porridge made from either maize or other cereal meal. As indicated in the survey findings [3], in most households vegetables are served at least once a day as the main or only relish.

Processing and preparation of ALVs is a critical factor in the promotion of their production, consumption and conservation. Although different communities in Zambia have their own traditional methods for processing and preparation of these vegetables, there has been limited documentation of such information. Changes in the food cultures that have taken place over the years pose threats to the continued existence of local knowledge pertaining to such food preparation and processing methods. The promotion of exotic vegetables such as cabbage or spinach has masked the value of local food cultures which over years threatens the continued existence of local knowledge on to preparation and preservation of ALVs.

To promote the production, marketing and utilization of ALVs and help to realize their potential as sources of household food and income, a survey was undertaken under the Bioversity programme on ALVs covering Hoffmeyer, Subcentre and Chikumbi communities with the aim of determining the priority ALVs and assessing their status in terms of genetic diversity, production, processing and marketing.

This article highlights the activities undertaken under the above studies, the major findings in terms of opportunities for promotion of ALVs, and recommendations made on action required in terms of interventions to promote the production, marketing and consumption of ALVs in Zambia.

Methodology

Two studies were undertaken: the household survey and the documentation of processing and preparation of ALVs were conducted in Hoffmeyer, Subcentre and Chikumbi communities of Nyimba, Siavonga and Chibombo districts respectively (Figure 1). Each of the selected communities was equivalent to an Agricultural Camp, which is an official designated unit for the purposes of delivery of agriculture extension services.

Hoffmeyer is located in Eastern Province about 380 km from Lusaka lying in Agro-Ecological Zone (AEZ) II with mean annual rainfall of about 700 mm. The Subcentre is located in Southern Province about 130 km from Lusaka lying in Gwembe Valley within the Agro Ecological Zone I, characterized by a semi-arid and dry sub-humid climate with mean annual rainfall of 650 mm, while Chikumbi is located in Central Province about 20 km north of Lusaka, lying in Agro-Ecological Zone II, which is characterized by mean annual rainfall of between 800 and 1000 mm.

The planning and implementation of the household survey was carried out by a multidisciplinary team involving personnel from the National Plant Genetic Resources Centre, Vegetable Research Team, Food Technology Unit of the National Institute for Scientific and Industrial Research (NISIR), agricultural extension and a local NGO involved in community resource conservation and use. Local community leaders were co-opted into the core team in the field and were instrumental in facilitating access to the communities and gave interpretation where necessary. Data and information were collected using participatory rural appraisal and more specifically a semi-structured questionnaire was administered targeting heads of households. Further information was collected through focus or guided group discussions (Figure 2).

The questionnaire was designed to capture data and information on demographic, household resources, genetic diversity of ALVs, cultivation practices, seed supply systems and storage, post harvest handling and preparation. A total of 280 households across communities were sampled. Of the total number of households sampled, 89 were from Chikumbi, 95 from Subcentre and 96 from Hoffmeyer. Analysis of quantitative data was done by calculating frequencies and percentages of various responses and the summary information presented in form of tables and charts.

The documentation of the processing and preparation methods was conducted by a team of technical staff from the Food Technology Research Unit (FTRU) of NISIR, National Plant Genetic Resources Centre of Zambia Agriculture Research Institute and Department of Field Services of MACO. A guided participatory approach, focus group discussions (FGD) using a checklist, was used to obtain information. In addition to FDG, supervised cooking demonstrations using

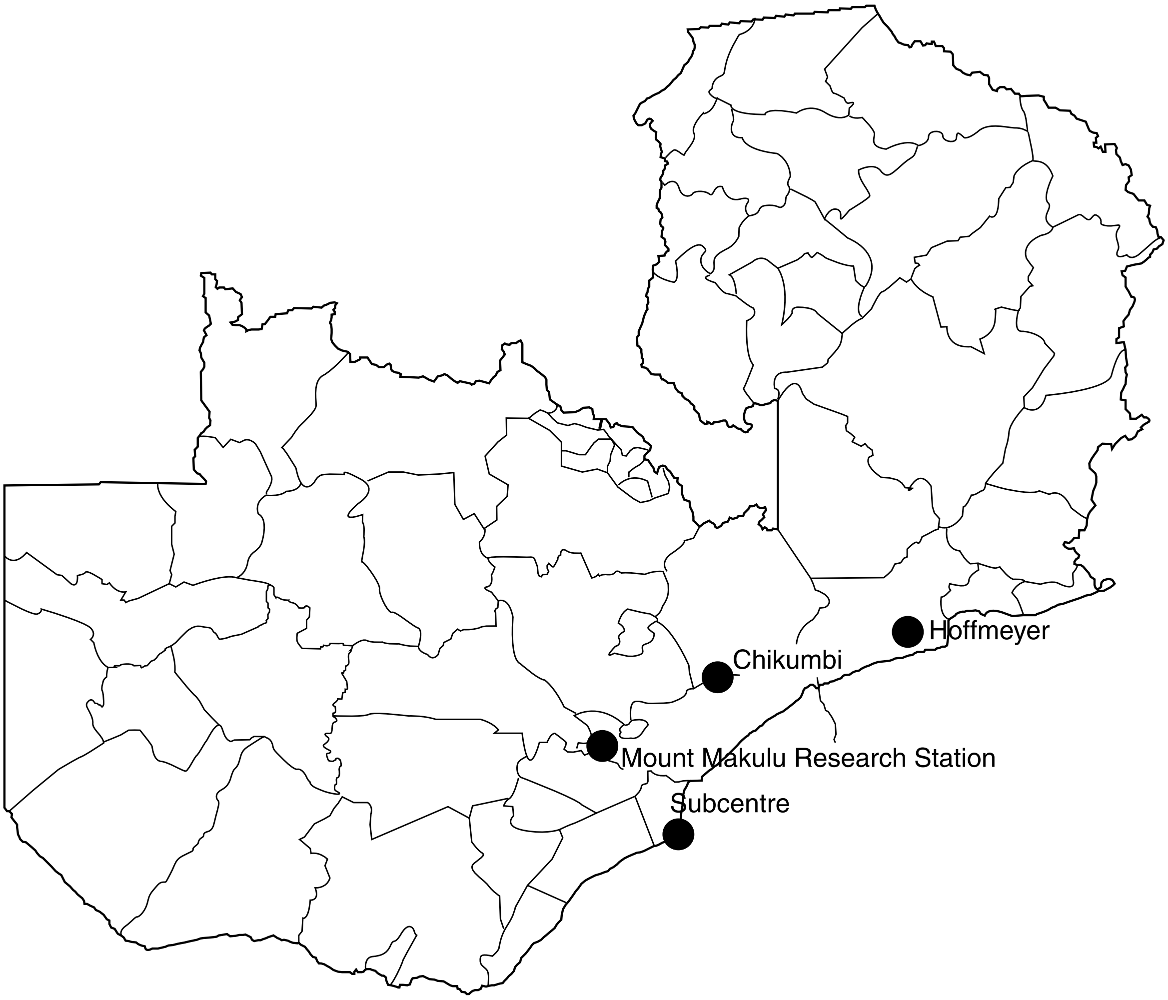

Figure 1: Location of the sites for the household survey

Figure 2: Information gathering through focus group discussion in Hoffmeyer

traditional recipes were conducted by local women in each of the communities to facilitate the collection of detailed data. Further information on preparation and processing of fresh and preserved ALVs was also obtained from one of the hotel restaurants in Lusaka.

Findings

Cultivation and variability of African leafy vegetables

From the household survey it was found that most households in the target communities cultivated both exotics and ALVs. Across the communities, about 33% of the households cultivated only ALVs while 4% only cultivated exotic vegetables compared to 63% who grew both. In general the cultivation of ALVs is more common in the surveyed communities compared to exotic vegetables.

Comparison among target communities showed that Subcentre had the highest number of households cultivating only ALVs (42%), followed by Chikumbi (27%). In Hoffmeyer, 12% of households cultivated exotic vegetables only compared to Subcentre and Chikumbi with 1 and 2% respectively (Figure 3).

About 57% of the households across the target communities considered some ALVs as semi-cultivated while 42.5% considered them as cultivated crops. A small percentage of households (1.8%) solely depended on gathering them as weedy and semi-wild species. The ALVs considered as semi-cultivated, weedy and wild are in most cases *Amaranthus* spp. *and Cleome gynandra*.

In general, the area planted with vegetables is very small, with about 48% of the households cultivating less than 0.001 hectares. In general more land was allocated to ALVs than exotic species across the communities.

The genetic diversity of ALVs as indicated by the number of known varieties was generally low. Although a few households indicated knowing up to five different varieties for some of the priority species, more than 90% of the households knew only two varieties. *Abelmoschus esculentus*, followed by *Cucurbita* spp. seems to have more genetic diversity while *Cleome gynandra* showed the least diversity with only three varieties known in all the communities.

Seed supply systems and on-farm seed maintenance of ALVs

The survey revealed that about 81% of households across the communities use own-saved seed to grow ALVs while about 10% obtain them free of charge from neighbours and relatives. Only a small proportion of households (1%) obtained seed from outside their own communities. This is an indication of limited trade involving seeds of ALVs. In the case of *Abelmoschus esculentus*, it was found that there was a higher incidence of seed being obtained from outside the community compared to other species. This is more pronounced in the Subcentre community.

Results further indicate a higher incidence of seed purchase from within communities for *Brassica carinata* (12%), while being negligible for other species. The practice seems to be common in Subcentre and Hoffmeyer.

Figure 4 gives a picture of how seed of priority ALVs is sourced in the three different target communities. In general there was more seed exchange among neighbours or relatives in Chikumbi followed by Hoffmeyer. Free seed exchange within the community was least common in Subcentre, which had the highest incidence of households purchasing seed from within the community.

The majority of households (42%) reported sourcing improved seed of ALVs from own farm-saved seed, while 30% obtained seed through purchasing from outside their local community. The practice of obtaining improved seed of ALVs from own farm-saved seed was commonest in Subcentre (60%) followed by Hoffmeyer (54%) with Chikumbi being the least (12%). On the other hand, Chikumbi had the highest proportion of households sourcing seed within the local community through purchasing (36%). Both Subcentre and Hoffmeyer had low incidences of seed purchase.

The survey also revealed that generally seed of all ALVs was being stored in sealed tins after harvesting and processing and kept in homesteads. In a few cases (3%) seeds of *Cleome gynandra* and *Abelmoschus esculentus* were stored by hanging over the fire place. The African calabash was also used in a few cases especially in the storage of seeds of *Cucurbita* spp. (6%). No chemical treatment was reported. The use of ash treatment was reported in the storage of seeds of *Abelmoschus esculentus* by some households (12%).

In terms of storage period it was found that seed was generally being stored for a period of less than one year from harvest to the next planting season. Some households, however, reported storing seeds of *Abelmoschus esculentus* and *Cucurbita* spp. for over one and two years.

Local cultivation practices and cropping systems used

Information gathered from the survey indicates that the five priority ALVs have been under cultivation in the target communities for more than 20 years.

The commonest planting method for *Amaranthus* spp. and *Cleome gynandra* was found to be direct seeding by

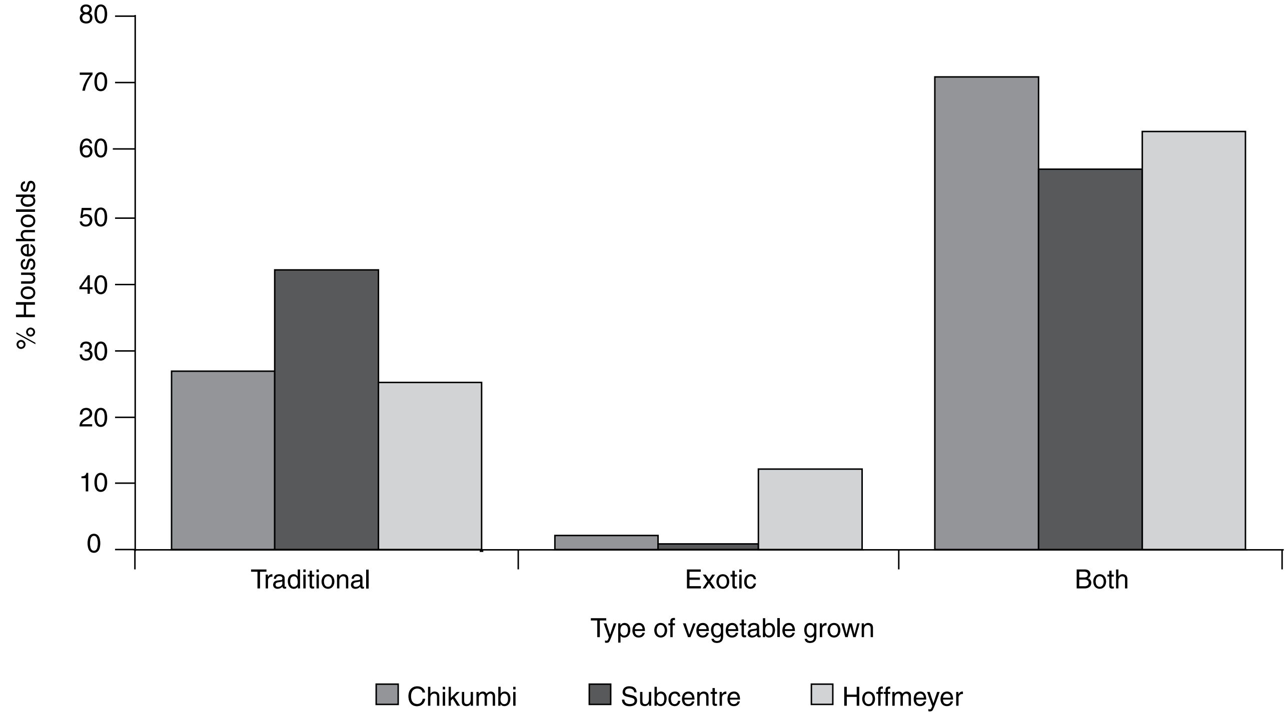

Figure 3: Type of vegetables grown in the three target communities

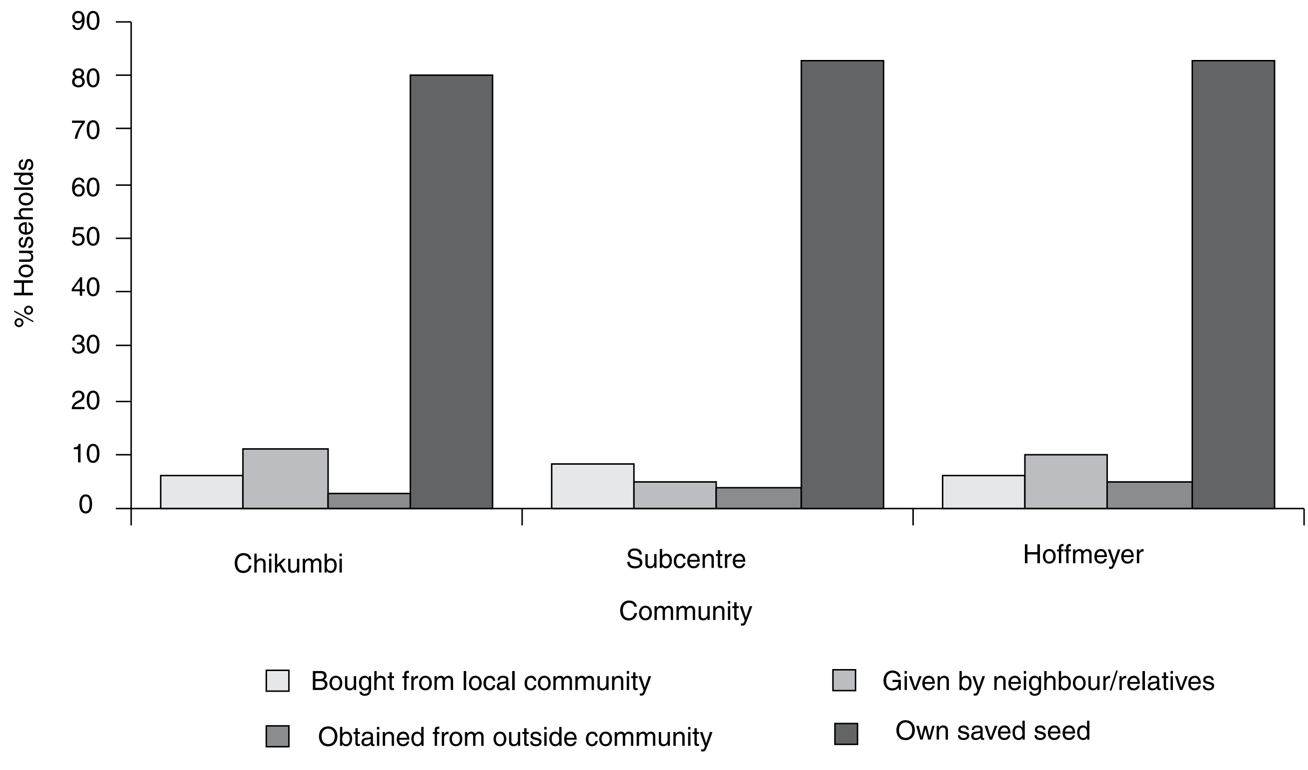

Figure 4: Source of seed for ALVs in the three target communities

broadcasting. This is more prevalent in *Cleome gynandra* (76%). Direct seeding in rows or lines was found to be the commonest planting method in *Abelmoschus esculentus*, *Cucurbita* spp. and *Brassica carinata*. *Cucurbita* spp. was also found to be planted in hills either in rows or lines or at random.

Transplanting followed by planting in rows or lines was found to be commonest in *Brassica carinata*. Transplanting was however, found to be a rare practice among the households across the communities.

Most households prefer to plant or grow these priority ALVs during the warm and wet season, which is from late November to early April. In a few cases *Amaranthus* spp. was planted in the hot dry season under irrigation. In Subcentre and Chikumbi, *Brassica carinata* was also planted in the hot dry and cool dry seasons under irrigation. Cucurbits were also reported to be grown in the hot dry season in all the communities.

A number of cropping systems, including inter-row, mixed and sole cropping are used in the cultivation of ALVs. The commonest cropping systems were found to be mixed and sole cropping. Sole cropping was more prevalent in Abelmoschus esculentus followed by Brassica carinata.

There is more inter-row cropping practised in *Cucurbita* spp. cultivation than any other ALVs. Inter-row cropping was being practised by some households for *Abelmoschus esculentus, Cucurbita* spp. and *Brassica carinata*. This practice was, however, found to be commonest in *Abelmoschus esculentus* followed by *Cucurbita* spp. (Figure 5).

Harvesting, processing and preservation methods

Most of the households indicated that they only harvested leaves of *Amaranthus* spp. (84%) and *Brassica carinata* (88%) for consumption. Only in a few cases were leaves with tender stems harvested for *Amaranthus* spp. (13%) and *Brassica carinata* (7%). It was also revealed that mainly tender leaves of *Brassica carinata* were harvested, as older leaves tended to be tough and bitter, making them unpalatable.

In the case of *Cleome gynandra*, leaves were the most harvested part of the plant accounting for 64% of the households, followed by leaves and stems (21%) and a small proportion of harvested leaves and flowers (6%).

For *Abelmoschus esculentus* the commonest harvested parts of the plant across communities were leaves and flowers (41%). This practice was more prevalent in Chikumbi (51%) and Hoffmeyer (44%). In Subcentre, 22% of the households harvested both fruits and leaves. Across the communities only 11 % of the households harvested leaves only. Harvesting of fruits only was common in Chikumbi.

The most harvested parts of the plant for *Cucurbita* spp. were leaves and flowers (52%), followed by leaves only (33%). In a few cases, stems together with leaves and flowers are harvested. Most of the harvested flowers are males as female flowers are deliberately left to bear fruits.

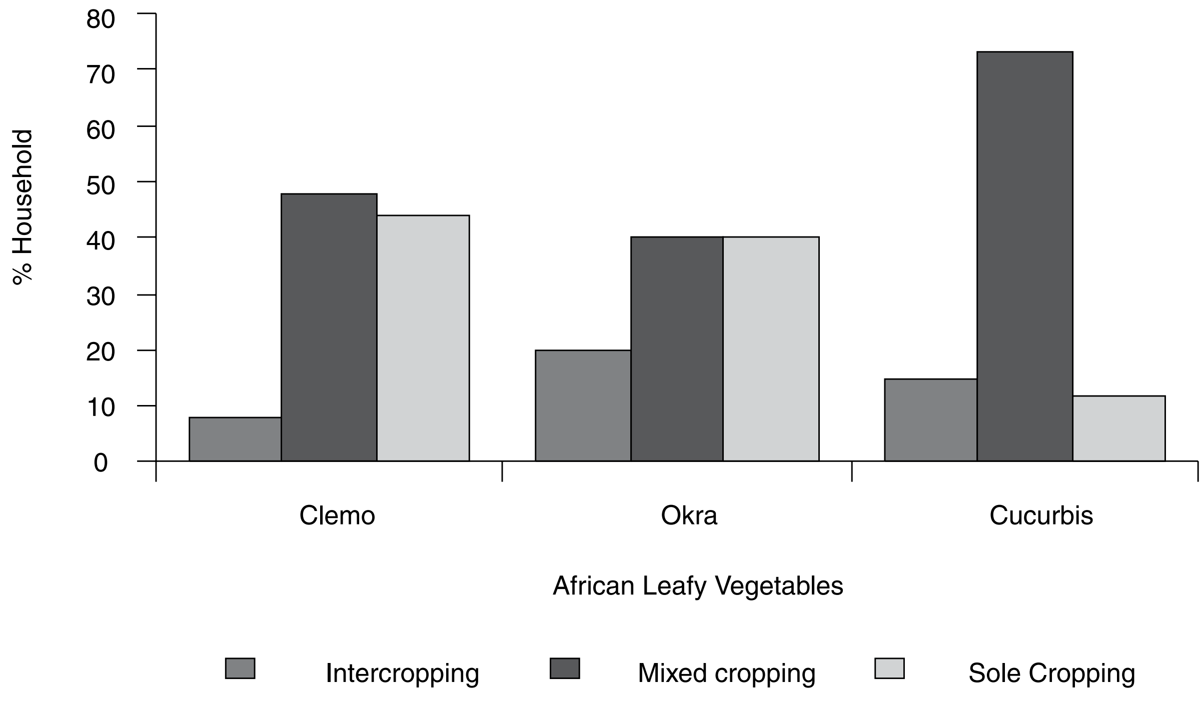

Figure 5: Comparison of cropping systems used for some ALVs species.

In terms of responsibility for harvesting of the vegetables, it was largely women (over 60%) who were involved followed by children and mainly girls (about 30%) except for *Abelmoschus esculentus* and *Cucurbita* spp. where children accounted only for 24% and 23% respectively.

In over 50% of the cases, households indicated that they chopped the vegetables before drying. This was however less prevalent in *Amaranthus* spp. and *Cleome gynandra* where 40% and 16% respectively dried the whole leaf. Chopping was found to be more prevalent in *Cleome gynandra* (80%), *Abelmoschus esculentus* (89%) and *Cucurbita* spp. (74%) In cucurbits, some households reported removal of the outer fibrous material from the leaves before chopping, either for direct cooking or drying.

Majority of households (69% and 95%) indicated drying *Amaranthus* spp. (69%) and *Abelmoschus esculentus* (95%) without blanching. *Abelmoschus esculentus* is generally not blanched owing to its mucilaginous nature. In the case of *Cleome gynandra, Brassica carinata* and *Cucurbita* spp., about 60% indicated that they blanched the vegetables before sun drying. Blanching of leafy vegetables improves colour and carotene retention due to inactivation of enzymes but causes losses of ascorbic acid (Vitamin C).

Reed mats or sacks were the common drying surfaces. In 46% of the cases, drying surfaces are placed on raised platforms while the rest spread them on the ground. Putting drying surfaces on platforms is done in order to protect vegetables from domestic animals and dust. The vegetables may, however, still be prone to insect infestation. A small proportion of households (5%), mainly from the Subcentre community, dried vegetables on rooftops. Naturally occurring flat stone surfaces are taken advantage of and used as drying surfaces where these are found. The drying process is said to be faster on the stone than the mat or sack.

Over 50% of the households reported that the preserved vegetables lasted for more than four months while about 30% indicated that vegetables lasted between two and four months. It is therefore clear that the latter group runs out of preserved vegetables before the next rain season as the dry period lasts for about six months. The preserved vegetables are used for both own consumption and sale. About 50% of the households preserved vegetables for both selling and own consumption while 40% used the preserved vegetables for consumption only. Few households, less than 5%, preserved vegetables solely for sale.

The households indicated that the quantity of preserved vegetables varied from year to year and depended on yields or amounts harvested.

Preparation and consumption of ALVs

For both fresh and dried vegetables the survey results (Figure 6) showed that over 50% of the households had knowledge of two to four preparation methods of all vegetable types across the communities visited except for dried *Abelmoschus esculentus* where the majority (56%) indicated that they used only one method of cooking. The common method of cooking was boiling (over 60%) and most of the households (60%) took less than 30 minutes to cook these vegetables except for *Cleome gynandra* where 44% and 36% took between 30 and 60 minutes and more than 60 minutes respectively. Households were also asked to indicate the ingredients or recipes they use in cooking these vegetables. Water, salt, soda (sodium bicarbonate) and

Figure 6: Documentation of the recipes for the African leafy vegetables

groundnuts were the main ingredients used. A few households (25%) indicated using cooking oil. Water and soda were the only ingredients used in cooking *Abelmoschus esculentus* by most households (65%).

Majority of households (over 70%) consumed ALVs as relish accompanied by 'nshima', a thick porridge, made mainly from the staple food crop, maize. In all the cases, all household family members consumed vegetables. In some cases however, it was revealed that men might decline to eat *Abelmoschus esculentus*.

Most households (60%) indicated appreciation and knowledge of the nutritive value of fresh vegetables while fewer (50%) said the same for dried vegetables. This may suggest that households were aware of nutrient losses in preserved vegetables arising from the drying process. Households from Hoffmeyer community and to some extent those from Chikumbi area seemed more knowledgeable than those from Subcentre.

Marketing of ALVs in supermarkets

A survey of formal marketing of ALVs was undertaken in Lusaka, targeting major supermarkets such as Melisa, Shoprite, Embassy and Woodlands Berries. The survey aimed to collect information pertaining to types and forms of ALVs marketed, packaging, quality assurance, seasonality of supply, and consumer preference.

The findings of the market survey indicated that most of the supermarkets source their supplies of these vegetables from local farmers in the peri-urban areas of Lusaka.

The supermarkets ensure that vegetables ordered are of good quality and are kept in hygienic conditions. In most cases, the vegetables are sold off within two days of getting the supply, otherwise the vegetables are discarded. Vegetables are packaged in half kg bundles and sold between 500 and 800 Zambian Kwacha, equivalent to 25 -30 cents (US Dollar).

On availability, it was found that supermarkets get ALV supplies throughout the year. The vegetables were, however, said to be more abundant during the rainy season. From the experiences of the supermarkets, it appears the most preferred ALVs by consumers are *Abelmoschus esculentus*, *Amaranthus* spp., and *Cucurbita* spp.

Discussion

Genetic diversity of priority African leafy vegetables

In general the cultivation of ALVs is more common in the surveyed communities compared to exotic vegetables. It was surprising that Hoffmeyer which is more of a rural setting had the lowest percent of households cultivating ALVs. This may, however, be explained by the presence of a long standing tradition of home gardens locally known as 'dimbas' in the area as in most parts of Eastern Province of Zambia.

It appears that infraspecific variation or diversity is lower in those ALV species that are sometimes handled as semi-cultivated and weedy or wild, probably because they have not gone through much human selection. The number of commonly cultivated varieties was even lower compared to the possible numbers known to exist. There were, for instance, no more than two commonly cultivated varieties for all the priority ALVs in all the communities.

Seed supply system

The survey results showed that a small proportion of households obtained the seeds of various ALVs from outside their communities. A higher incidence of seed purchase from within communities for *Brassica carinata* is probably due to the fact that this vegetable species is readily available on the market, competing favourably with some of the commonly grown exotic leafy vegetables such as *Brassica napus*.

The prevalence in local exchange of improved seed of ALVs in Chikumbi and Hoffmeyer, either through free gifts from neighbours or relatives, or through purchases may indicate a higher level of production of these vegetables for commercial purposes than in Subcentre (Figure 4). This may also indicate potential for local seed production and marketing within the community. The low levels of seed exchange among households within the community for Subcentre may be as a result of the subsistence nature of production of the ALVs in that area.

Harvestable and edible parts

Tender leaves may be preferred for harvesting in *Brassica carinata,* probably because older leaves tended to be tough and bitter and therefore less palatable.

It is not common to harvest leaves together with flowers, as most people would want to retain flowers for seed bearing. It would appear that in Hoffmeyer and Subcentre, households rarely harvest fruits of okra for own consumption only. However, across the communities, fruits are harvested largely for sale, either fresh or dried.

Most of the harvested flowers in pumpkins are males, as female flowers are deliberately left to bear fruits. This, however, does not seem to pose problems, as male flowers tend to be predominant in the pumpkin varieties used for vegetables.

When harvesting vegetables, precaution was taken to avoid over harvesting in order to allow for easy regeneration and continued growth of the plants.

The number of children involved in the harvesting of *Abelmoschus esculentus* and *Cucurbita* spp. is relatively lower probably because these vegetable species need great care to enable the plants bear fruits. The involvement of men in the harvesting of vegetables is minimal and this may only happen when the harvested vegetables are meant for sale.

Processing and preservation methods

The survey results showed that preservation of some ALVs for consumption and sale during lean periods was an important activity across communities. As documented [4], the process leading to the preservation of ALVs follows a series of steps including harvesting, cleaning, cutting, blanching, sun drying and storage. It was common practice across the communities to preserve these vegetables when there was a surplus. In most cases *Cleome gynandra* and *Amaranthus* spp. were not preserved in Hoffmeyer, as most households preferred consuming them as fresh vegetables. Majority of households in Chikumbi (65%) and Subcentre (95%) indicated that they dried *Amaranthus* spp. and *Abelmoschus esculentus* without blanching. However, in preserving *Brassica carinata*, *Cleome gynandra*, *Cucubita* spp. and other local vegetables, blanching is followed by sun drying across the communities as is the case when preserving any other vegetables [5], [6]. Blanching of leafy vegetables improves colour and carotene retention due to inactivation of enzymes but causes losses of ascorbic acid (vitamin C).

A variety of drying surfaces were used for drying these vegetables including man- made items such as reed mats and sacks, which are either placed directly on the ground or on raised platforms locally known as 'Thala'. Naturally-occurring flat stone surfaces are taken advantage of and used as drying surfaces where these are found. The drying process is said to be faster on the stone than the mat or sack. Across the communities, preserved ALVs are stored in polypthylene plastic bags. High density polyethylene (HDPE) plastic bags, tightly sealed, could also be used to store dried vegetables. HDPE are a relatively good barrier against air, moisture and odours [7]. If allowed into the dried vegetables, moisture, air, dust and odours could speed up deterioration of the vegetables and the expected shelf life may not be attained. In addition, HDPE is a strong film that gives a strong heat seal and withstands puncturing and tearing [7]. This property could be very useful as preserved vegetables often get attacked by rats and insects during storage in these communities. Traditionally, some households store their dried vegetables in 'Chikwati', a baggage made from broad leaves of certain tree species, and in turn hung in the roof inside the house or put in the crib.

Preparation methods

Processing and preparation of ALVs is a critical factor in the promotion of the production, consumption and conservation of these vegetables.

The majority of households indicated that preparing these vegetables either in the fresh or dried form was easy except for *Cleome gynandra* which was difficult mainly on account of the need to reduce the bitter taste through repeated decanting of water during boiling, thus taking long to cook.

Using soda introduces a characteristic taste, which most people prefer. Salt is added to relish for taste, while groundnuts and cooking oil are important ingredients in vegetable preparation as they increase the nutrient density and enhance palatability. In addition, oil aids absorption of fat-soluble vitamins such as vitamin A, which can be obtained from vegetables from their precursor beta-carotene. The type of ingredients used to some extent also determines the dietary quality of these people since other nutrients needed by the body are provided by vegetable relishes.

Although different communities in Zambia have their own traditional methods for processing and preparation of these vegetables, there has been limited documentation of such information. As observed [8], changes in the food cultures that have taken place over the years pose threats to the continued existence of local knowledge on traditions of food preparation and processing.

Consumption of the ALVs

Although ALVs are consumed as relish accompanied by 'nshima', a thick porridge made mainly from the staple food crop maize, this could be consumed unaccompanied during periods of the year when there is a shortage of maize meal.

Although the importance of leafy vegetables in human nutrition lies in provision of vitamins, especially vitamin C, they contain other nutrients such as carbohydrates, minerals and to a small extent, protein. Households from Hoffmeyer community and to some extent those from Chikumbi area seemed more knowledgeable than those from Subcentre. The protection of the body against diseases and infections, increase of blood and provision of energy to the body were mentioned as some benefits that can be derived from eating vegetables.

Marketing of ALVs in supermarkets

The growing demand for the ALVs by people, especially in the peri-urban and urban areas and availability of niche markets in major cities and towns provide an opportunity for the promotion of production of these vegetables.

Conclusion and recommendations

The household survey revealed that the majority of households in the selected target communities depend on agriculture for their livelihoods and that the selected priority ALVs are widely utilized, though to varying levels.

Leafy vegetables in general play an increasingly important role as source of income in the target communities, especially those near major towns and cities. Improved access to urban markets by the rural communities has the potential of stimulating production of ALVs. Promotion of ALV production in peri-urban areas with easy access to urban markets has therefore a higher chance of producing positive results in Zambia.

In general, ALVs in the target communities are grown and more available during the rainy season while exotic commercial vegetable species such as rape and cabbage which are usually produced for sale are grown during the dry season. Interventions aimed at promoting the production of ALVs during the dry season alongside some of the traditional commercially-grown vegetables are recommended.

The survey has also revealed that some priority ALVs such as *Amaranthus* spp. and *Cleome gynandra* are to a large extent treated as semi-cultivated and weedy plants in Zambia. This has, to some extent contributed to the low production levels as well as the relatively low genetic variability within species. Crop improvement in these ALV species would therefore require an infusion of germplasm from sources outside the country.

It is clear from this study that farmers in the target communities have no access to improved varieties of the priority ALVs and that seed for these is obtained mainly from locally-saved seed within communities. The study has further pointed to an emerging local seed trade in which *Abelmoschus esculentus* and *Brassica carinata* are the main crops involved.

It is evident that there is very limited use of inorganic fertilizer but more use of organic sources in the production of ALVs. This provides a good opportunity for the promotion of organic farming that could be a platform for a market niche for most rural and peri-urban households.

The study has highlighted the role women play in agriculture in general and in the production of food crops in particular. The cultivation and in particular the harvesting of ALVs is mainly undertaken by women in the target communities. Men are beginning to get involved where these are grown for sale.

All the priority ALVs included in this study are processed for preservation, though to varying degrees, through sun drying either directly or after blanching. There is need to assess the nutritive status of the preserved vegetables with a view to improving the processes and minimizing nutrient loss or degradation.

In rural communities, preserved vegetables are normally meant for own consumption but some of it is now finding its way to markets for sale. The amounts of vegetables preserved do not normally last the entire dry season. The introduction of solar driers would hasten the drying process and therefore increase the amount of vegetables that are preserved.

There seems to be limited variation in the methods of preparation or recipes for most of the priority ALVs with the main ingredients being water, salt, soda (Sodium bicarbonate) and groundnuts. Recipe emphasis should be placed on use of ingredients such as cooking oil and groundnuts to increase the nutrient density of the vegetables.

The study showed that there is some modest level of appreciation on the nutritive value of ALVs among households in the target communities. There is need to intensify nutrition education on the benefit of fresh and dried vegetables.

Some local restaurants, including hotels, are taking up the preparation of some popular ALVs and serving them to their customers. This presents an opportunity that could be exploited in the promotion of these vegetables, in both production and consumption.

Preserved ALVs are traditionally, almost invariably, dried under direct sunlight. There is need to improve the drying methods taking into account hygienic considerations as well as the need to minimize nutrient degradation and loss. In this regard the use of solar dryers (Tray dryers) could be investigated.

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The importance of traditional leafy vegetables in South Africa

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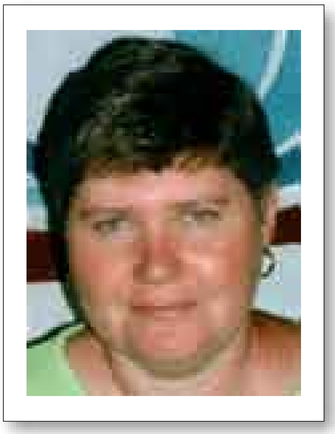

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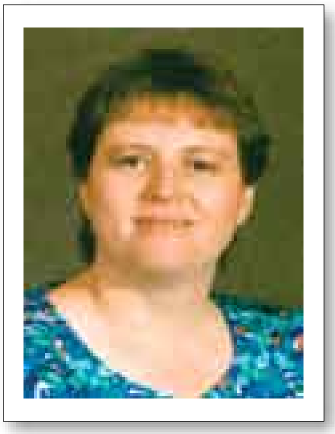

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Willem Jansen van Rensburg

Abstract

The use of traditional leafy vegetables in communities has been noted in several studies. These studies highlighted concerns about the loss of knowledge. The aim of this work was to enhance the role of African leafy vegetables (ALVs) in the nutrition of vulnerable groups in South Africa through improved preparation, promotion of consumption, processing, landrace improvement programme, and management of their genetic diversity. Researchers needed to establish the extent of the use, conservation status and awareness of these plants, to ensure effective research decisions. This report gives the results of these studies. Localities that differed in ethnicity and climate were targeted. The data collection phase used a questionnaire survey, and rapid and participatory methodologies to collect information from the women. Traditional leafy vegetables were found to be a very important source of food in summer, but especially in winter. Several drying methods are used to ensure the availability of these vegetables during the winter. Pumpkins and cowpeas were the only crops grown, with some of the others occasionally broadcast. The most popular crops for consumption with all the age groups were amaranth and pumpkins, with jute mallow (*Chorcorus* sp.) and spider plant (*Cleome gynandra*) more popular in the northern areas of South Africa. Where cowpeas were available, they were seen as the most valuable dried leaf product, as they were used as a safety crop due to their long shelf life. Ethnicity and gender had an effect on the use and preferences for the different crops, with men preferring the more bitter taste, and women and children preferring the milder taste. Different ethnic groups showed differences in bitterness of the vegetables and composition of the leaf mixes. In many areas, seed systems were poor as the traditional role of keeper of the seed had been lost. Constant downgrading of traditional vegetables and associated knowledge by research and extension had led to the labels of ‘backward knowledge’ and ‘poverty foods’. This led to a shift in food use and willingness of the youth to learn about and eat these crops. Awareness creation contributed to a change in the perceptions amongst the youth and adults, leading to increased demand for information and seed. It was determined that traditional leafy vegetables played an important role in food security in rural South Africa, but the status of the crops, as well as their conservation, need to be addressed to ensure sustainable use.

Key words: Leafy vegetables, food security, conservation

Introduction

Traditionally, agricultural research in South Africa was focused on large-scale commercial farmers and their mono-cropping systems. In the last decade, however, the focus has shifted towards the subsistence and semi-commercial farmers, but the work was still mainly based on the common commercial crops. Based on interactions between agro-ecological and socio-economic factors, the Brundtland Commission identified three types of agriculture: industrial agriculture, green revolution agriculture and resource-poor agriculture [1]. Most of sub-Saharan agriculture falls within the resource-poor category characterized by marginal soils that are mainly rainfed. Resource-poor agriculture has complex farming systems and is risk prone, thus farmers employ diverse livelihood methods. South African farmers in the resource-poor group are mainly subsistence farmers who use a mixture of traditional and conventional practices.

The importance of indigenous knowledge and traditional crops in the survival strategies of rural people has only recently been recognized by research. The traditional leafy vegetables are still mostly treated as weeds by many research and extension personnel who criticize farmers for not keeping this weed population under control, thus labelling this important food as not worthy of the space it occupies.

Foods harvested from the veld consist of different parts of the plant used. These can include roots, tubers, stems, rhizomes, leaves, flowers, fruits, nuts, gums, berries, cereals and legumes. In South Africa, local people formerly ate a diet of meat, milk, wild cereals and wild plants, but the Pedi proverb "Meat is a visitor, but 'morogo' a daily food" ('morogo' are traditional leafy vegetables) has become a reality for most [2]. The use of traditional leafy vegetables in communities has been noted in several studies, with a countrywide study on foods from the veld being done from 1936 to 1982. This study had highlighted their concerns about the loss of knowledge on these traditional food plants [2]. Since then, studies on traditional vegetables have generally been small and localized. In an effort to enhance the role of ALVs in the nutrition of vulnerable groups in South Africa, research is needed to establish the extent of the use, conservation status and awareness of these plants. The ultimate goal is to promote the use of African vegetables through improved preparation, promotion of consumption, processing, landrace improvement, and management of their genetic diversity by building on the indigenous knowledge and adding scientific technologies where necessary. This paper reflects on the use, preparation, processing, consumption, conservation and cultivation of the African vegetables.

Materials and methods

Choice of villages

The work was done in seven villages in South Africa that differ in ethnicity, geography and climate. Maps showing these different aspects were used to help identify the different villages, with areas where extension was active taking priority to ensure effective translation of the information. Diversity in the villages ensures as wide a range as possible of uses and status of the traditional vegetables, thus being more representative of the diversity found within the country. The villages each represented a geographical area and an ethnic grouping. The villages were:

- Watershed, Ladysmith, KwaZulu-Natal: predominantly Zulu, close to the foothills of the Drakensberg Mountains with semi-arid conditions, summer rainfall, hot summers and bitterly cold winters (snows occasionally). Watershed's closest large town is about 45 minutes by taxi. There is no direct taxi service.
- Bushbuckridge, Limpopo Province: predominantly Shangaan, but five cultural groups are present. High summer rainfall, sub-tropical, mild winters, close to the Kruger National Park. Bushbuckridge is peri-urban, with supermarkets close by.
- Mars and Glenroy, near Polokwane, Limpopo Province: two neighbouring villages with predominantly Pedi people, semi-arid with hot summers, cold winters, low summer rainfall, mainly savannah type landscape. Mars and Glenroy's closest large town is about one hour away, no direct taxi service.
- Qunu, Umtata area, Eastern Cape (old Transkei): higher lying areas with hot summers and mild winters. Mainly summer rainfall. Dominated by the Tembu-Xhosa. Qunu is about 30 minutes from a fresh produce market by taxi.
- Tshonya, Eastern Cape (old Transkei): predominantly Amapondo-Xhosa. Mainly summer rainfall, drier than Dimfi, very hot summers and mild winters. Tshonya is closer to a large town, about 45 minutes by taxi.
- Dimfi, Eastern Cape (old Transkei): predominantly Amapondo-Xhosa. Coastal, sub-tropical climate, year round rain (mainly summer), mild winters, hot and humid summers. Far from a big town. Dimfi is the last village on a dirt road that becomes impassable during rainy periods. It is poorly serviced by taxis and is about 75 minutes from the closest large town.

Data collection and analysis

This paper combines two separate studies. The work done for Bioversity International (former IPGRI) was done in Watershed, Bushbuckridge, Mars and Glenroy and concerned itself with ALVs. Data in all the areas were collected using participatory methods, with the Bioversity study also using a questionnaire survey. A sample size of 5-10% of the population (80 questionnaires per village) was used for the questionnaire survey, applying a random sampling method. Some basic statistics were used with Excel to determine the descriptive variables. The tools from both rapid rural appraisal (RRA) and participatory rural appraisal (PRA) were used with the Bioversity and Agricultural Research Council (ARC) studies. As is appropriate when collecting indigenous knowledge, a number of specific questions were developed beforehand to ensure that information relevant to future indigenous vegetable research was generated and recorded [3]. The type of information needed determined the tools used, which included participatory mapping, direct matrix pair-wise ranking and scoring, seasonal calendars, direct observation, trend diagrams, semi-structured interviews, group interviews, local resource collection, shared presentation and analysis, self correcting field notes and intriguing practices and beliefs.

Results

The results are reported in sub-sections, for better presentation of the information. Any percentages given are based on the Bioversity study in the four villages mentioned above.

The communities

In the Bioversity study areas in rural South Africa, the average household size was between six and seven people per household with every second home having a pensioner and each household having 3-4 children under 18 and 2-3 adults between 18 and 65. An average of 1.46 people contribute to a household's income, of which most were household members working in the city and not included in the household size. Pensions (42.5% of households) and formal labour (32.5% of households) were the two most important sources of income for most families. The average monthly income of R774 (US$112.3 at R6:1US$) means that there is about US$0.57 per person per day. Male-headed households represented 45% of the households interviewed.

Knowledge, status, preferences and plants used

Knowledge of the different groups of plants was available from males and females. In all the villages the leafy vegetables tended to be the domain of the women only. Knowledge of fruit and cereals seemed to be in the male domain, with the children having only rudimentary knowledge of either and of traditional foods. The education of the children was blamed for the lack of knowledge, as small boys have to go to school and do not spend days in the veld looking after livestock and surviving on their knowledge of wild plants. The girls only tend to know the common and abundant traditional vegetables such as Amaranth, Cleome, cucurbits and cultivated vegetables (pumpkins, cowpeas, and so on) as they spend their days at school and have to do homework before dark. Women are the main cooks, and are sometimes supported by the girls in the family. 'Backward knowledge' and 'poverty foods' were labels linked to traditional vegetables and the associated knowledge, thus discouraging youth from learning about them.

The status of the leaves in the different gender and age groups varied with the different cultural groups. The Zulu, Shangaan, Swazi, Tsonga, Pedi and Ndebele groups tended to eat the leafy vegetables as a relish for the stiff porridge, and though not always preferred by men, was eaten by all. The Xhosa groups see leafy vegetables as a 'woman's food', and prefer to eat meat. The Xhosa mix the leaves into the stiff maize porridge and eat it as one dish. No gender differences were noted with the cucurbits, and the wide variety of cucurbits helped to increase the variety in taste. Pumpkins are planted by 98.3% of the households, making this an extremely important crop. Various types of cucurbits are planted, ranging from squashes to pumpkins and watermelons. All cucurbits are highly valued as they provide fruit, leaves and sometimes flowers for the diet. This makes the use of orange and yellow cucurbits very important in the alleviation of vitamin A malnutrition, given consumer preference for them.

The different areas tended to highlight the differences in cultural choice in taste and plant preference. The most popular crops identified as the most important five crops listed by households for home use included amaranth (45.8%) and pumpkins (96.7%), with jute mallow (*Chorcorus* sp.) (44.4%) and spider plant (*Cleome gynandra)* (64.4%) popular in the areas where they grow. Where cowpeas (58.3% listed in top five) are available, they are seen as the most valuable dried leaf product, as they are used as a safety crop due to their long shelf life. Balsam pear (*Momordica balsamina*) was very popular (43.3%) in the northern regions where it grows, with the leaves used when the plant is young and the older leaves used as a spice in the leaf mix. Ethnicity and gender had an effect on the use and preferences of the different crops. Generally men prefer the bitter taste of Blackjack (*Bidens pilosa* L.), though they are used in the mix of leaves to help add taste to the dish. Cucurbits were highly valued in all regions. Amaranth was used in all the areas, with the Zulu using it mainly alone or as part of a mix of leaves. Spider plant is generally preferred to Amaranth in the areas where it grows (the hotter northern parts of South Africa), with Amaranth used as part of a mix of leaves. Lamb's quarters (*Chenopodium album* L.) is commonly used in the Eastern Cape, but is not so important in the northern regions. In each region individual crops were grown that were only used by a specific ethnic group.

Fresh and dried vegetables

Traditional leafy vegetables (TLVs) are a very important source of food in the summer, but especially in the winter. Food is very expensive in winter and the dried traditional vegetables form the basis of nutrition in most rural households, contributing up to about 80% of their total (excluding maize) food use in winter. Women try to add some other source of protein (usually in the form of chicken head and feet) once a week. Households with many members who do not have an income tend to rely more on the traditional vegetables. This is especially true where unemployment is high and in the households where children no longer qualify for the child support grants. Most rural households know the importance of these foods in food security.

Several drying methods are used to ensure the availability of these leafy vegetables during the winter. In some areas of the Eastern Cape the knowledge of how to dry some of the different vegetables seems to have been lost. The older people feel that some of the information may have been lost due to the high incidence of war and unrest (from 1960s to the beginning of 1990s) in the area. This lack of knowledge on drying is causing many problems in food availability in the winter and spring months. Most of the leaves are dried in the sun, with the northern parts generally practising both blanching and non- blanching, while the Xhosas tend to dry without blanching. Shelf life of all the vegetables except Cowpeas

(*Vigna unguiculata* L.) was felt to be not satisfactory.

Access to a market had an influence on the use of traditional vegetables. In the Bioversity study area, 56.9% of total income was reportedly spent on food, with 67.8% of the women being able to decide how much is spent on food. A stronger reliance on TLVs was noted where transport was infrequent or expensive. Because of the social grants systems, family members have to go to town once a month, thus enabling them to buy supplies that keep well (oil, maize flour, sugar, etc.). Tinned foods are very expensive and fresh fruit and vegetables can only be kept for a short time.

This emphasizes the need for home-grown foods when others are not available. The traditional vegetables are commonly looked upon as an additional source of food, due to their ability to grow in these generally marginal areas where low inputs and rain-fed conditions are common. Marketing of products fluctuates and is very limited. The women are the main marketers and this enables them to use the proceeds to pay for household necessities. The importance of this source of income should not be underestimated, as it is used for health care, education, unexpected needs and food.

Cultivation

Cultivation of traditional vegetables is not very comprehensive, with the main reason for cultivation given as household food security. Only 40.8% of farmers growing TLVs do irrigate them, but mostly by hand. Further investigation showed that mainly pumpkins are irrigated, with the other crops growing under dry land conditions. About half of the fertilizers are provided by cattle manure, while mainly composting and inorganic fertilizers contribute the other half.

Pumpkins are grown by 98.3% of the households interviewed, followed by cowpeas (53.3%). Cowpea production information has been lost in many households. In Watershed, KwaZulu-Natal, the active NGO in the area had re-introduced the crop to the community upon their request, after both seeds and production knowledge had been lost. Occasional broadcasting is done for Balsam pear, watermelons, Amaranth, Spider plant and Black jack.

Conservation

Discussions about the conservation status of TLVs elicited many concerns and explanations. The introduction of exotic vegetables ('good foods that you can buy in the shops') has had a negative effect on the use of TLVs in communities. The preferences of people have changed to the exotic vegetables and the use of fat in preparation methods has made it very popular with the young people. Drought and the rainfall pattern (heavy thunderstorms) had great impact on the availability of these plants. Drought led to over-harvesting of the plants, thus depleting seed banks. With the first thunderstorms (common rainfall pattern in most areas) the seeds are washed away due to the loss of topsoil and seed traps that can support growth. The bulk of TLVs used is made up of only a few different species, with many of the less used species becoming scarce or having been lost.

Awareness of nutritional importance and general knowledge

Awareness of importance of TLVs to nutrition is not very high; it is mainly perceived as being nutritious because the generations before them have survived on them. TLVs have been labelled as 'poverty food', with the knowledge associated with it labelled as 'backward knowledge'. These labels have led to a shift in food use and less willingness of the youth to learn about and eat these crops.

Discussion

The small percentage of people contributing to household income causes the household to be very vulnerable to outside influences. The World Health Organisation (WHO) HIV/AIDS statistics show increasingly more people in South Africa are affected by this pandemic [4]. AIDS has an impact on rural life as many people who live in the cities return to their rural areas when they become ill. The loss of a household member's labour as a result of HIV/AIDS-related illness and death or even the loss of labour occasioned by caring for afflicted household members affects the household in a number of ways. The illness often leads to loss of household labour supply as someone needs to care for the ill person, resulting in the spread of the activities between the remaining household members who are already involved in other livelihood activities. In cases where the ill person had sent remittances home, this income would also be lost by the family [5]. The implication is that many households will not be able to carry out all of the existing or increased number of tasks, or at least not without making considerable sacrifices in other livelihoods. The WHO November 2005 figures show that 29% of pregnant women test positive, with the deaths since 1997 having doubled in the 25-44 age group. Since 1997 infection rates have grown with 62% being in the group of people above 15 years. These statistics emphasize the value of crops that can be harvested with minimal inputs in labour and finances.

Ethnic groups tended to prepare their traditional vegetables in only one way, and exposure to other preparation methods has enabled them to increase the variety in their diet. This important step in popularizing the vegetables in the diet will need to be addressed. The young find the preparation of the vegetables 'boring'. By handing out the recipes of different ethnic groups to women, their ability to vary the diet increases, and as these are prepared by people with the same type of resources, it makes the recipes more accessible to them [6].

Drying of leafy vegetables helps to address the food shortages during the winter and spring when fresh food must be bought. Changing from mainly fresh to mostly dried products in the diet has debilitating effects on community members, as diarrhoea is common during the transition phase. Community members can ill afford this weakening of the immune system at a time when infectious diseases (flu, colds, TB) are highly prevalent. Ways of planting some fresh produce during winter by using recycled water should be looked at.

In many areas, seed systems are in a poor state as the role of keeper of the seed has been lost, leading to scarcity and even loss of some crops. The traditional role of keeper of the seeds in the communities has not been passed on and is part of the disintegration of the social systems in many rural areas. Revival of these roles within communities is critical in ensuring the availability of basic genetic diversity for future needs [7]. The loss of genetic diversity needs to be addressed, as genetic diversity supports food security and can provide security against pests, diseases and environmental conditions [8]. Almekinders and De Boef stress that neither traditional nor improved varieties fully meet the farmers' needs [7]. The genetic diversity within communities is an important basis for future agricultural development in the world.

The labels of 'backward knowledge' and 'poverty food' led to the youth not being interested in these traditional crops. Where awareness of the value of these plants has been created, the youth interest also heightened [6], thus improving the status of the traditional plants and knowledge. Heightening the profile of traditional vegetables would help to improve the status of these 'poverty foods/ backward knowledge', thus making them more acceptable to the younger generation. The awareness raised contributed to a change in the perceptions amongst the school children and adults who had participated, leading to increased demand for information and seed. This is an important step that must not be ignored in areas where this kind of labelling has taken place and needs to be seen as a long-term action that should spread throughout South Africa.

Conclusion

Local peoples' indigenous agricultural knowledge plays an important role in achieving food security and conserving biological diversity [9] and can help increase the efficiency of development programmes [10,11]. Development planning has often failed to achieve sustainable development and created dependencies due to erosion of indigenous knowledge (IK) about traditional vegetables and lack of awareness of benefits that the communities get by eating them.

Traditional leafy vegetables play an important role in food security in rural South Africa, and are usually not assessed for their influence on the livelihood strategies of rural people. The high unemployment rate in rural areas and the AIDS pandemic is placing huge demands on labour and food supplies, and there is an increasing need to make use of hardy, well adapted crops that need minimal labour and other inputs. With the dry spells, changing climate and marginal soils experienced by many poor people, traditional vegetables might provide some relief. About half of children between one and nine years of age consume less than 50% of the required vitamin A in South Africa [12]. This can be partly addressed by promoting the cultivation of these crops, as the pumpkins and Amaranth are high in vitamin A.

Promoting traditional vegetables to help diversify the food on the plate would help to create a larger market for these vegetables. To achieve this, the 'poverty food' label needs to be addressed. Placing these vegetables in the supermarkets would help to increase the status of the crops, as they are currently mainly sold in informal markets.

Recommendations

These hardy, adapted plants that tend to grow better than introduced crops in the marginal and dry areas should be further investigated. The following are some research needs that should be addressed: (i) developing appropriate intercropping production techniques for the high yielding traditional crops to help increase food security in winter; (ii) evaluating the crops prepared or dried to help establish the most effective ways of preserving the nutritional content; and (iii) developing a low-input crop rotation system that incorporates traditional and exotic crops in the local farming system.

Owing to its poor status in most communities, knowledge of the crops is being lost at an alarming rate. Documentation and gene-bank actions need to be given a high priority and should be combined with awareness activities in which the different aspects of traditional leafy vegetables are addressed. Awareness creation is a long term aspect that is commonly neglected, but this could have the effect of preserving a dead culture, causing leafy vegetables to become a curiosity crop.

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Diversité et gestion des légumes de cueillette au Togo

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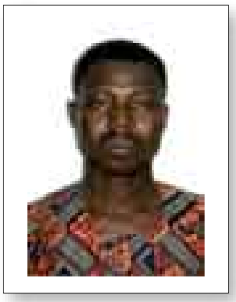
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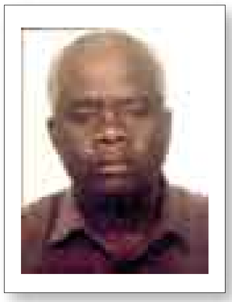
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Résumé

En Afrique subsaharienne et particulièrement au Togo, les légumes de cueillette ont été longtemps négligés par la communauté scientifique et les agents de développement, bien qu'ils soient d'importants compléments alimentaires. La présente étude constitue un premier état des lieux sur l'utilisation des légumes de cueillette au Togo pour une valorisation de ces ressources. Pour ce faire, des enquêtes ethnobotaniques ont été menées chez 20 groupes ethniques dans 50 villages distribués sur toute l'étendue du territoire togolais. Les informations obtenues ont été complétées par des observations directes de terrain et l'ensemble des données obtenues ont été catégorisées suivant les ethnies, les zones agro-écologiques, les lieux et périodes de récolte, etc. Au total, 105 espèces dont un ou plusieurs organes sont utilisés comme légume ont été recensées. Elles ont été rangées dans 82 genres et 45 familles dont les Fabaceae, les Malvaceae, les Moraceae, les Asteraceae sont les plus nombreuses. Certaines espèces (*Adansonia digitata, Fagara zanthoxyloides, Ocimum gratissimum, Talinum triangulare, Vernonia amygdalina* et *Vitex doniana*) sont largement distribuées et utilisées par divers peuples tandis que d'autres sont spécifiques à des régions agro-écologiques données ou à des groupes ethniques donnés. La plus forte richesse d'espèces légumières a été notée au nord du pays chez les Nawdba et les Kabyè, suivis des Lamba, Moba, Tchokossi et Tamberma. Les organes consommés sont les feuilles (67%), les fruits (18%), les fleurs (6%) et les racines (6%). La période de récolte varie suivant les espèces : 33% des légumes recensés sont récoltés en saison sèche, 14% en saison des pluies et 53% en toute saison. La cueillette, la transformation, le conditionnement et la commercialisation sont des activités dévolues aux femmes. Cette étude a montré que divers organes de nombreuses plantes sont utilisés comme légumes de cueillette par les différentes communautés socio-ethniques du Togo. Elle constitue une première étape d'un programme de valorisation effective des ressources végétales.

Mots-clés**:** Togo, légumes, cueillette, ethnobotanique, diversité

Introduction

Dans les pays tropicaux en général et en Afrique subsaharienne en particulier, l'intérêt des plantes sauvages pour l'alimentation des populations rurales est très largement reconnu [1]. Plusieurs espèces végétales alimentaires ont été recensées et décrites aussi bien en Afrique occidentale [2] qu'en Afrique centrale [3]. En effet, pour couvrir leurs besoins alimentaires, les populations rurales africaines ont recours à l'agriculture de subsistance qu'elles complètent par des espèces sauvages comestibles dont les légumes [4]. Selon la FAO, les plantes légumières sont toutes les plantes dont les feuilles, les fruits et les racines sont utilisés dans la préparation des sauces [5]. Chweya et Eyzaguirre ont montré que les légumes feuilles tropicaux sont riches en protéines et peuvent contribuer à assurer la sécurité alimentaire des populations pauvres [6, 7]. Ils peuvent aussi constituer de par leur composition, un complément appréciable de calories, de vitamines, de fibres, de sels minéraux et de protéines dans l'alimentation [7-10]. Ces légumes locaux tirent encore leur importance particulière pour les pays sub-sahariens du fait que les légumes cultivés coûtent souvent plus cher sur le marché [7].

En dépit de cette importance, les plantes légumières de cueillette sont souvent négligées par la communauté scientifique et les services de développement. Or la vulgarisation et la sauvegarde de ces ressources phytogénétiques locales nécessitent l'existence d'une base de données actualisée sur leur diversité, leur distribution, les différents organes utilisés et les considérations socio-culturelles. Cette étude, vise à faire un premier état des lieux en vue d'une valorisation plus effective de ces ressources au Togo.

Matériel et méthodes

La démarche méthodologique adoptée dans la présente étude est basée sur des enquêtes ethnobotaniques complétées d'observations directes de terrain. Pour ce faire, un échantillonnage stratifié à deux niveaux a été réalisé sur tout le pays : le premier niveau de stratification correspond aux cinq zones écologiques du Togo (Figure 1) tandis que le second niveau correspond aux ethnies [11]. Cinquante villages distribués sur toute l'étendue du territoire togolais, en tenant compte des cinq zones écologiques et de 20 ethnies, ont été prospectés. Pour chacune des ethnies considérées, un à trois villages ont été sélectionnés au hasard pour les enquêtes ethnobotaniques.

Dans le cadre de la présente étude, nous avons eu recours à des interviews semi-structurées avec des groupes de 3 à 15 individus (avec une moyenne de huit individus) correspondant soit aux membres d'une même famille soit à des individus de plusieurs familles rassemblés à cet effet. Dans le premier cas, ces entretiens ont lieu dans les domiciles et dans le second cas, ils ont eu lieu sur la place du village. La parole a été donnée de façon à faire participer les hommes, les femmes et les enfants. Toutefois, étant donné que le sujet porte sur les légumes, une activité plus réservée aux femmes, ces dernières ont été plus sollicitées lors des enquêtes. Les informations collectées concernaient le nom vernaculaire de toutes les espèces légumières utilisées dans le milieu, l'organe utilisé, le lieu de récolte (formations végétales naturelles, jachères, champs, jardins de case), les périodes de disponibilité (saison sèche ou pluvieuse), la fréquence et les occasions d'utilisation, l'implication de chaque membre de la famille dans la cueillette et le conditionnement des plantes ainsi que dans la préparation des sauces. Les noms des plantes sont recueillis en langues locales et traduits si possible en français, suivis d'une description. Des échantillons de plantes ont été récoltés avec l'aide des informateurs et identifiés sur place. Ceux qui n'ont pas pu être correctement déterminés, ont été mis en herbier en vue d'une identification ou d'une confirmation au laboratoire. La nomenclature suivie est celle de la flore de Hutchinson et Dalziel [12] et de Brunel et al. [13, 14]. Les échantillons sont déposés à l'herbier de l'Université de Lomé.

Les informations recueillies sur le terrain ont permis de dresser la liste des espèces spontanées ou sub-spontanées dont les parties entrent dans la préparation de la sauce. Ces espèces ont été catégorisées suivant les familles botaniques, les types biologiques, les lieux et périodes de récolte. La distribution de ces plantes suivant les zones écologiques et les ethnies prospectées a été faite afin de relever les affinités et les particularités. Une matrice espèces x ethnies a été soumise à une analyse factorielle de correspondance dans le but de mettre en évidence ces affinités ou ces particularités. Ces différents traitements ont été faits à l'aide des logiciels □□□□□®, □□□□□ □□ 6.4® et □□ □□□□□®.

Résultats

Diversité des espèces légumières de cueillette

Au total, 105 espèces légumières de cueillette réparties en 82 genres et 45 familles ont été recensées (annexe). Les familles les plus représentées sont : les Malvaceae et les Moraceae (six espèces chacune) ; les Fabaceae, les Tiliaceae et les Asteraceae (cinq espèces chacune) ; les Caesalpiniaceae, les Convolvulaceae et les Euphorbiaceae (quatre espèces chacune) ; les Amaranthaceae, les Bombacaceae, les Labiatae, les Palmae, les Rubiaceae, les Rutaceae et les Verbenaceae (trois espèces chacune). Les familles des Annonaceae, Apocynaceae, Asclepiadaceae, Sapindaceae et des Solanaceae contiennent deux espèces chacune. Toutes les autres familles sont représentées par une seule espèce. La liste des espèces inventoriées est présentée dans l'annexe qui donne des indications sur les parties utilisées et les noms vernaculaires dans les différentes ethnies prospectées.

L'analyse de la distribution des espèces légumières de cueillette suivant les cinq zones écologiques montre que les zones I et II sont de loin, celles qui renferment le plus grand nombre d'espèces consommées. Elles sont suivies de la zone III. Les plus faibles nombres sont obtenus dans les zones IV et V (Figure 2). Certaines espèces comme *Adansonia digitata, Fagara zanthoxyloides, Ocimum gratissimum, Talinum triangulare*, *Vernonia amygdalina* et *Vitex doniana* sont signalées dans les cinq zones écologiques attestant leur utilisation par la majorité des ethnies du Togo.

Ces espèces sont ainsi intégrées aux habitudes alimentaires de toute la population. En revanche, d'autres espèces sont relativement spécifiques à une seule zone écologique (Tableau 1). C'est le cas par exemple de *Jacquemontia tamnifolia* signalée seulement dans la zone écologique V, de *Pentadesma butyracea* dans la zone III, de *Sterculia tragacantha*, *Piper*

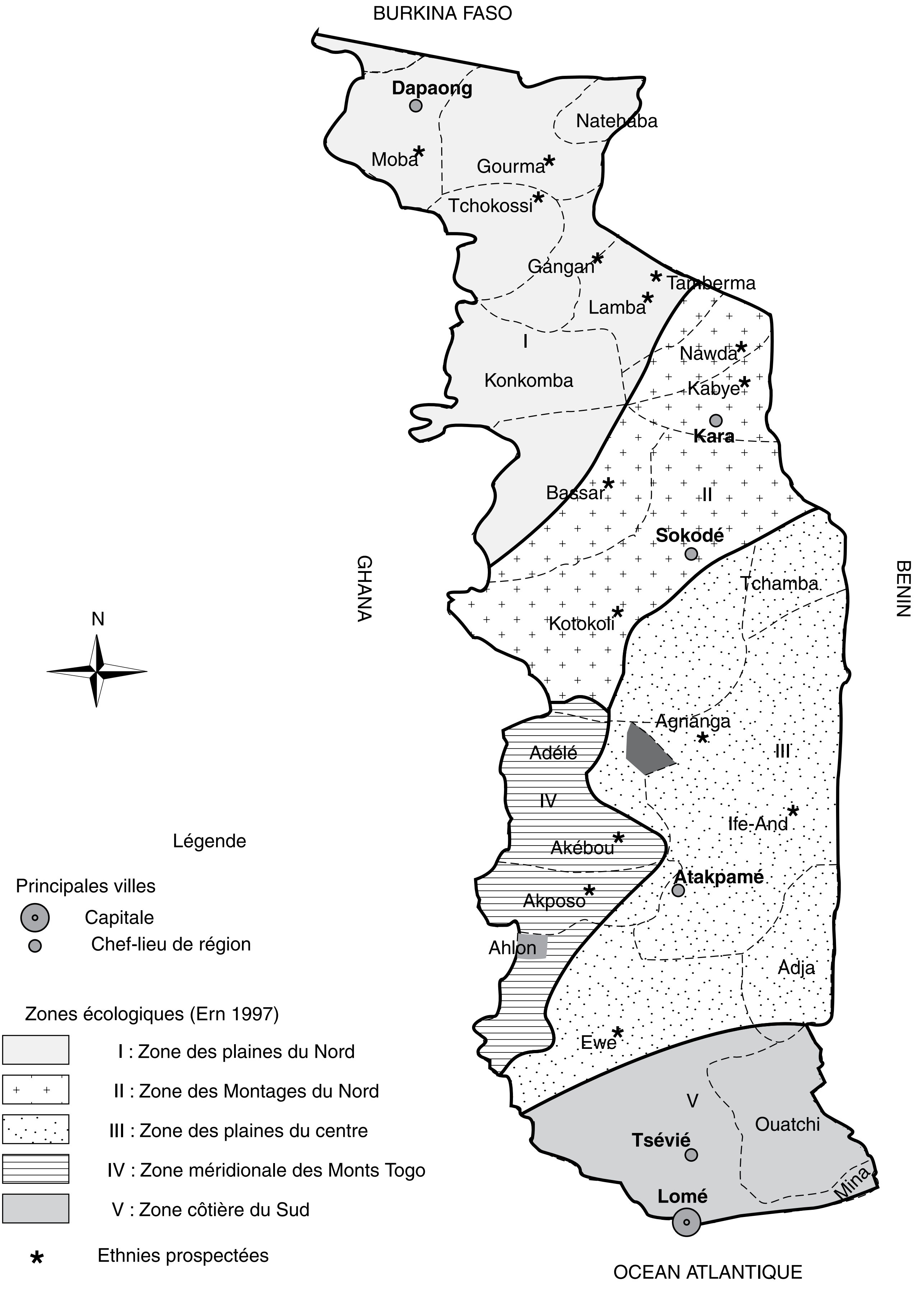

Figure 1. Distribution des ethnies suivant les zones éco-floristiques du Togo

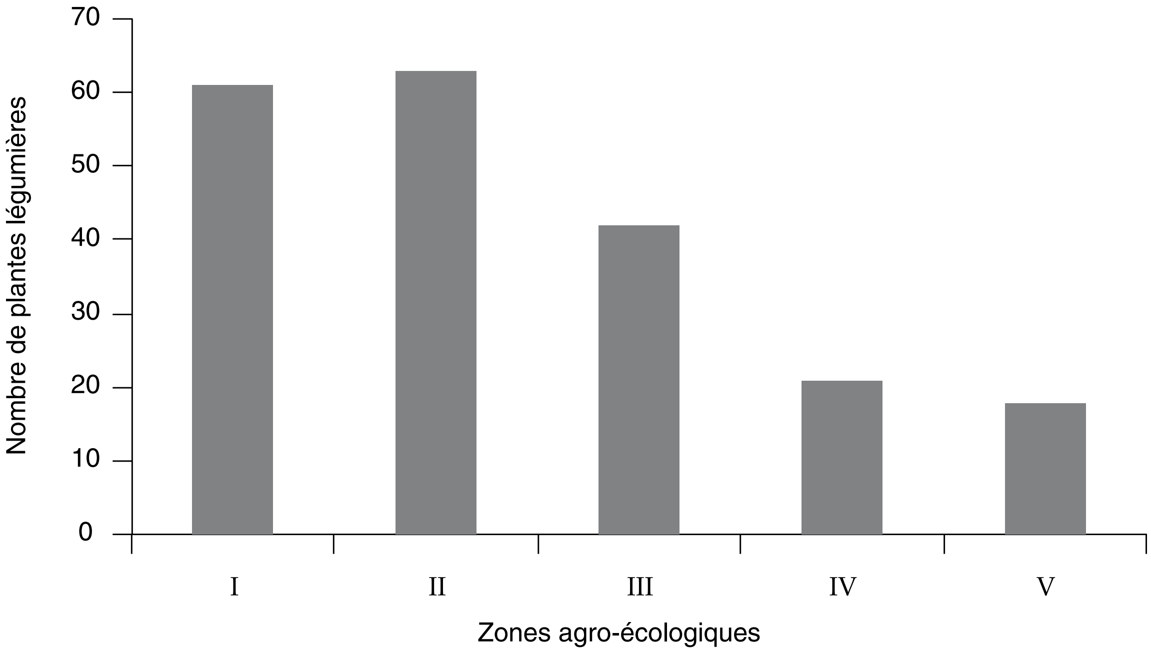

Figure 2. Distribution des espèces légumières suivant les cinq zones éco-floristiques (I à V) du Togo

Tableau 1: Répartition des espèces légumières de cueillette spécifiques à chaque zone éco-floristique

Zone I (17 espèces) *Amaranthus spinosus* L., *Balanites aegyptiaca* (L.) Del., *Coreopsis barteri* Oliv. & Hiern, *Crotalaria calycina* Schrank., *Cucurbita pepo* L., *Cynometra megalophylla* Harms, *Ficus ingens* (Miq.) Miq., *Grewia mollis* Juss., *Heliotropium indicum* L., *Hibiscus surattensis* L., *Ipomoea batatas* (L.) Lam., *Leptadenia hastata* (Pers.) Decne, *Merremia kentrocaulos* (C. B. Cl.) Hallier f., *Pterocarpus santalinoides* L'Hér., *Sclerocarya birrea* (A. Rich.) Hochst., *Strychnos spinosa* Lam., *Tridax procumbens* L.
Zone II (19 espèces) *Alchornea cordifolia* (Schum. & Thonn.) Müll. Arg., *Aloe buttneri* A. Berger, *Borassus aethiopum* Mart., *Chenopodium ambroisiodes* L., *Cochlospermum tinctorium* A. Rich., *Daniella oliveri* (Rolfe) Hutch. & Dalz., *Eriosema pulcherrimum* Taub., *Gardenia erubescens* Stapf. & Hutch., *Holarrhena floribunda* (G. Don) Dur. & Schinz, *Hyphaene thebaica* (L.) Mart., *Mangifera indica* L., *Mitracarpus villosus* (Sw.) DC., *Paullinia pinnata* L., *Parinari curatellifolia* Planch., *Phyllanthus muellerianus* (O. Ktze.) Exell., *Securidaca longepedunculata* Fres., *Synaptolepis retusa* H. H. W. Pearson., *Stachytarpheta indica* (L.) Vahl., *Ximenia americana* L.
Zone III (5 espèces) *Ficus exasperata* Vahl, *Hibiscus articulatus* Hochst, *Pentadesma butyracea* Sabine, *Saba senagalensis* (A. DC.) Pichon, *Sphenostylis schweinfurthii* Harms
Zone IV (4 espèces) *Fagara macrophylla* (Oliv.) Engl., *Piper guineense* Schum. & Thonn., *Portulaca oleracea* L., *Sterculia tragacantha* Lindl.
Zone V (3 espèces) *Erythrina senegalensis* DC., *Jacquemontia tamnifolia* (L.) Griseb., *Ochna afzelii* R. Br.

guineense, *Portulaca olarecea*, *Fagara macrophylla* et *Hibiscus articulatus* dans la zone IV. Les zones I et II renferment un nombre important d'espèces légumières de cueillette propres.

Les organes les plus utilisés sont les feuilles (67%) et les fruits (18%) ; suivis par les fleurs (six pour cent) et les racines (six pour cent). Les écorces de tronc, les bourgeons foliaires, les tubercules sont très peu utilisées avec pour chacun de ces types un pour cent des plantes recensées (Figure 2). Parmi les feuilles consommées, les jeunes feuilles représentent 44%. En considérant le nombre d'organes par espèce, un seul organe est consommé chez 90% des espèces, deux organes à la fois chez huit pour cent des plantes et trois organes à la fois (feuilles, fleurs, graines) chez trois pour cent des espèces (*Ceiba pentandra*, *Cissus populnea* et *Grewia venusta*) (Figure 3).

La distribution des fréquences spécifiques en fonction des ethnies montre trois groupes d'espèces :

- 12 espèces largement utilisées par plusieurs ethnies avec une fréquence supérieure ou égale à 50% (*Adansonia digitata*, *Ceiba pentandra*, *Vitex doniana*, *Ceratotheca sesamoides*, *Parkia biglobosa*, *Ocimum gratissimum*, *Bombax costatum*, *Corchorus aestuans*, *Vernonia amygdalina*, *Blighia sapida*, *Gynandropsis gynandra* et *Moringa oleifera*);
- 17 espèces sont communes à cinq ethnies soit une fréquence de 25%;
- 30 espèces sont communes à deux ethnies;
- et 47 autres espèces ne sont consommées que par une seule ethnie (Figure 4).

En effet, *Alchornea cordifolia* est seulement signalée chez les Kabyè alors que *Hymenocardia acida* ne l'est que chez les Yaka, Gangan et Bassar. *Ficus gnaphalocarpa*, *Corchorus tridens* et *Pergularia daemia* appartenant respectivement aux Moraceae, Tiliaceae et Asclepiadaceae, sont consommées exclusivement par les Gourma, Ifè, Moba et Yanga. On note cependant, l'absence de la consommation de *Parkia biglobosa* et *Sesamum indicum* chez les Akébou, Akposso et Ewé.

Les plus fortes richesses floristiques en légumes de cueillette sont observées chez les Nawdba, les Kabyè, les Lamba, les Moba, les Tchokossi et les Tamberma, tous des peuples de la partie septentrionale du Togo (Figure 5). Cette importance relative s'explique d'une part, par la disponibilité de la ressource dans leur environnement immédiat et d'autre part, par le fait que les populations de ces zones «déshéritées» ont souvent recours à divers produits végétaux autres qu'agricoles pour améliorer leur alimentation quotidienne.

L'analyse factorielle des correspondances (AFC) a permis de discriminer quatre groupes ethniques suivant les plantes légumières consommées. Deux ethnies (Kabyè et Nawdba) s'isolent et forment chacune un groupe attestant la spécificité des espèces légumières consommées. En revanche, quatre

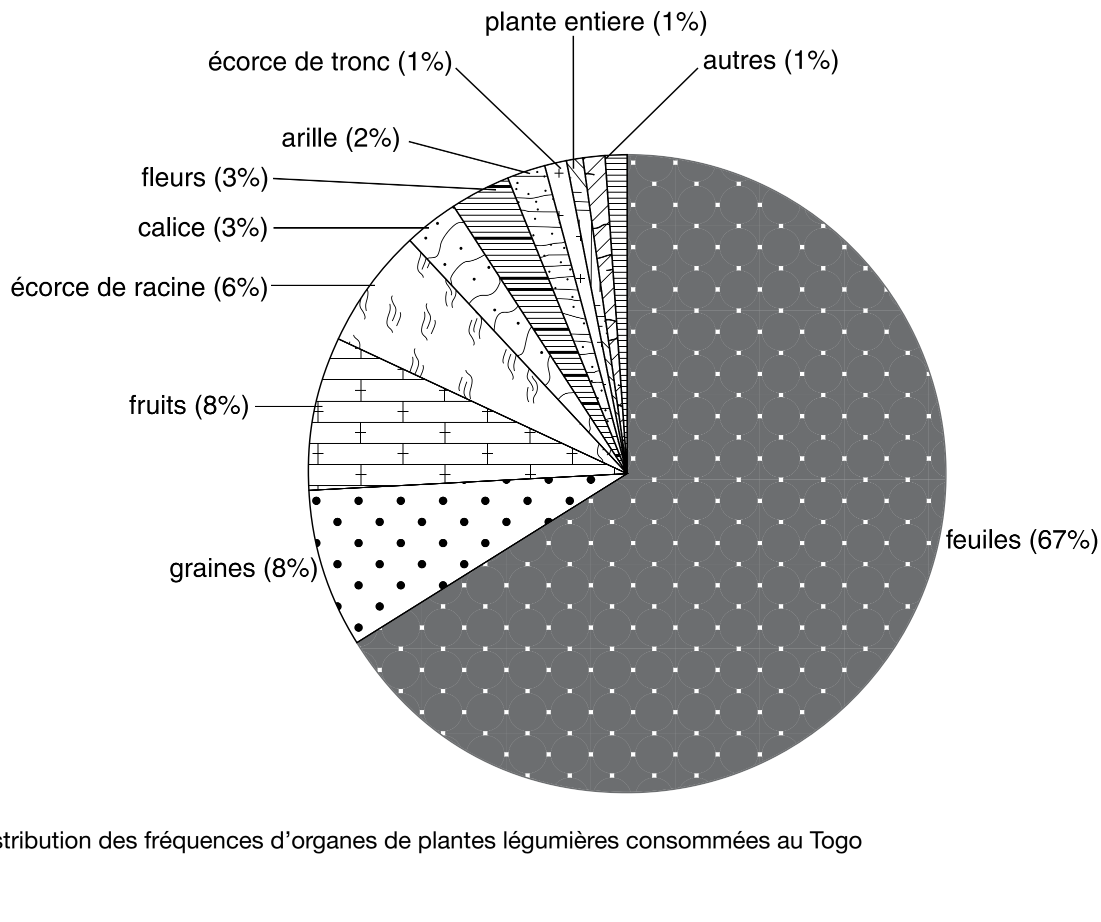

Figure 3. Distribution des fréquences d'organes de plantes légumières consommées au Togo

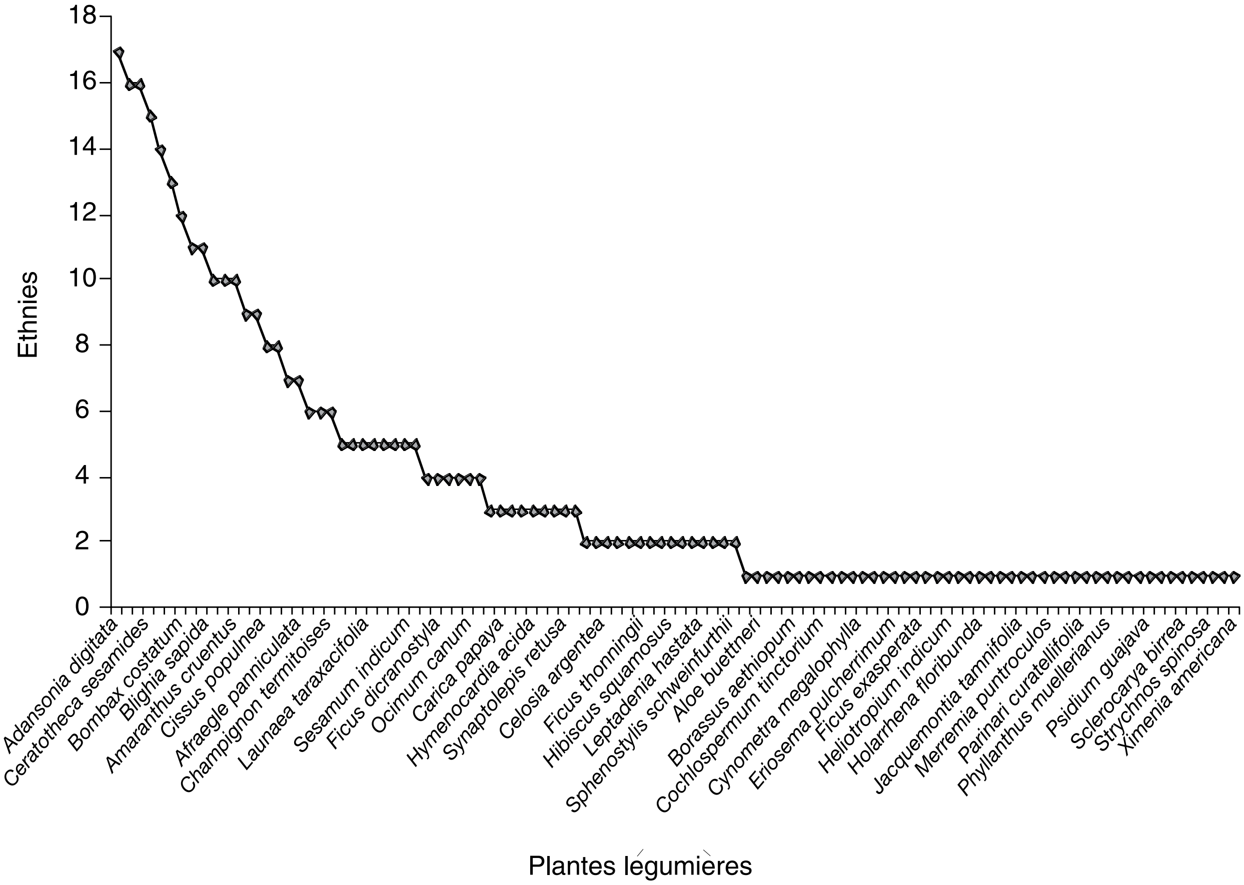

Figure 4. Distribution des fréquences des plantes légumières suivant les ethnies au Togo

ethnies de l'extrême nord (Moba, Yanga, Tchokossi, Temberma) forment un groupe, montrant la similarité des espèces utilisées par ces ethnies. Le reste des ethnies (du centre et du sud) forment le dernier groupe (Figure 5).

Récolte des plantes légumières

Le spectre biologique des espèces recensées montre que les phanérophytes (54%) et thérophytes (36%) sont les plus utilisées (Figure 6). Aussi, conscientes des conséquences de ces prélèvements sur la survie d'espèces aussi utiles, certaines populations cultivent ou conservent dans les champs et jachères, certaines espèces légumières telles que *Adansonia digitata*, *Parkia biglobosa*, etc. Les lieux et les périodes de récolte varient suivant les espèces et les zones écologiques. Le prélèvement des légumes se fait dans les formations végétales naturelles (savanes, forêts, buissons, fourrés, etc.), les jachères, les champs, les jardins de case avec une prédilection des champs, jardins de case et savanes. Cependant, l'approvisionnement peut se faire aussi par achat. La période de récolte varie également en fonction de la disponibilité et de la phénologie des espèces. La récolte s'étale dans le temps et permet une disponibilité à tout moment. Ainsi, 53% des espèces recensées sont récoltées en toute saison, 33% en saison sèche et 14% en saison des pluies. Ceci s'explique par le fait qu'en saison pluvieuse, la priorité est donnée aux espèces légumières cultivées.

Notons que les organes récoltés sont consommés soit frais, soit conditionnés dans le cas où la récolte est abondante. La récolte, le conditionnement et la commercialisation des plantes légumières sont souvent assurés par les femmes, quelquefois soutenues par les enfants et rarement par les hommes. Les principaux types de conditionnement sont le séchage suivi de la réduction en poudre ou d'une pré-cuisson suivie du séchage. La commercialisation des espèces légumières permet aux femmes de tirer des revenus financiers substantiels.

Habitudes socio-culturelles et plantes légumières

La consommation des plantes légumières chez presque toutes les ethnies prospectées est un fait de l'héritage. Mais il existe des cas où l'habitude alimentaire est acquise par brassage culturel. C'est ainsi que les Tamberma disent consommer la sauce de feuilles d'*Heliotropium indicum* car ils ont vu les Lamba en consommer.

Certains légumes ne sont pas consommés par certains membres de la famille, surtout les hommes. Les raisons évoquées sont les troubles digestifs, les considérations totémiques et les effets supposés sur les facultés reproductrices (surtout masculines). En effet, chez les Mossi, la consommation des feuilles d'*Adansonia digitata* (*Toukala* en langue locale) est conditionnée par certaines pratiques rituelles préalables. Chez

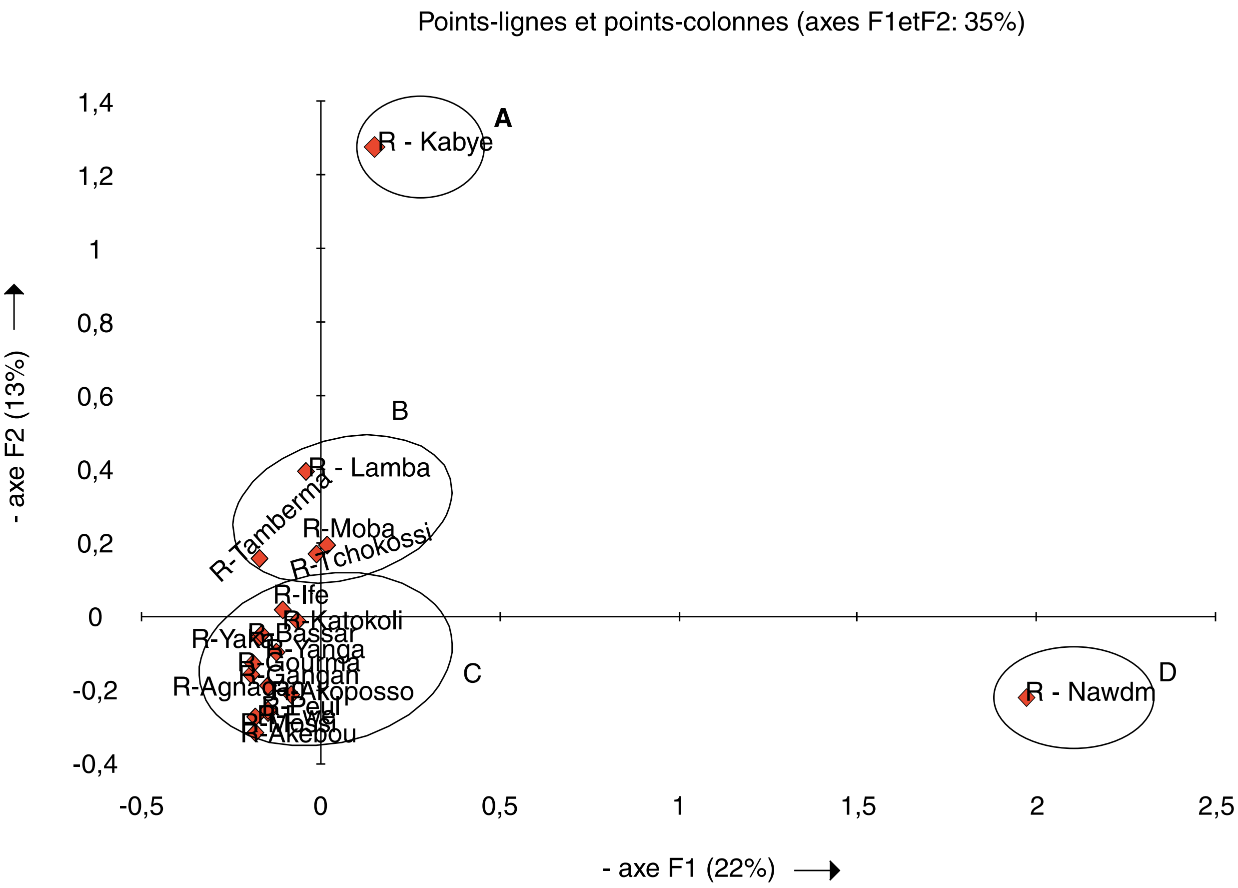

Figure 5. Discrimination des différents groupes ethniques suivant les premiers plans de l’AFC (axes 1 & 2) [A, Kabyè ; B, Lamba, Moba, Tamberma et Tchokossi ; C, Ifè, Bassar, Yanga, Gangan, Akposso, Akebou, Mossi, Agnaga, Kotokoli ; D, Nawdm]

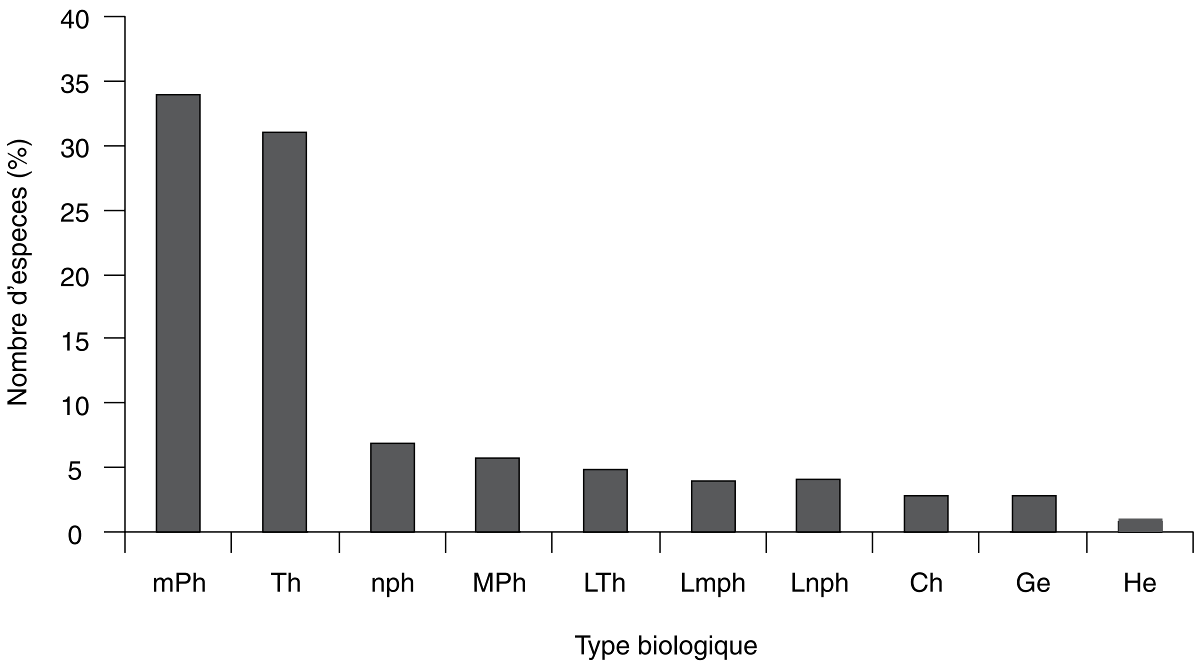

Figure 6. Spectre biologique des espèces légumières recensées au Togo (MPh : mégaphanérophytes ; mPh : microphanérophytes ; nph : nanophanérophytes ; Th : térophytes ; Ch : chaméphytes ; Ge : géophyte ; He : hémicyptophytes ; L : liane)

les Lamba, les Moba, les Kabyè, les Tchokossi, *Ceratotheca sesamoides* et *Bombax costatum* ne sont pas consommés par les initiés. Chez les Kabyè, la consommation de sauces de péricarpe de fruits de *Cissus populnea* et des sépales de *B. costatum* est possible uniquement pour les femmes et les enfants en dehors de la concession. Les consommateurs et les ustensiles doivent être purifiés avant de rentrer à la maison. Les Ouatchi ne consomment pas *Corchorus aestuans* pour des raisons totémiques. Chez les Kotokoli, la sauce de feuilles de *C. sesamoides* est interdite aux chasseurs. La sauce de sépales de *B. costatum* provoquerait ou accentuerait les hémorragies nasales alors qu'elle est un totem pour d'autres peuples. Les feuilles âgées de *Ceiba pentandra* sont plus appréciées que les jeunes feuilles qui affaibliraient ou neutraliseraient les facultés reproductrices masculines.

Discussion

De nombreuses études ethnobotaniques en Afrique tropicale ont montré l'importance des plantes sauvages comestibles (légumes et fruitiers) dans l'alimentation des populations rurales [1, 3]. Dans la région du Shaba (République Démocratique du Congo), une liste de 252 plantes sauvages comestibles dont les légumes a été dressée [3]. Ce chiffre quoique supérieur à celui obtenu dans la présente étude prend en compte aussi bien les plantes légumières de cueillette que les fruitiers sauvages. Par ailleurs, les populations des zones à climat sec ont recours à des compléments alimentaires de cueillette surtout en saisons sèches [10, 15, 16]. Les 105 espèces légumières inventoriées dans cette étude témoignent de la diversité relativement élevée de légumes de cueillette au Togo et en Afrique inter-tropicale [17].

Malgré l'importance que requièrent ces plantes, le mode de prélèvement des différents organes consommés (feuilles, fruits, fleurs, racines, bourgeons foliaires) constitue dans certains cas un danger pour la survie des espèces [18]. En plus du mode de prélèvement, la valorisation et la gestion durable de ces ressources devront tenir compte des réalités socioculturelles et du partage des tâches dans les communautés rurales. En effet, les femmes aidées parfois par les enfants ont en charge les activités de cueillette, de conditionnement et de commercialisation des plantes légumières. Diverses études en Afrique sub-saharienne ont démontré le rôle prépondérant des femmes dans la gestion des plantes légumières [3, 11, 19-21].

La diversité des plantes légumières et surtout de cueillette est liée aux différents lieux de prélèvement qui sont les jardins de case, les formations végétales environnantes (savanes, forêts, buissons, fourrés, etc.), les jachères, les champs. Ces informations vont dans le même sens que celles de Busson [16, 17]. En ce qui concerne la période de récolte, elle varie aussi en fonction de la disponibilité des légumes. Cependant, les légumes de cueillette récoltés en saison pluvieuse sont séchés et réduits en poudre, et conservés pour couvrir la saison sèche ou les périodes de soudure [4].

La valeur nutritionnelle des légumes de cueillette est aussi un argument de leur valorisation [2]. D'une manière générale, l'utilisation de ces plantes légumières est liée à leur richesse en substances nutritives (protéines, éléments minéraux, etc.) [8, 15, 17, 19, 22-28]. En dehors de leurs qualités alimentaires, les espèces légumières de cueillette possèdent aussi des propriétés médicinales [29].

Conclusion

Cette étude a permis de montrer que la flore togolaise regorge une importante richesse en espèces légumières de cueillette. Au total, 105 espèces de plantes légumières de cueillette regroupées en 82 genres et 45 familles, ont été recensées. Elles ont été récoltées surtout dans les champs, les jachères et les jardins de case, mais aussi dans les différents écosystèmes des cinq zones éco-floristiques du Togo. Le plus grand nombre d'espèces légumières consommées est observé chez les ethnies du Nord du pays (zones I et II) particulièrement chez les Nawdba et les Kabyè.

Les feuilles restent les parties les plus prélevées. La période de l'année au cours de laquelle, elles sont plus demandées est la saison sèche. En ce moment de l'année, la nourriture manque et l'on a souvent recours à des compléments alimentaires. Cette observation est particulièrement vraie dans les zones I et II du pays. Les femmes représentent le groupe humain dont l'activité quotidienne est tournée vers les légumes de cueillette. Elles interviennent ainsi dans leur cueillette, leur conditionnement, leur commercialisation et leur préparation. Elles constituent de ce fait, une population cible à prendre en compte dans tout programme de valorisation de ces ressources. Enfin, plusieurs autres espèces possèdent aussi des vertus thérapeutiques dont certaines sont avérées.

Cette étude n'est qu'une première étape d'un programme qui se poursuivra par la valorisation effective de plantes légumières à travers certains produits à valeur ajoutée telle que la «moutarde traditionnelle» de graines de néré (*Parkia biglobosa*). Ainsi, on pourra atteindre un des objectifs du réseau sous-régional NERE-Culture et Biodiversité en Afrique Subsaharienne.

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Annexe: Liste des plantes légumières de cueillette inventoriées au Togo

Famille	Nom scientifique	Zone écologique	Organes utilisés[1]	Noms en langues locales[2]
Acanthaceae	*Asystasia gangetica* (L.) T. Anders.	I, II, V	fe	Agbadoudou (Ko), Djagoudjagou (N), djademdem (Tk)
Amaranthaceae	*Amaranthus cruentus* L.	I, II, III, IV, V	fe	Ewouliha (Akp), Karatchitou, Alefoo (Ko), Alefoo (L), Gnenkpena (Mb), Karesmou (N), Boulba (P), Alefoo (Tk), Korolè (Yg)
	Amaranthus spinosus L.	I	fe	Tkantsèti (Ta)
	Celosia argentea L.	I, III	fe	Fifinkoè (Ka), Nasara Nda (Tk)
Anacardiaceae	*Mangifera indica* L.	II	fe	Tambat (N)
	Sclerocarya birrea (A. Rich.) Hochst.	I	fe	Nagnâ (Mb)
Annonaceae	*Annona senegalensis* Pers.	I, II, III	fe, ca	Knapesong (B), Bobo (Ga), Tilibaba (I), Tchotchorè (Ka), Tchotchodè (Ko), Enamodi (Ta), Ktemolo (Yk)
	Xylopia aethiopica (Dunal) A. Rich.	II, IV	fr	Tchotchou (Aké), Soozé (Ko), Lambasitou (L)
Apocynaceae	*Holarrhena flribunda* (G. Don) Dur. & Schinz	II	ra	Tiholga (N)
	Saba senagalensis (A. DC.) Pichon	I	ect	Lowou (Ka)
Asclepiadaceae	*Leptadenia hastata* (Pers.) Decne	I	fe	Onabendoumdkou (Gr), Leulog (Yg)
	Pergularia daemia (Forssk.) Chiov.	I, II, III	fe	Otountolgo (Gr), Ogbofou (I), Halbodo (Ka), Nogdouk, Tountolgue (Mb), Nogxok (Yg)
Asteraceae	*Coreopsis barteri* Oliv. & Hiern	I	fe	Tchakpala (Ka)
	Launaea taraxacifolia (Willd.) Amin.	II, III, IV, V	fe	Adodro (Akp), Adodro (I), Adodro (Ka), Haroro (L), Adonta (N)
	Tridax procumbens L.	II	fe	Godolegnew (Ka)
	Vernonia amygdalina Del.	I, II, III, IV, V	fe	Madasi (Ag), Kpowoe (Aké), Aloma (I), Fayo (Ka), Souwaka (Ko), Souwaka (L), Yabatouo (Mb), Souwakatiibe (N), Trotchanti (Ta), Souwaka (Tk)
	Vernonia colorata (Willd.) Drake	I, III, V	fe	Houloudo (KA), Haso (L), Trotsanti (Ta), Wowui (Tk)
Bombacaceae	*Adansonia digitata* L.	I, II, III, IV, V	fe, gr, fr	Glal (Ag), Kotoleguè (Aké), Ebli (Akp), Detore (B), Adzidotsi (E), Boutoob (Ga), Tokala (Gr), Otchè (I), Télou (Ka), Kodoro (Ko), Télo (L), Toukala (Mb), Tode (N), Boutob (Ta), Chiragna (Tk), Telo (Yk), Tiekada (Yg)

Famille	Nom scientifique	Zone écologique	Organes utilisés[1]	Noms en langues locales[2]
	Bombax costatum Pelleger.& Vuillet	I, II, III	ca, fl, fe	Boufob (B), Lefogle (Ga), Faule (Gr), Holèè, Houtou (Ka), Foula (Ko), Hola, Houlou (L), Faule (Mb), Bougb (N), Boufoo, Efouaga (Ta), Sângboko (Tk), Holo (Yk), Voaga (Yg)
	Ceiba pentandra (L.) Gaertn.	I, II, III, IV, V	fe, gr, fl	Komoulé (Ag), Gore (Aké), Iwouna (Akp), Begbegbo (B), Gbougbem (Ga), Gbenfare (Gr), Agou (I), Komoua (Ka), Komou (Ko), Koemo (L), Fouk (Mb), Goumgbe (N), Bokom (Ta), Ngna (Tk), Kounbia (Yk), Goung (Yg)
Boraginaceae	*Heliotropium indicum* L.	I	fe	-
Caesalpiniaceae	*Cassia occidentalis* L.	I, III	fe	Hountchètchè (Ag), Toukpankpan (Gr),
	Cynometra megalophylla Harms	I	gr	Ekpenyoale (Ga)
	Daniella oliveri (Rolfe) Hutch. & Dalz.	I	fe	Tcharè (Ka)
	Tamarindus indica L.	I	gr	Pouskè (Yg)
Capparaceae	*Gynandropsis gynandra* (L.) Briq.	I, II, III, IV	fe	Bisobo (Ag), Saboé (Akp), Sanboe (I), Sânboe (L), Tchalba (Mb), Sonboe (N), Tchèlbaadjè (P), Nantsagara (Ta), Awotchè (Tk), Gounnè (Yg)
Caricaceae	*Carica papaya* L.	II, V	fe, fr	Borofoudè (Ko), Sekero (L), Adoubgou (N)
Chenopodiaceae	*Chenopodium ambroisiodes* L.	II	fe	Hounamre (L)
Chrysobalanaceae	*Parinari curatellifolia* Planch.	II	ra	Fokrougou (N)
Cochlospermaceae	*Cochlospermum tinctorium* A. Rich.	II	ra	Kalgatingada (N)
Commelinaceae	*Commelina benghalensis* L.	I, II	fe	Gbomhânté (N), Kalaboto (Tk)
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	I	fe	Dankad (Mb)
	Ipomoea pes-caprae (L.) Sweet	I	fe	Adjademdem (Tk)
	Jacquemontia tamnifolia (L.) Griseb.	V	fe	-
	Merremia kentrocaulos (C. B. Cl.) Hallier f.	I	fe	Tignakouadi (Ta)
Cucurbitaceae	*Cucurbita pepo* L.	I	fe, fr	Kpenkpalouare (Mb), Yoga (Yg)
Euphorbiaceae	*Alchornea cordifolia* (Schum. & Thonn.) Müll. Arg.	II	fe	Zowou (Ka)
	Hymenocardia acida Tul.	I, II	fe	Nakolem (B), Boulamam (Ga), Kalentséla (Yk)
	Phyllanthus amarus Schum. & Thonn.	III, IV, V	gr, fr, fe	Senkalen (Ag), Ehli (Akp), Alibiso (I), Alenbeso (L)
	Phyllanthus muellerianus (O. Ktze.) Exell	II	ra	Madgou (N)
Fabaceae	*Crotalaria calycina* Schrank.	I	fe, fr	Sero (Ta)
	Eriosema pulcherrimum Taub.	II	tub	Gengeb (N)

Famille	Nom scientifique	Zone écologique	Organes utilisés[1]	Noms en langues locales[2]
	Erythrina senegalensis DC.	II	ect	Kolgradagoufelgou (N)
	Pterocarpus santalinoides L'Hér.	I	fe	Kpesna (Mb)
	Sphenostylis schweinfurthii Harms	I, II	fl	Adjadjalmla (Ka), Sansongbè (N)
Guttiferae	*Pentadesma butyracea* Sabine	III	fr	Agbeta (L)
Labiae	*Englerastrum gracillimum* Th. C. E. Fries	II	fr, fe	Dahêntibadjounga (N)
	Ocimum canum Sims.	I, II, III	fe	Konongzoga, Aswoeloo (Ka), Saswalé (L), Nounounbouk djak (Mb), Tifansanloti (Ta)
	Ocimum gratissimum L.	I, II, III, IV, V	fe	Hetchagni (Ag), Krèkè (Aké), Dekpenyire (Akp), Zogbeti (E), Lignal (Ga), Anoubaba (I), Asowou (Ka), Kounazoorou (Ko), Haso (L), Nounounbouk (Mb), Bouditi (N), Tîgnati (Ta), Haago (Yk)
Liliaceae	*Aloe buttneri* A. Berger	II	rhi	Nagelmgou (N)
Loganiaceae	*Strychnos spinosa* Lam.	I	fe	Kampoade (Yg)
Malvaceae	*Hibiscus articulatus* Hochst	III	gr	Biawotata (I)
	Hibiscus asper Hook. f.	I, II	fe	Pougnato (Ka), Guansangana (Mb), Kpamgante (N), Tkamboti (Ta)
	Hibiscus cannabinus L.	I, II, III	fe	Agbamla (Ka), Agnemantè (L), Balgui (Mb), Boro Nda (Tk), Boda (Yg)
	Hibiscus sabdariffa L.	I, II	fe, ca	Dgbènmèrè (Ko), Gouande (Mb), Nda (Tk)
	Hibiscus squamosus Hochr.	I	fe	Agbamlè (Ka), Hikontdjoko (Ta)
	Hibiscus surattensis L.	I	fe	Hikointsaari (TA)
Meliaceae	*Pseudocedrela kotschyi* (Schweinf.) Harms	I, II	ect, ecr	Kobota (B), Hilidetewouè (Ka), Tekilè (Yk)
Mimosaceae	*Parkia biglobosa* (Jacq.) R. Br.	I, II, III	fe, gr, bf	Boudoubou (B), Boudoub (Ga), Odouk (Gr), Ngba (I), Solow (Ka), Solo (Ko), Douk (Mb), Doob (N), Naré (P), Bounoua (Ta), Ndèrè (Tk), Soungbiri (Yk), Douang, Anè (Yg)
Moraceae	*Ficus dicranostyla* Mildbr.	I	fe, fr	Touana (Gr), Hilwotou (L), Touana (Mb), Touana (Tk)
	Ficus exasperata Vahl	II	fe	Kalayodo (Ka)
	Ficus gnaphalocara (Miq.) A. Rich.	I, III	fr, fe	Okankan (Gr), Akpan (I), Kinkanân (Mb), Dânba (Tk)
	Ficus ingens (Miq.) Miq.	I	fe	Okankpoun (Gr)
	Ficus sur Forssk.	I, II	fe	Dekankande, Diyokoré (B), Bounkankansaan (Ga), Kedia (Ko), Boukankan (Ta), Hirkekaro (Yg)

Famille	Nom scientifique	Zone écologique	Organes utilisés[1]	Noms en langues locales[2]
	Ficus thonningii Blume	I, II	fe	Kériwè (Ka), Kèdéga (N)
Moringaceae	*Moringa oleifera* Lam.	I, II, III, V	fe, fr	Seregégni (Ag), Yovovitsi (E), Boukpantob (Ga), Eganbagatii (Gr), Sepe (L), Gânbadouk (Mb), Gorongonde (N), Héigaaré (P), Gânbartik (Tk), Karlè, Gambatig (Yg)
Myrtaceae	*Psidium guajava* L.	I	fe	Alelo (L)
Ochnaceae	*Ochna afzelii* R. Br.	II	ecr	Ragmolgou (N)
Oleaceae	*Ximenia americana* L.	II	ra	Roumouloung (N)
Palmae	*Borassus aethiopum* Mart.	II	pe	Kpaadb (N)
	Elaeis guineensis Jacq.	II, III, IV	fr, pe	Orikpe (Aké), Edi (Akp), Okpè (I), Bagnanb (N)
	Hyphaene thebaica (L.) Mart.	II	pe	Lankpadga (N)
Pedaliaceae	*Ceratotheca sesamoides* Endl.	I, II, III, IV	fe	Djagoudjagou (Ag), Adjagblè (Akp), Koudjou (B), Kounanou (Ga), Ognao (Gr), Adjakpalè (I), Koulooro, Hounoum (Ka), Nizooti (Ko), Wourou (L), Kounkounnalkou, Bolong (Mb), Noome (N), Toualanti (Ta), Bounloun (Tk), Houloum (Yk), Boundou (Yg)
	Sesamum indicum L.	I, II, III, V	fe	Hounoum (Ka), Bolon (Mb), Boundou (Mo)Nome (N)
Piperaceae	*Piper guineense* Schum. & Thonn.	IV	fr	Kouleboe (Aké)
Polygalaceae	*Securidaca longepedunculata* Fres.	II	ra	Djarmrakou (N)
Portulacaceae	*Portulaca oleracea* L.	IV	fe	Ebouatcho (Akp)
Portulacaceae	*Talinum triangulare* (Jacq.) Willd.	II, III, IV, V	fe	Tchorogotchorogo (Ag), Gèboriatso (Akp), Yovogboma (E), Yovogboma (Ka), Gbomgnarètè, Bagouma (N)
Rubiaceae	*Gardenia erubescens* Stapf. & Hutch.	II	gr	Bena (N)
	Mitracarpus villosus (Sw.) DC.	II	fe	Agnasow (Ka)
	Nauclea latifolia Sm.	II, III	fe, ecr	Pomposi (Ag), Kouvougnon (B), Ktilengnissa (Yk)
Rutaceae	*Afraegle paniculata* (Schum. & Thonn.) Engl.	I, II, III	ecr	Dekounbotirè (B), Ngonè (Ka), Kilmawo (Ko), Agondè (L), Agondè, Konga (N), Akoundo (Yk)
	Fagara macrophylla (Oliv.) Engl.	IV	ecr	Sasalo (Aké)
	Fagara zanthoxyloides Lam.	I, II, III, IV	ecr	Sasalé (Ag), Ouhé (Akp), Salisali (I), Kalao (Ka), Kalawou (L), Poolou (Mb), Kalambagou (N)

Famille	Nom scientifique	Zone écologique	Organes utilisés[1]	Noms en langues locales[2]
Sapindaceae	*Blighia sapida* C. König	I, II, III, V	ari, fe	Pepeemo (B), N'pime (Gr), Ntchein (I), Kpesna (Ka, Kposon, Kpeso (L), Kpiik (Mb), Feiga (N), Bousoudom (Ta), Kpessia (Yk), Tiisa (Yg)
	Paullinia pinnata L.	II	ra	Ligdagnina (N)
Sapotaceae	*Vitellaria paradoxa* C. F. Gaertner	I, II	fr, gr	Bokpaabo (B), Osam (Gr), Boutab (Ta), Somia (Yk), Gnoro (Yg)
Solanaceae	*Solanum torvum* Sw.	III, IV	fr	Kpengè (Aké), Kânton (L)
Sterculiaceae	*Sterculia tragacantha* Lindl.	IV	fe, bf	Folifoli (Aké), Ofiobo (Akp)
Thymelaeaceae	*Synaptolepis retusa* H. H. W. Pearson	II	fe	Degelendjoure (B), Kpangadè (N), Kaanselem (Yk)
Tiliaceae	*Corchorus aestuans* L.	I, II, III, V	fe, gr	Alûlui (E), Ntcho (I), Kolanbabaka, Kolong (Ka), Kovoloko (Ko), Koholon, Aflonyolo (L), Boulvaka (Mo), Barguite (N), Fakououré (P), Sândjaka (Tk), Dinkaala (Yg)
	Corchorus olitorius L.	I, II	fe	Koelon (Ka), Ayoyo (Ko), Aholo (L), Barguite (N), Adèmè (P), Ayoyo (Tk), Boulbak (Yg)
	Corchorus tridens L.	I, II, IV, V	fe	Iliyou (Akp), Aluloui (E), Ognao (Gr), Founfog (Mb), Bagmonti (N), Boulbag (Yg)
	Grewia mollis Juss.	I	fe	Yenbion (Mb), Yônbou (Tk)
	Grewia venusta Fresen.	I, II, III, V	fe, fl, gr	Biyongbo (B), Kouyon (Ga), Lekpenkpak (Gr), Sola (I), Walo (L), Bsaato (Ta), Yônbou (Tk), Bola (Yk)
Verbenaceae	*Lippia multiflora* Moldenke	I, III	fe	Magnafè (Ag), Tignati (Ta)
	Stachytarpheta indica (L.) Vahl.	II	fe	-
	Vitex doniana Sweet	I, II, III, IV, V	fe	Otitikpe (Aké), Owli (Akp), Dengzalende (B), Fontsi (E), Bounnam (Ga), Onang (Gr), Ori (I), Tchangbeiw, Yogororose (KA), Tîngbarou (Ko), Kpagnarou (L), Onang, Gnân (Mb), Aadougou (N), Mantôme (Ta), Kotogna (Tk), Kpegnaro (Yk), Koun, Aate (Yg)
Vitaceae	*Cissus populnea* Guill. & Perr.	I, II, III	fr, gr, fe	Didindi, Lefafale (B), Onandogo (Gr), Kpolokpolo (I), Mènè (Ka), Kefefeliko (Ko), Ayade (L), Yombiayona (Mb), Amêmê (Yk),
Zygophyllaceae	*Balanites aegyptiaca* (L.) Del.	I	fe	Tchiernla (Yg)

[1] Organes utilisés. ari : arille ; bf : bourgeons foliaires ; ca : calice; ecr : écorce de racines ; ect : écorce de tronc ; fe : feuilles ; fl : fleurs ; fr : fruits ; gr : graine ; pe : plante entière ; ra : racine ; rhi : rhizome

[2] Groupes ethniques qui utilisent la ressource. Ag : Agnagan ; Aké : Akébou ; Akp : Akposso ; B : bassar ; E : Ewé ; Ga : Gangan ; Gr : Gourma ; I : Ifê ; Ka : Kabyè ; Ko : Kotokoli ; L : Lamba ; Mb : Moba ; Mo : Mossi ; N : Nawdm ; P : Peul ; Ta : Tamberma ; Tk : Tchokossi ; Yk : Yaka ; Yg : Yanga

Taxonomic identification and characterization of African Nightshades (*Solanum* L. Section *Solanum*)

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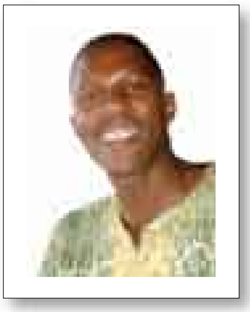
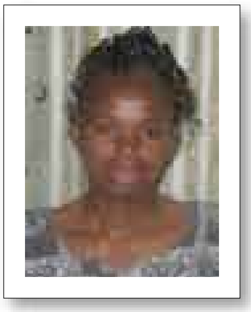


Gideon Njau Mwai



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Abstract

African nightshades play an important role in meeting the nutritional needs of rural households, and are reported as being particularly rich in protein, vitamin A, iron and calcium. Nightshades are among three top priority African indigenous vegetables identified for improvement and promotion through research. A major constraint facing this objective is the scantiness of taxonomic and nomenclatural knowledge on African nightshades, resulting in extensive synonymy and confusion. As a consequence, the toxic species are difficult to discriminate from those with high nutritional value. It is also difficult to identify species with good agronomic traits for genetic enhancement. This study was conducted to identify, characterize, and delimit African nightshade species. Fifty accessions of *Solanum* section *Solanum* from eastern, southern and western Africa were raised in a greenhouse at the Botanical and Experimental Garden, Radboud University, Nijmegen, the Netherlands. A descriptor list with 48 vegetative and reproductive characters was developed and used to characterize flowering and fruiting plants. Chromosome counts were done on root squash preparations from one week-old seedlings, aided by digital enhancement of microscopic images. Nine species were represented in the study material, including two diploids: *Solanum americanum* and *Solanum chenopodioides*; five tetraploids: *Solanum retroflexum, Solanum villosum, Solanum florulentum, Solanum grossidentatum* and *Solanum tarderemotum*; and two hexaploids: *Solanum nigrum* and *Solanum scabrum*. Most of the section *Solanum* species were distinguishable and easily identified. The exception was *S. florulentum* and *S. tarderemotum* which were identified tentatively and assigned respective names, but are difficult to differentiate and require further studies. The *S. florulentum/tarderemotum* group has three distinguishable variants and further studies are needed to determine the taxonomic status of each as a separate species, subspecies or genotypic/phenotypic variants. Furthermore, *S. retroflexum, S. villosum* and *S. scabrum* each had a high degree of within-species variation, and further studies are recommended to determine whether the variations within each constitute subspecies.

Key words: *Solanum* sp., identification, characterization

Introduction

Africa is richly endowed with plant genetic resources, with many well-adapted indigenous food crops that have long been grown on the continent. These crops play an important role in the food security of many resource-poor farming families, and have potential value as a genetic resource for the global community [1, 2]. Hence it is sad that African researchers, policy makers and farmers have neglected the potential of these crops in reducing food insecurity and poverty. Leafy vegetables, including several African indigenous vegetables (AIVs), are highly valued in the typical African diet as accompaniment to carbohydrate-based staples [3, 4].

Concerns regarding agrobiodiversity use and conservation, coupled with poverty alleviation have greatly contributed to reawakened interest in AIVs. It is increasingly recognized that communitites are, almost exclusively, the custodians of knowledge on how AIVs are grown and used, as well as their cultural value and genetic diversity. The best way to reduce the threat of loss of AIVs biodiversity is to improve their conservation through increased production and utilization, and improve their productivity to make them more competitive with exotics [1 - 5].

Although nightshades are historically considered inedible poisonous plants or troublesome agronomic weeds in Europe and the Americas [6-8], their status is completely different in western, eastern and southern Africa as well as in India, Indonesia and China, where they have for long been used as leafy herbs and vegetables, as a source of fruits and dye, and for various medicinal uses [7-9]. In Kenya, black nightshades occur in many areas where they are known by a variety of local names such as '*managu'* (Kikuyu), '*ndulu'* (Kamba), '*osuga'* (Luo), '*lisutsa'* (Luhya), '*rinagu'* (Kisii), '*mnavu'* (Giriama), '*ksoyo'* (Pokot), '*kisochot'* (Elgeyo). They are often cultivated in small kitchen gardens, and occasionally collected from the wild for domestic use and sale in markets [10]. These vegetables play an important role in meeting the nutritional needs of rural households, being particularly rich in protein (especially the amino acid methionine, which is rarely found in plants), Vitamin A, iron and calcium. Medicinally, they are used for stomach upsets, duodenal ulcers, swollen glands and teething problems [7, 8].

Vegetable nightshades are among the three top priority AIVs identified for further research and development due to their potential role in improving the nutritional and economic status of marginalized and poor rural, urban and peri-urban populations [2, 3]. Recent studies in East Africa have revealed increased use of AIVs and decreased use of exotics (cabbage, kale, spinach), mainly because AIVs require lower inputs to produce compared to exotics, and consequently are more affordable for many rural households in the low-income bracket. AIVs are easily available and cheap in village markets, but expensive in under-supplied urban markets, indicating that they have potential to become commercially important and increase their market share [9, 11].

The nightshades comprise a group of approximately 30 species making up section *Solanum* of the genus *Solanum*; constituting a large number of closely related morphogenetically distinct taxa, and typified by the true Black nightshade, *Solanum nigrum* L. [12]. This section is among the largest and most variable groups in the genus *Solanum*, with species that are distributed from temperate to tropical regions and from sea level to altitudes above 3500 metres [8]. Nightshades grow well under high moisture conditions, with rainfall of about 1500 mm, and temperature between 20 and 30^{o}C. They do well in fertile soils that are rich in nitrogen, phosphorus, and high organic matter content [7].

Nightshades taxonomy has long been beleaguered by complexity, resulting in extensive synonymy and confusion [6, 13]. The causes for such complexity include historical reasons, phenotypic plasticity, genetic variation, polyploidy, natural hybridization and discordant variation [12]. Much of this complexity has been resolved for Europe, Asia, the Americas and Australia, leaving Africa and South-East Asia as the two major geographic regions where a comprehensive taxonomic treatment of the section is lacking [6, 8, 12, 14, 15]. Taxonomic resolution is necessary not only for effective biodiversity conservation, but also to understand the economic potential and opportunities that might accrue from these genetic resources. Consequently, Edmonds and Chweya [8] recognized the need for taxonomic studies using living African germplasm to supplement the previous work of several authors who mainly used herbarium material [16-18].

The toxic and medicinal properties of S. nigrum have been documented from early times [8]. All nightshades are known to contain solanine and other related glyco-alkaloids, as well as high levels of nitrate-nitrogen. Consequently, consumption of some nightshades reportedly causes stomach problems, indicating potential toxicity [3]. Due to the previously mentioned lack of adequate taxonomic resolution of the African taxa, it is difficult to identify the taxa containing high levels of toxins, as well as those with good agronomic traits for genetic enhancement. Consequently, popularization and genetic enhancement of these otherwise nutritionally-rich vegetables has been hindered.

Objectives

The goal of this study was to address taxonomic complexity using nightshade germplasm collected in eastern, southern and western Africa. Specific objectives of the study were to characterize accessions of *Solanum* section *Solanum* from eastern, southern and western Africa; and to identify and delimit *Solanum* section *Solanum* species represented in the collection.

Materials and methods

Fifty accessions of African nightshades from eastern, western and southern Africa were raised in pots filled with vermiculite and peat soil under standard greenhouse conditions at the Botanical and Experimental Garden, Radboud University Nijmegen, The Netherlands. The strategy adopted was to use morphological and cytological (chromosome counts) characters of the living material to distinguish accessions belonging to different species and ploidy levels.

Descriptor list

An initial descriptor list was developed, including all morphological characters described by Edmonds and Chweya [8]. The resultant descriptor list was revised several times to cover the variation observed to occur in the plants growing in the greenhouse at the time of this study, culminating in a final version with 48 morphological characters. Character states were determined for each descriptor to represent the whole range of variation observed in the growing plants.

Scoring for morphological characters

Scoring for 47 (except chromosome counts) morphological characters was done according to the final version of the descriptor list on flowering and fruiting plants. Hair-type characters were scored with a magnifier and the presence or absence of stone cells in mature berries was checked in all the 50 accessions. Characters were scored based on either a majority of plants (qualitative) or mean of 10 random measurements (quantitative). Data were entered into computer in form of a matrix of character states; and cluster analysis done using NT-SYS software, using SIMQUAL (similarities for qualitative data) with UPGMA and simple matching and SAHN (sequential agglomerative hierarchical clustering).

Chromosome counts

Fresh seeds of the 50 accessions were sown in vermiculite-filled pots. One week after seedling emergence, root tips were obtained and fixed in 50% acetic acid for10 minutes; digested in 10% hydrochloric acid for five minutes; placed on a microscope slide and stained with two drops of Fuchsin dye. Stained tips were allowed to stand for three to five minutes, then washed with 45% acetic acid and excess dye blotted with tissue paper and mounted in a drop of 45% acetic acid. A cover slip was put on and the root tip squashed by tapping on the cover slip gently to spread the root tip, taking care not to scatter cells too widely. Prepared slides were preserved by applying nail varnish around the cover slip and stored at 4ºCuntil observation under compound microscope. Counting of the chromosomes was done by selecting cell plates at the late anaphase/early metaphase or late metaphase/early telophase stage of mitosis, in which chromosomes were properly condensed and well spread out such that individual chromosomes were easy to distinguish and count. Microscopic images were digitally enhanced to expedite the counting.

Results

Nine *Solanum* section *Solanum* were represented in the 50 African accessions, spread across three out of the four known ploidy levels. There were two diploid species, five tetraploid species and two hexaploid species (Figure 1, Table 1). Below are detailed descriptions of each of the nine species represented in this study as observed on greenhouse-grown plants. Distinctive characteristics of each species are highlighted (Table 2).

Solanum americanum *Miller*

Plants: up to 1.3 m high with erect well developed tertiary branches. Stem and nodes: purplish green in colour, glabrous and without wings. Leaves: ovate-lanceolate with entire margins, acute apex, and green veins or light purple; veins occasionally with purplish tinge, glabrous, petiolate with petioles winged all the way, blade length 2x blade width and 2x petiole length. Fruiting peduncle: facing upward, 2x as long as fruiting pedicel, glabrous. Fruiting pedicels: erect. Inflorescence: cymose-umbellate with few (≤7) flowers. Flowers: 10 mm with white corolla fused at the base, petal length 2x petal width; anthers yellow; styles usually not exserted; mature sepals: lanceolate, reflexed away from berries. Mature berries: 6-8 mm globose dark purple/black, very shiny, falling from calyces when ripe. Stone cells: usually absent. Cytology: 2n = 24, diploid.

Solanum chenopodioides *Lam.*

Plants: up to 1.5 m high with erect tertiary level branches. Stem: greenish purple with small finely dented wings, densely pubescent with long eglandular hairs. Leaves: ovate-lanceolate with entire margins and acute apex, greyish green with light green veins, densely pubescent with eglandular hairs, petioles winged half-way, blade length 2x blade width and 3 x petiole lengths. Fruiting peduncle: deflexed, densely pubescent, 3x longer than fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: a mixture of simple cymes and forked cymes on same plant, with few (5) to many (12 on forked cyme) flowers. Flowers: 12-14 mm, corolla: white, fused below half-way, petal length 4x petal width; anthers: yellow; styles: exserted just beyond the anthers and straight; mature sepals: broadly triangular, adherent to berries, sepal length and width approximately equal. Mature berries: 7-9 mm, slightly flattened, black, dull, and remaining on plant when fully ripe. Stone cells: absent. Cytology: 2n = 24, diploid.

Solanum nigrum *L.*

Plants: up to 1 m high with widely spreading tertiary level branches. Stems: purple with purple nodes, small to medium sized wings either prominently or finely dented, glabrous to sparsely pubescent with short eglandular appressed hairs when present. Leaves: ovate or lanceolate with entire sinuate or sinuate-dentate finely lobed margins and acuminate to acute apices; greyish green to purple with greenish purple to purple veins; glabrous or sparsely pubescent with short, glandular appressed hairs when present. Fruiting peduncle: horizontal or facing upward, sparsely to densely pubescent, ranging from equal to 3x pedicel length. Fruiting pedicel: reflexed. Inflorescence: either cymes, or a mixture of cymes and extended forked cymes on same plant, few (below 7) to many (above 20) flowered. Flowers: 11-14 mm; white corolla: fused either at the base or below halfway; petal length 2-3 times petal width; yellow anthers; styles: either exserted just beyond or not exserted, either curved or straight; mature sepals: triangular ovate or broadly triangular, usually reflexed away from (occasionally adherent to) berries, sepal length equal to or 2x longer than wide. Mature berries: 8-12 mm slightly flattened to rounded, dark-purple to black, usually dull, remaining on plant when fully ripe. Stone cells: absent. Cytology: 2n = 72, hexaploid.

Solanum retroflexum *Dunal*

Plants: up to 0.7 m high with widely spreading erect branches, bushy. Stem:purplish green in colour with green to purplish nodes, small wings along the stem with or without dents,

Table 1: Solanum section Solanum species represented in 50 African accessions

Provisional name	Ploidy level	Number of accessions
Solanum americanum	diploid	1
Solanum chenopodioides	diploid	1
Solanum grossidentatum	tetraploid	1
Solanum retroflexum	tetraploid	3
Solanum villosum	tetraploid	14
Solanum florulentum	tetraploid	8
Solanum tarderemotum	tetraploid	2
Solanum nigrum	hexaploid	6
Solanum scabrum	hexaploid	14

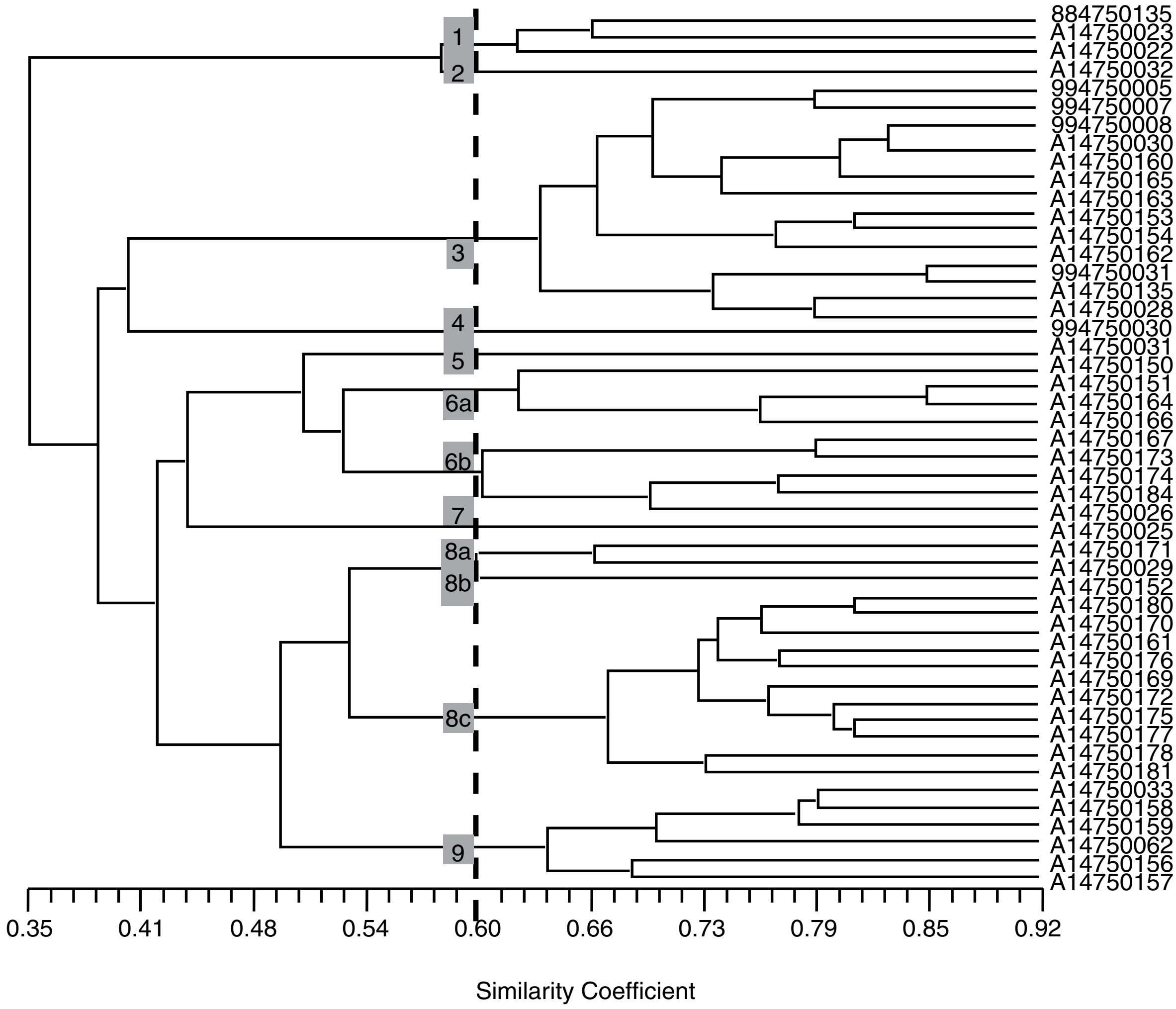

Figure 1: Clustering pattern of 50 African *Solanum* section *Solanum* accessions using morphological and cytological descriptors. The dotted line demarcates variation between (right) and within (left) species. 1: *S. retroflexum*; 2: *S. grossidentatum*; 3: *S. scabrum*; 4: *S. americanum*; 5: *S. tarderemotum*; 6: *S. florulentum*; 7: *S. chenopodioides*; 8: *S. villosum*; 9: *S. nigrum*.

Table 2: Distinctive characters of nine African *Solanum* section *Solanum* species

Species	Distinctive characters
Solanum americanum	• Berries shiny and globose when ripe, dropping from pedicels • Leaves and stems glabrous; stems semi-woody thin
Solanum chenopodioides	• Dull purplish black berries when ripe; don't drop from plant • Strongly reflexed peduncles in between nodes: stems and leaves pubescent with eglandular hairs; semi-woody stems
Solanum grossidentatum	• Spreading plants; berries light-yellowish green, drop with pedicels • Stems and leaves covered by dense glandular hairs
Solanum retroflexum	• Spreading habit with strongly dentate leaf margins • Dull, soft dark purple berries with waxy surface, do not drop • Stems and leaves pubescent with glandular/eglandular hairs
Solanum villosum	• Berries yellow-orange when ripe, don't drop or falling from pedicels • Leaves and stems densely pubescent or subglabrous
Solanum nigrum	• Dark purple, slightly shiny/dull berries, dropping from pedicels • Leaves and stems green/purplish in colour, subglabrous
Solanum scabrum	• Conspicuously larger plant parts (all) compared to other nightshade species • Berries purple, shiny, large, do not drop • Stems with strongly dentate ridges
Solanum florulentum	• Erect or spreading to prostrate; berries light green/ purple, drop with pedicels; styles exserted; inflorescences extended or forked cymes; berries purple • Stems and leaves subglabrous; leaves lanceolate
Solanum tarderemotum	• Spreading plants with strongly dentate ridges; berries small (5-7mm), light green or purple, dropping with pedicels

densely pubescent, with long eglandular erect hairs. Leaves: ovate with clearly lobed dentate margins and acute to obtuse apices, greyish green in color with light green or purplish veins, densely pubescent with short or long glandular erect hairs, petioles winged all the way, blade length equal to blade width, and 2x petiole length. Fruiting peduncle: facing upward, densely pubescent, 2x longer than fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: cymose, few to many flowered (7-13). Flowers: 11-13 mm, white corolla: fused half-way or below half-way, petal length 2x petal width; anthers: yellow; styles: exserted clearly beyond the anthers and straight; mature sepals: either lanceolate or triangular-ovate, reflexed away from berries. Mature berries: 10-12 mm slightly flattened, dark purplish black with dull surface, remaining on plant when fully ripe. Stone cells either present or absent. Cytology: 2n = 48, tetraploid.

Solanum grossidentatum *A. Richard*

Plant: up to 1 m high, widely spreading with extensively branched erect branches, bushy. Stem: green with green nodes, not winged, densely pubescent with long glandular erect hairs. Leaves: ovate-lanceolate with clearly lobed dentate margins and acute apices, greyish green in color with light green veins, densely pubescent with long glandular erect hairs. Fruiting peduncle: facing upward, densely pubescent and twice as long as fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: cymose, few flowered (≤ 7). Flowers: 12-14 mm, white corolla: fused below half-way, petal length 2x petal width; anthers: yellow; styles: exserted clearly beyond the anthers, straight; mature sepals: lanceolate, 3x as long as wide, adherent to berries. Mature berries: 8-11 mm, slightly flattened, yellowish green with dull surface, dropping with pedicels when ripe. Stone cells: present. Cytology: 2n = 48, tetraploid.

Solanum scabrum *Miller*

Plants: up to 2 m high; erect, with primary and secondary branches (occasionally tertiary). Stem and node colour ranging from green to purplish green to purple with medium to prominent wings that are prominently dented; glabrous to sparsely pubescent with short eglandular, appressed or intermediate hairs where present. Leaves: ovate with entire to sinuate margins and acute (occasionally obtuse) apices, colour ranging from light green to green, dark green and greenish purple, and vein color ranging from light green to purple; glabrous to sparsely pubescent with short, eglandular appressed to intermediate hairs where present; blade length equal to blade width and 2x, 3x or more times longer than petiole length, petiole winged half-way. Fruiting peduncle: facing upward, sparsely to densely pubescent and 3x or more longer than fruiting pedicel.

Fruiting pedicel: erect or reflexed. Inflorescence cymose-umbellate, many flowered (8-20). Flowers: large ≥16 mm, corolla: white or light purple and fused below half-way, petal length 2x petal width; anthers: yellow or brown; styles: not exserted or exserted either clearly or just beyond the anthers, either curved or straight; mature sepals: rounded in shape, reflexed away from berries, sepal length equal to width. Mature berries: large (≥16 mm), slightly flattened, dark purplish black, shiny and remaining on plant when fully ripe. Stone cells: absent. Cytology: 2n = 72, hexaploid.

Solanum villosum *Miller*

subsp. *miniatum* (Bernh. ex Willd.) Edmonds

Plants: up to 1 m high, spreading or erect, short branches to third level. Stem: green with node colour ranging from green to purplish green to purple; small to medium sized wings (1-2mm) either finely dented or not dented; glabrous to sparsely pubescent with short, eglandular appressed to intermediate hairs where present. Leaves: lanceolate to ovate with entire, sinuate, sinuate-dentate or dentate margins that may have clearly defined lobes or none, leaf apex acuminate to acute, light green to green lamina with light green or green veins; blade length either half as long or equal to blade width, and ranges from half as long to 3x longer than petiole length; petiole winged all the way or half-way. Fruiting peduncle: facing upward, sparsely to densely pubescent, 3x or more, longer than fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: cymose, occasionally cymes mixed with forked cymes on same plant, few (7) to many flowered (above 20). Flowers: small (<10 mm), corolla: white fused either half-way or below half-way, petal length to width ratio ranging between 1 and 3; anthers: yellow; style: not exserted or exserted just beyond the anthers, straight where exserted; mature sepals: lanceolate (occasionally triangular-ovate), reflexed away from berries, sepal length 2 to 4 times sepal width. Mature berries: 7-9 mm, higher rounded; orange; dull; remaining on plant when fully ripe. Stone cells: absent. Cytology: 2n = 48, tetraploid.

subsp. *villosum*

Plants: medium up to 1.2 m high with widely spreading erect branches, branched to tertiary level only. Stems: greenish purple with greenish purple nodes; small wings without dents, densely pubescent with long, glandular erect hairs. Leaves: ovate with finely lobed dentate margins and acute apex, greenish purple with light green veins; densely pubescent with long glandular erect hairs; blade length equal to blade width and 2x petiole length, petioles winged all the way. Fruiting peduncle: densely pubescent, horizontal, 2x as long as fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: cymose, few flowered (< 7). Flowers: 10-12 mm; corolla: white, fused half-way, petal length equal to width; anthers: yellow; styles: clearly exserted beyond anthers, straight; mature sepals: triangular-ovate, reflexed away from berries, sepal length equal to width. Mature berries: 8-10 mm, globose; orange; dull; remaining on plant when fully ripe. Stone cells: absent. Cytology: 2n = 48, tetraploid.

Solanum tarderemotum *Bitter*

Plants: up to 0.7 m high with spreading erect or prostrate branches. Stem: green to greenish purple with purplish nodes and small finely dented wings; glabrous to sparsely pubescent with short appressed eglandular hairs. Leaves: small to medium sized, lanceolate to ovate with entire margins and acuminate to acute apices; green with light green or purplish veins; sparsely pubescent with short, eglandular appressed to erect hairs; blade length 2x blade width and 3x to 4x petiole length;, petioles winged all the way or half-way. Fruiting peduncle: deflexed, horizontal or facing upward, sparsely to densely pubescent; twice as long as fruiting pedicel or more. Fruiting pedicel: reflexed. Inflorescence: extended mixed with (few) forked cymes many flowered (8-16). Flowers: small (≤11 mm); corolla: white fused below half-way or at the base; petal length 2 to 3 times petal width; anthers: yellow; style: either exserted well beyond the anthers, curved or straight, or not exserted; mature sepals: lanceolate to ovate to broadly triangular, either reflexed or adherent to berries, sepal length equal or 2x sepal length. Mature berries: 6-10 mm, slightly flattened, occasionally rounded; light green or pinkish purple; dull; falling with pedicels when ripe. Stone cells present. Cytology: 2n = 48, tetraploid.

Solanum florulentum *Bitter*

Plants: tall, up to 1.8 m high with erect branches branched to tertiary level only. Stem: green with greenish purple nodes and prominent wings that are prominently dented; sparsely pubescent with long eglandular intermediate hairs. Leaves: ovate-lanceolate with clearly lobed sinuate-dentate margins and acuminate apices; green with light green veins; sparsely pubescent with long eglandular intermediate hairs; blade length 2x blade width and 3x petiole length; petiole winged all the way. Fruiting peduncle: facing upward, sparsely pubescent, 3x as long as fruiting pedicel. Fruiting pedicel: reflexed. Inflorescence: extended cymes, forked cymes or both mixed on same plant, many flowered (8-20). Flowers: 12-14 mm, corolla: white, fused below half-way; petal length 2x petal width; anthers: yellow; styles: exserted clearly beyond anthers and curved; mature sepals: broadly triangular, adherent to berries, sepal length equal to sepal width. Mature berries: 8-10 mm, slightly flattened, dull dark purple; falling with pedicels when ripe. Stone cells: present. Cytology: 2n = 48, tetraploid.

Discussion

The tetraploid species *Solanum retroflexum* was represented by two phenotypes: two pubescent accessions with eglandular haired stems and glandular haired leaves; and one glabrous accession. Other than for the pubescence, the two phenotypes were identical. The great variation in the pubescence of *S. retroflexum* has been recognized by Edmonds and Chweya and Jacoby et al. [8, 19]. Furthermore, these authors recognize two subspecies of *S. villosum* differentiated mainly by their pubescence. We hypothesize that the two *S. retroflexum* variants represent two subspecies distinguishable by pubescence [8, 20].

The identification and differentiation of *Solanum florulentum* and *Solanum tarderemotum* is still shrouded in confusion. Names that are used for these tetraploid species include *Solanum eldorettii* and *Solanum eldoretianum*. The name *Solanum eldorettii* was coined by Kilian Mtotomwema from Tanzania in 1987 without a proper description and without a publication, because he was of the opinion that the green berries characteristic of these plants do not fit within *S. nigrum* because the '*nigrum*' epithet implied the plants should have black fruit. It is now clear, however, that these taxa belong in *Solanum* section *Solanum*. The taxa are reported to be popular leafy vegetables in several highland regions in East Africa including the Central, Rift Valley and Southwestern highlands in Kenya; Northern Tanzania and Southern Tanzania, and Ethiopia. It is probable that once they are better understood, they will also be found in other Eastern Africa regions [3].

The *S. eldorettii*-type accessions clustered together, although there is considerable morphological variation (Figure 1); with variants with green berries and others with purple berries; and extended cymose inflorescences or branched/forked cymes and yet others have intermediate characteristics with a mixture of simple and branched inflorescences on the same plant. Although recent attempts have been made to describe the variation within this group, the distinction between *S. florulentum* and *S. tarderemotum* (Table 2) is not yet clearly defined [3, 8, 9, 20]. Ongoing work at Radboud University Nijmegen, The Netherlands, is expected to shed insight into the morphological and genetic relationships and delimit these species.

Further investigations are needed to establish whether the highly variable sub-groups observed in *S. florulentum* and *S. villosum* (cluster groups 6a, 6b and 8a-8c) (Figure 1) constitute single or several taxa. Molecular taxonomic techniques might be particularly helpful in this regard. Furthermore, since some species were represented by only one accession, the use of more extensive and representative germplasm collections is recommended to validate the current results.

Conclusion

This study documented the occurrence of nine *Solanum* section *Solanum* species in East, West and South Africa comprising a polyploid series with two diploids: *Solanum americanum,* and *S. chenopodioides*; five tetraploids: *S. retroflexum, S. villosum, S. florulentum, S. grossidentatum* and *S. tarderemotum*; and two hexaploids: *S. nigrum* and *S. scabrum*. Further studies, using a more comprehensive germplasm collection, are recommended to elucidate the taxonomic status of the *S. florulentum*/*S. tarderemotum* group as well as intra-specific variants of *S. villosum*, *S. scabrum* and *S. retroflexum.*

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Caractérisation des accessions de quatre espèces de légumes-feuilles traditionnels (*Hibiscus sabdariffa* L., *Vigna unguiculata* (L.) Walp, *Amaranthus* L. spp. et *Moringa oleifera Lam*) au Sénégal

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Résumé

La modernisation de l'agriculture caractérisée par l'abandon des variétés traditionnelles au profit de nouvelles variétés plus homogènes et à haut potentiel de rendement a conduit à la réduction de la diversité génétique. La collecte et la caractérisation de la diversité des écotypes locaux deviennent alors une nécessité. C'est ainsi que 64 accessions collectées lors de trois missions de collecte et 18 accessions de la banque de gènes du Centre pour le Développement de l'Horticulture (CDH) ont fait l'objet de caractérisation à la station de recherche de l'ISRA-CDH. Le matériel était composé de 48 accessions de bissap (*Hibiscus sabdariffa* L.), 19 de niébé (*Vigna unguiculata* (L.) Walp), 9 d'amarante (*Amaranthus* (L.) spp.) et 6 accessions de 'Nébéday' (*Moringa oleifera* Lam).

Un dispositif complètement aléatoire en bandes simples sans répétition a été mis en place. Les clés de caractérisation des 4 espèces avec une version adaptée ont été utilisées. Cette caractérisation a permis de mettre en évidence la diversité intra-spécifique de chacune des 4 espèces mais également le mouvement des semences (ou gènes) sur des distances pouvant atteindre 800 km. On note en moyenne que 35 % des accessions collectées sont constituées de doublons. L'analyse de la diversité spécifique des accessions dans les localités visitées a révélé que 57 % d'entre elles sont sous haute menace d'érosion génétique.

Cette caractérisation agro-morphologique devrait être complétée par des études plus approfondies notamment sur le plan biochimique et moléculaire pour permettre d'infirmer ou de confirmer les résultats obtenus. L'utilisation d'un nombre plus important d'accessions des différentes espèces et d'autres méthodes de caractérisation pourraient contribuer à l'établissement de *core collection*, qui reste la meilleure stratégie de conservation du germoplasme.

Mots-clés: légumes feuilles traditionnels, caractérisation, agro morphologique, core collection, diversité

Introduction

Les ressources phytogénétiques constituent la clé de la sécurité alimentaire et du développement agricole durable. Pourtant, la diversité végétale de la terre est gravement menacée. Les souches sauvages des plantes agricoles disparaissent au fur et à mesure que le développement détruit leurs habitats. Au champ, les paysans abandonnent les variétés traditionnelles au profit des variétés améliorées [1].

On s'inquiète de plus en plus de voir les connaissances traditionnelles sur les espèces cultivées et les espèces sauvages disparaître rapidement. Une bonne part de ces informations est détenue par les femmes et échappe, en grande partie, au public. Au fur et à mesure que les sociétés changent, les jeunes générations n'acquièrent pas toujours l'expérience de leurs aînés. La modernisation de l'agriculture qui utilise de nouvelles variétés plus homogènes et à haut potentiel de rendement conduit à la réduction de la diversité génétique [2]. La collecte de la diversité des écotypes locaux devient alors une condition inéluctable pour garantir la sécurité alimentaire.

Mais il faut noter qu'en général, le matériel génétique issu de collectes est de faible quantité [3]. Les besoins de conservation (*in situ* ou *ex situ*) et d'utilisations ultérieures (amélioration des plantes, alimentaires, pharmacognosie etc.) requièrent un accroissement de la quantité de semences et une meilleure connaissance des caractéristiques des phénotypes issus de ce matériel. Dès lors, la régénération (ou multiplication) et la caractérisation deviennent des étapes nécessaires à tout processus d'utilisation ultérieure. Cette multiplication des semences va permettre la duplication à des fins de conservation. Une partie du matériel génétique est destinée à la conservation pour le moyen terme, une autre à la collection de travail (court terme) et un échantillon de sécurité est réservé à la conservation pour le long terme (banques de gènes nationales et internationales) [3].

Le matériel collecté lors des trois différentes missions est composé de génotypes de niébé (*Vigna unguiculata* (L.) Walp), bissap (*Hibiscus sabdariffa* L.), amarante (*Amaranthus* L. spp.) et 'Nébéday' (*Moringa oleifera* Lam). C'est ainsi que 9 accessions d'amarante, 6 de nébéday, 48 de bissap et 19 accessions de niébé ont été semées à la station de recherche de l'ISRA-CDH.

Matériels et méthodes

Les essais ont été mis en place à la station de recherche de l'Institut Sénégalais de Recherches Agricoles / Centre pour le Développement de l'Horticulture (ISRA / CDH).

Un dispositif complètement aléatoire en bandes simples sans répétition a été mis en place [4]. Le semis a été fait manuellement le 23 mai 2003 sur une parcelle ayant comme précédent cultural une jachère. Les accessions de bissap, de niébé, d'amarante et de Nébéday ont été cultivées en se référant aux recommandations des fiches techniques élaborées à cet effet [5, 6, 7, 8].

Les clés de caractérisation du Nébéday et de l'amarante de *l'Asian Vegetable Research and Development Cente*r [3, 9] ont été utilisées et pour le niébé, celle confectionnée à partir des publications de l'ISRA-CNRA de Bambey [6]. Une version simplifiée de la clé de Bricage a été utilisée pour la caractérisation du bissap [10]. Les variétés les plus étudiées ont été utilisées comme référence ou « témoin ». Il s'agit de Vcdh, Vimto, et Koor (bissap), ISRABambey1, ISRABambey2 et ISRABambey3 (niébé), AVRDC1 et AVRDC2 (amarante) et pour le Nébéday l'accession MAVRDC.

Différents paramètres du développement végétatif et floral, de la production en feuilles et de la production en semences ont été étudiés. Ces paramètres ont été mesurés aussi bien sur les plants issus du démariage que ceux restant sur la parcelle. Les mesures ont été faites sur un échantillon dont le nombre de pieds par accession était de 5 pour le bissap et l'amarante, 10 pieds pour le niébé et 3 pieds pour le Nébéday. Onze variables ont été mesurées sur les plants de chacune des 48 accessions de bissap, 16 variables sur chacune des 19 accessions de niébé, 29 variables sur chacune des 9 accessions d'amarante et 32 sur chacune des 6 accessions de Nébéday.

La détermination du taux de matière sèche pour toutes les accessions des 4 espèces consistait à prélever un échantillon de 20 grammes de limbe foliaire frais et de l'étaler sur un morceau de papier journal déposé sur la paillasse du laboratoire (à l'ombre) pendant 14 jours. Les mensurations sur la longueur et la largeur pour chacune des accessions des 4 espèces se faisaient sur un échantillon de 5 feuilles bien développées pris au hasard. Celles portant sur la longueur et le diamètre des gousses de niébé et de Nébéday se faisaient sur un échantillon de 10. Un pied à coulisse était utilisé pour l'évaluation du diamètre et une règle graduée de 50 cm pour la détermination de la longueur.

L'évaluation du poids de la biomasse totale a été faite avec une balance portable et celle des variables dont le poids est inférieur à 600 g avec une balance électronique (marque SARTORIUS de portée 600 g).
Parmi les 11 variables mesurées sur le bissap, 9 ont été intégrées dans l'analyse statistique, les deux autres (poids de l'échantillon de feuilles fraîches (20 g) et temps de séchage des feuilles à l'ombre (14 jours)) étant identiques pour toutes les accessions. Les 9 variables sont la hauteur et l'encombrement des plantes, la biomasse totale par pied, le poids total des feuilles fraîches, la longueur et la largeur moyenne du limbe foliaire, le ratio longueur sur largeur ((L/l) < 1 (1), de 1 à 1,9 (2), de 2 à 2,9 (3) ≥ (4)), le poids des feuilles séchées à l'ombre et le taux de matière sèche.

Les 16 variables mesurées sur le niébé sont la biomasse totale et le diamètre moyen par pied, la hauteur et l'encombrement moyen par pied, le port de la plante (érigé (1) et rampant (2)), le poids des feuilles fraîches par pied, la couleur de la tige principale, le nombre moyen de nodules par pied, le poids total des nodules de 5 pieds, le poids de l'échantillon de feuilles fraîches, le poids des feuilles séchées à l'ombre, le temps de séchage, le taux de matière sèche, la longueur et la largeur moyenne des feuilles et le ratio longueur sur largeur.

Les 29 variables mesurées sur l'amarante sont la biomasse totale et le diamètre moyen par pied, la hauteur et l'encombrement moyen par pied à 43 jours après semis (43 jas), le port de la plante, le poids moyen des feuilles fraîches par pied, le poids total de feuilles, la couleur de la tige principale, le poids de l'échantillon de feuilles fraîches, le poids des feuilles séchées à l'ombre, le temps de séchage, le taux de matière sèche, le taux d'émergence au champ. A 120 jours après semis, les variables mesurées sont : la hauteur des plantes, la longueur et la largeur moyennes du limbe foliaire, la longueur de l'inflorescence latérale, la pigmentation des feuilles, la forme des feuilles, l'épaisseur des feuilles axillaires, l'index de développement des branches, la pubescence et la pigmentation des tiges, la forme de la marge foliaire, les types de nervures, la pigmentation des pétioles, le sexe, la densité de l'inflorescence et la couleur des feuilles.

Trente deux variables ont été mesurées sur le Nébéday à 266 jours après semis (jas) (le port de la plante, la longueur de la feuille, la largeur de la feuille, la couleur des feuilles, le goût des feuilles avant cuisson, la longueur et la largeur des folioles, la couleur du pétiole, la couleur et l'odeur des fleurs, la couleur des gousses, la longueur et la largeur moyennes des gousses, le nombre moyen de graines par gousse, le coefficient de conversion en poudre des feuilles séchées). A 41 jas, les variables mesurées concernent le diamètre de la tige, la hauteur et le nombre de feuilles de la plante, le taux de matière sèche et le temps de séchage des feuilles et à 78 jas, la diamètre de la tige principale, la hauteur de la plante, le taux de floraison, le nombre de rameaux latéraux, le poids total de 5 feuilles et le poids des limbes foliaires, le nombre et le poids total des feuilles par pied, le poids total en feuilles consommables et l'index de récolte, le taux de matière sèche et en fin le temps de séchage.

Pour chacune des espèces, toutes les données ont été saisies dans le logiciel EXCEL, les valeurs du taux de matière sèche (%) ont fait l'objet de transformation angulaire en utilisant la formule Arc sinus √%. Le logiciel de d'analyses statistiques multivariées R 1.6.1 a été utilisé [11]. Un quantidendrogramme généré à partir des données du bissap et des daisydendrogrammes générés à partir de celles du niébé, de l'amarante et du Nébéday.

En considérant les quatre espèces (bissap, niébé, amarante et Nébéday), la diversité génétique interspécifique des différentes localités à été étudiée. L'indice de diversité génétique de Richesse a été utilisé. Cet indice de diversité génétique définit le nombre d'accessions présentes dans la localité. Il combine la richesse de la localité en accessions et la probabilité de rencontrer l'accession ou l'espèce.

Résultats

Bissap (Hibiscus sabdariffa *L.*)

Les accessions de bissap se répartissent dans 4 groupes. Le groupe 1 renferme 21 accessions, le groupe 2 (9), le groupe 3 (3) et le groupe 4 (18). Le nombre de doublons s'élève respectivement à 7, 4, 1 et 7 pour les groupes 1, 2, 3 et 4. Le nombre total de doublons s'élève à 37 %. Il existe seulement 3 doublons sur 19 qui renferment des accessions collectées dans un seul site et les 16 doublons restant correspondent à du matériel collecté dans des endroits très distants atteignant parfois 800 km. Ce nombre relativement élevé de doublons montre le niveau relativement important d'échanges de semences entre productrices à l'échelle villageoise ou nationale. On note une certaine variabilité intra-spécifique caractérisée par la dissemblance observée entre 63 % des accessions (Figure 1).

Quatre des seize variables mesurées ont été choisies en vue de comparer les différents groupes de bissap. Il s'agit de la hauteur des plantes (hauteur), du poids des feuilles à l'état frais (pdsff), de la largeur des feuilles (largfeuille) et du taux de matière sèche (tms). Le choix de ces 4 variables s'explique par le fait que la hauteur est généralement corrélée à la productivité. Le poids des feuilles fraîches et le taux de matière sèche constituent des critères de productivité. La largeur des feuilles est également un critère de préférence des productrices, celles à grandes feuilles étant les préférées des productrices.

Du point de vue hauteur des plantes, le groupe 2 renferme des accessions avec des pieds de plus faible taille que les trois autres. Ces trois derniers semblent présenter des hauteurs de plantes sensiblement égales. On observe la même tendance sur la largeur des feuilles. Alors que le taux de matière sèche ne semble pas présenter de différence entre les groupes. Le poids des feuilles à l'état frais montre une dominance du groupe 3, suivi du 2 et 4. Alors que le groupe 1 présente la production la plus faible.

L'utilisation de l'Indice de diversité de Richesse montre que les marchés de Diaobé et de Matam sont les deux localités où on observe la plus grande diversité génétique en d'autres termes une plus grande chance de collecter des échantillons lors d'une prochaine mission. Ces deux premiers marchés sont suivis de ceux de Tamba et Missira (Figure 2). Cette grande diversité dans ces marchés pourrait s'expliquer par le fait qu'il s'agit de lieux d'échanges de semences, et ils se situent dans des localités relativement pluvieuses qui sont habitées par des populations productrices et consommatrices de feuilles [12].

A cela s'ajoute le fait que la plupart des productrices rencontrées achètent les semences dans les marchés. Un autre aspect important est le fait que le marché de Diaobé à un caractère non seulement national mais également sous régional. De par leurs caractéristiques agro-morphologiques dont certaines recoupent les critères de préférence des productrices (larges feuilles vertes, productivité, etc.), les pieds ps7 (ou L7) et ps28 (ou L28) appartenant au groupe 1 et ps24 (ou L24) du groupe 4 ont été sélectionnés et feront l'objet d'évaluation ultérieure.

Niébé (Vigna unguiculata (*L.*) *Walp*)

On distingue 8 groupes ou classes et le nombre de doublons représente 37 % des accessions (Figure 3). Le groupe 8, suivi des groupes 3 et 4 présentent une hauteur moyenne relativement supérieure aux autres. En terme de production de feuilles fraîches, le groupe 2 est supérieur aux autres ; il est suivi des groupes 3, 4 et 5. Le groupe 6 a la plus faible production.

Le taux de matière sèche et la largeur des feuilles ne semblent pas présenter une différence. Alors que du point

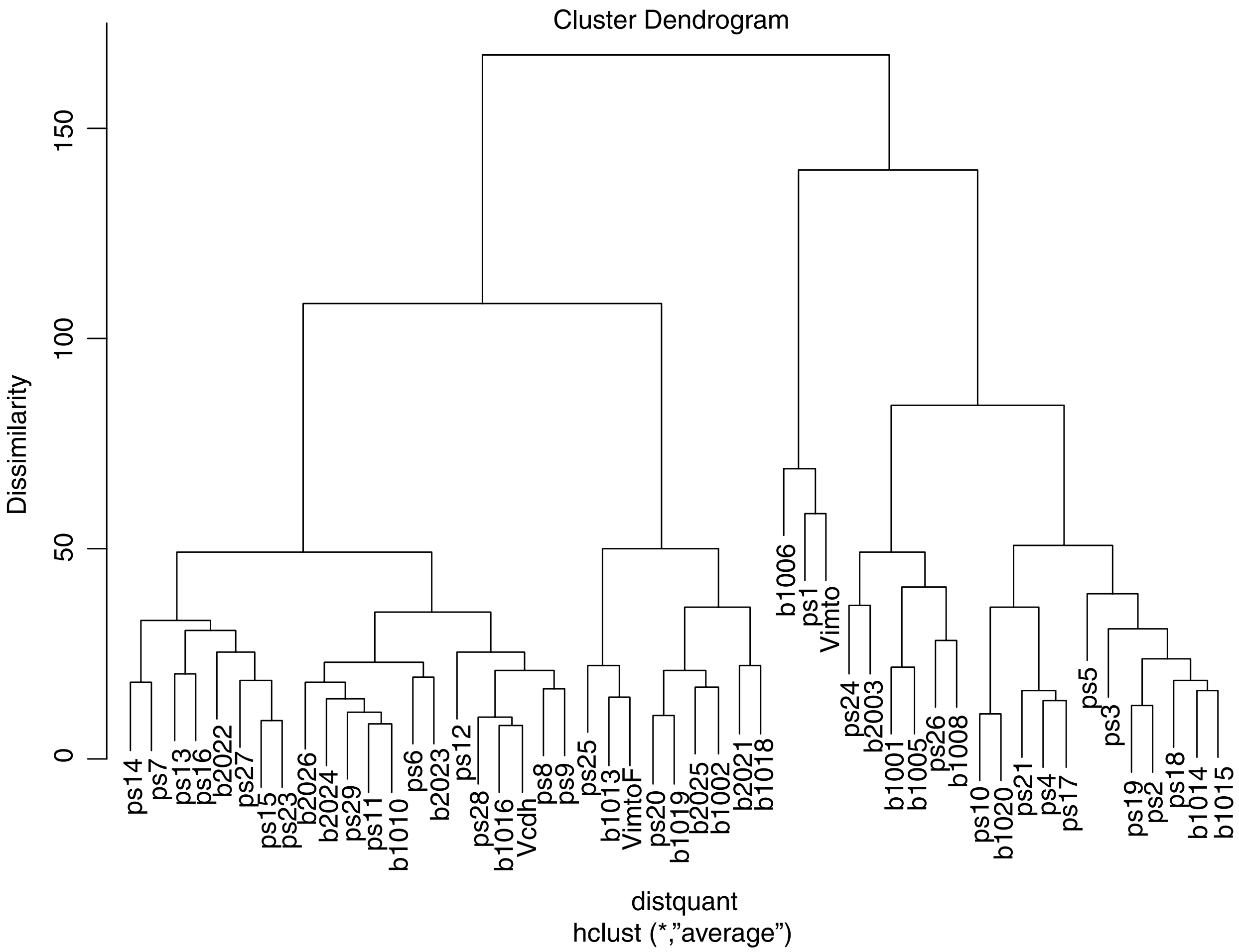

Figure 1: Quantidendendrogramme des acceesions de bissap

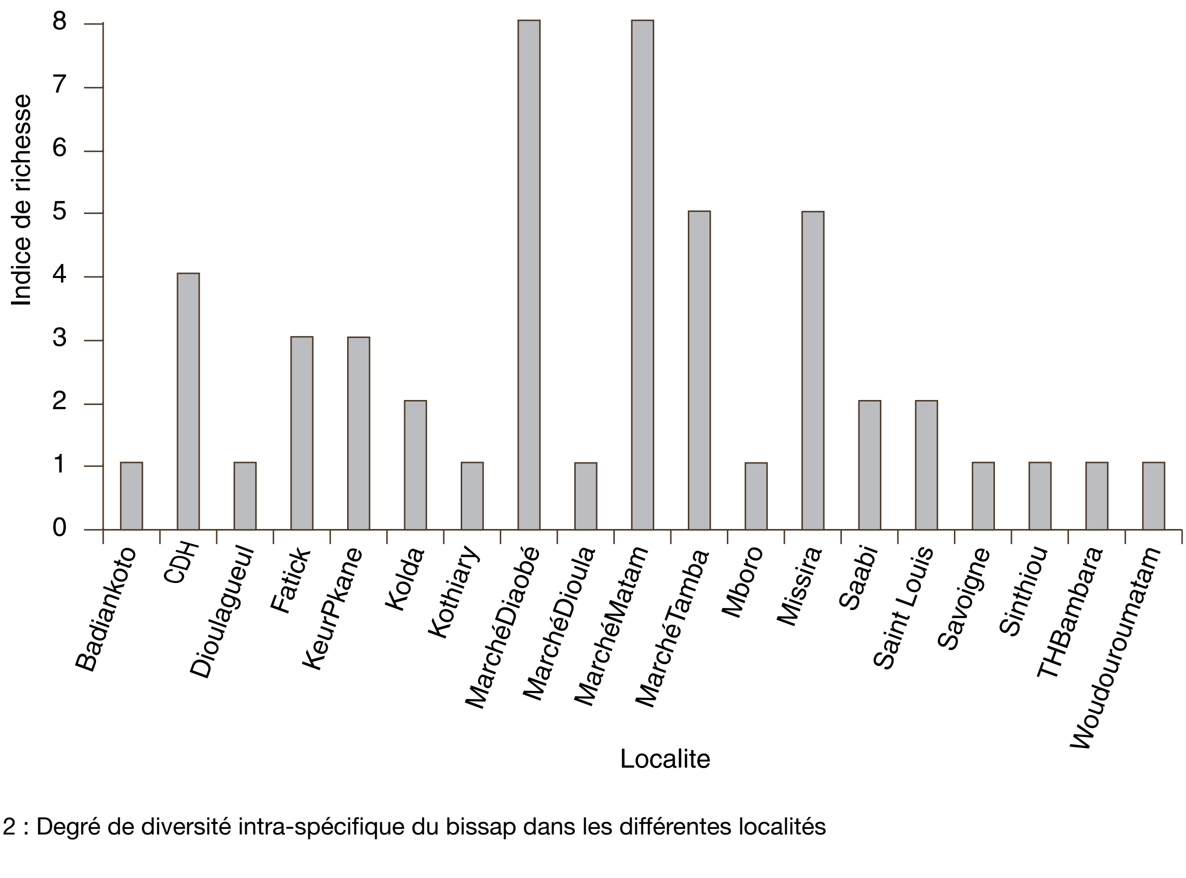

Figure 2 : Degré de diversité intra-spécifique du bissap dans les différentes localités

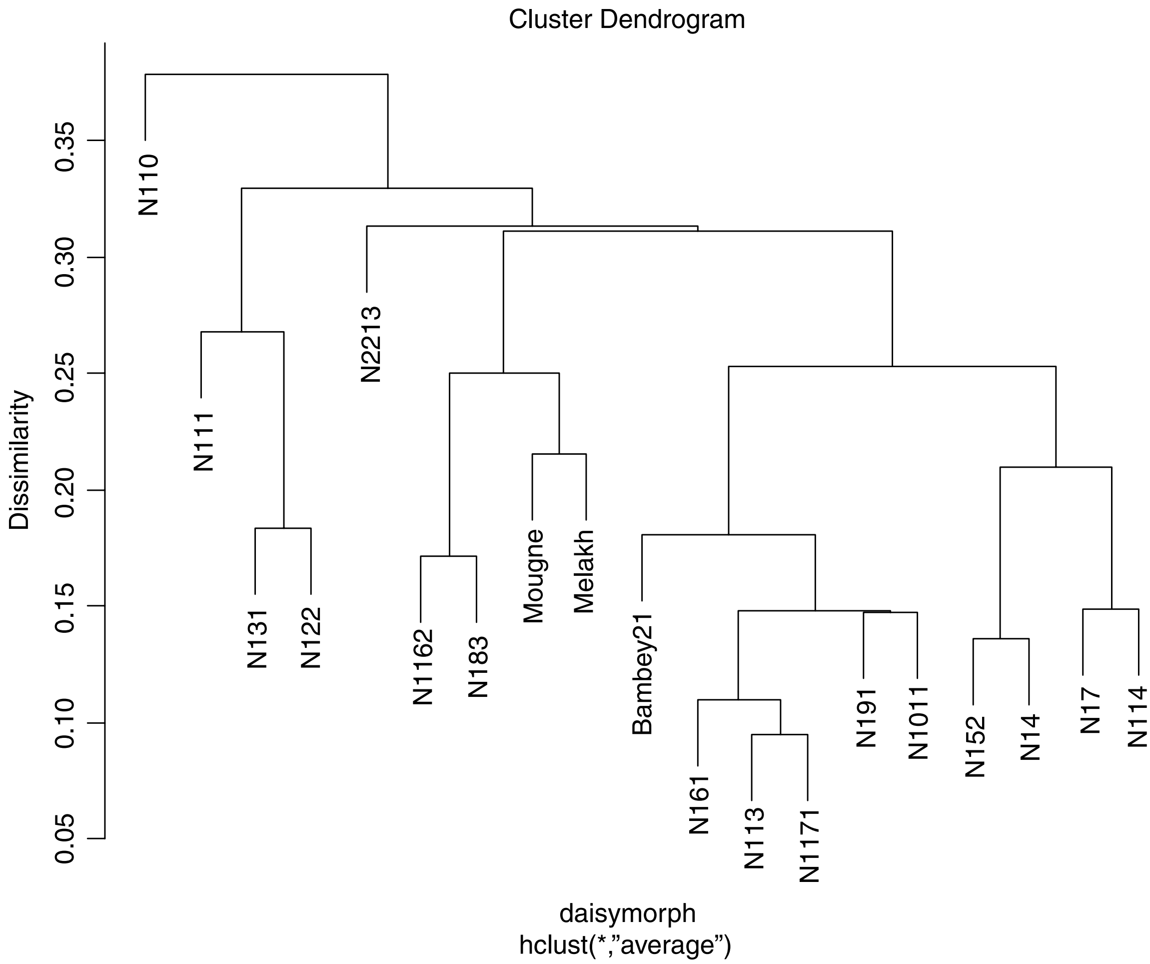

Figure 3: Daisydendrogramme des accessions de niébé

de vue nombre de nodules fixateurs d'azote par plante, les groupes 3 et 5, suivis du groupe 2 et 6 semblent présenter une capacité de nodulation supérieure. Les groupes 1, 4 et 7 ayant le niveau de nodulation le plus faible. En se référant aux critères de préférence des productrices (port érigé, feuilles vertes, tardiveté, etc.), les 7 pieds sélectionnés sont : N111 (ou Kolda11), N183 (ou YelingaraGF), Mougne, Bambey21 (ou Bambèye 21), N191 (ou Fatick9), N1O11 (ou Kolda 1) et N17 (ou YélingaraPF).

Amarante (Amaranthus *L. spp.*)

On distingue 6 groupes ou classes et le nombre de doublons représente 33 % (3/9*100) des accessions (Figure 4). L'analyse de ce graphique révèle un aspect relativement intéressant dans la gestion paysanne des semences. Si l'on sait que AFaroTamba1, AFaroTamba2 et AFaroTamba3 sont des lots différents prélevés au même endroit à partir de trois productrices de parcelles contiguës, on peut dire qu'elles cultivent un mélange de variétés traditionnelles et parfois même d'espèces.

En outre, il existe un flux très important d'échange de semences entre elles, car certains doublons (AFaroTamba2/AhamadiNoba et Adioulagueul/Amissira) sont composés d'accessions prélevées sur des distances pouvant atteindre 100 km. Il reste cependant que seules des études plus poussées au niveau moléculaire pourraient permettre de confirmer ou infirmer l'existence de ces doublons.

Les accessions AFaroTamba2 (ou Tamba4), AhamadiNoba (ou Tamba5), AVRDC1 (ou AVRDC) et AFaroTamba3 (ou Tamba7) ont été sélectionnées. Il s'agit de types ayant les caractéristiques de préférence des femmes productrices, à savoir larges feuilles et/ou type vert.

Nébéday (Moringa oleifera *Lam*)

On distingue 4 groupes ou classes et le nombre de doublons représente 33 % des accessions (Figure 5). On note que MAVRDC se détache complètement des autres accessions.

Les doublons (MCDH/MKothiary et MTamba/MDiourbel) renferment des accessions prélevées à des distances atteignant plus de 600 km. Cette observation nous amène à deux hypothèses : soit les semences ont été échangées ou les variables mesurées ne permettaient pas de mettre en évidence un certain niveau de dissimilarité entre ces accessions ou provenances. Seules des études au niveau moléculaire pourraient permettre d'apporter la lumière.

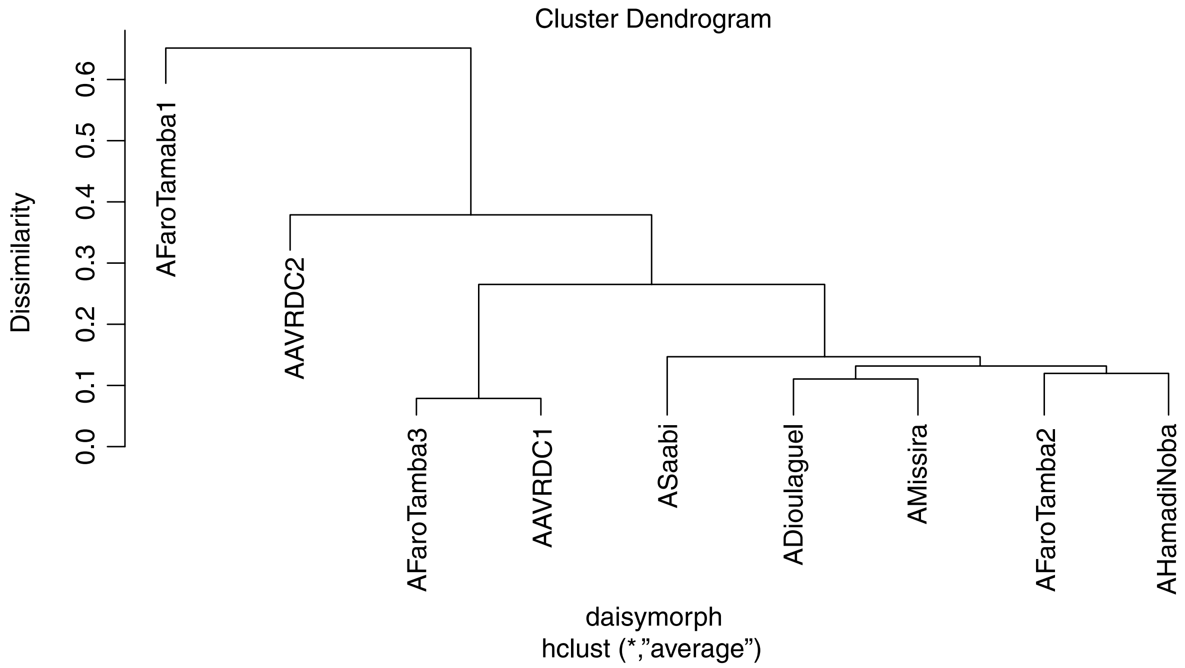

Figure 4: Daisydebrogramme des accessions de l"amarante

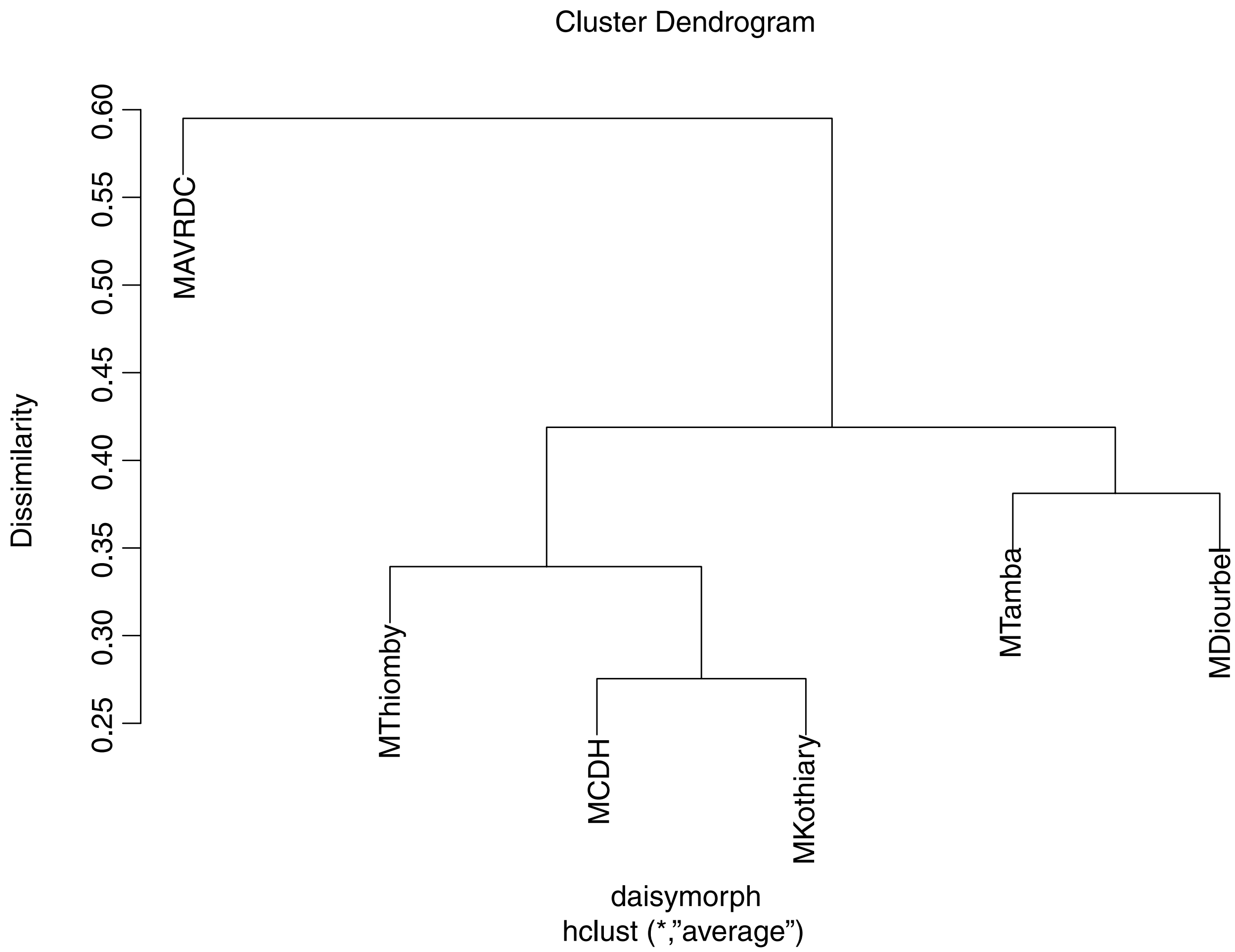

Figure 5: Daisydendrogramme des accessions de Nébéday

Les accessions ou provenances MAVRDC, MCDH et MKothiary ont été sélectionnées sur la base des critères des productrices et feront l'objet d'évaluation ultérieure.

Etude de la diversité inter-spécifique des localités

Les résultats de l'indice de Richesse ont permis d'évaluer le niveau de diversité inter-spécifique des localités visitées. A l'analyse du graphique, 55 % des localités sont sous haute menace d'érosion génétique, 27 % sont sous moyenne menace et 18 % sont sans risque d'érosion génétique (Figure 6).

Discussion

Au Sénégal, 54 % des ménages sénégalais vivent en dessous du seuil de pauvreté [13]. Près de 38 espèces végétales sont consommées au Sénégal pour leurs feuilles [12]. Ces légumes feuilles sont fortement consommés (23 $g^{-1}pers^{-1}j^{-1}$) et peuvent contribuer jusqu'à 100 % dans le revenu de certains ménages sénégalais [12]. Les femmes et les enfants en banlieues des grandes villes sont les plus touchés par la pauvreté. Les femmes sont les principaux acteurs de la production. Le développement de la production des légumes feuilles est cependant limité par un certain nombre de contraintes dont l'une des plus importantes est l'accès à des semences de qualité et en quantité. L'accès à ces semences nécessite une disponibilité d'une base génétique large, en d'autres termes, une grande diversité génétique. Cette dernière passe principalement par la collecte, la caractérisation, la conservation et la sélection de nouvelles variétés de façon participative. La conservation du germoplasme suppose une étroite collaboration entre les organisations de producteurs et les institutions de recherche (ou entre le paysan et le chercheur) [14].

Cela suppose l'organisation préalable de plusieurs rencontres entre paysans et techniciens de la recherche. C'est sans nul doute pour cette raison que le matériel qui a fait l'objet de caractérisation provient de plusieurs missions de collectes avec comme outil méthodologique l'approche participative. Cette dernière a nécessité une forte implication des femmes productrices de légumes feuilles. Les rencontres avec ces femmes ont permis de déterminer les principales caractéristiques morphologiques distinctives des accessions mais également les critères de préférences des femmes utilisatrices se rapportant à la morphologie ou au goût des feuilles après cuisson [15]. L'approche participative utilisée vise à montrer que la meilleure implication des paysans se manifeste par leur participation dans le processus de sélection et que la participation de la communauté est centrale pour la conservation de l'agro-biodiversité [16]. Ils ont précisé que la capacité des populations locales à améliorer la diversité génétique (c'est à dire chercher, sélectionner et échanger) est un élément important dans l'agriculture durable. L'échange

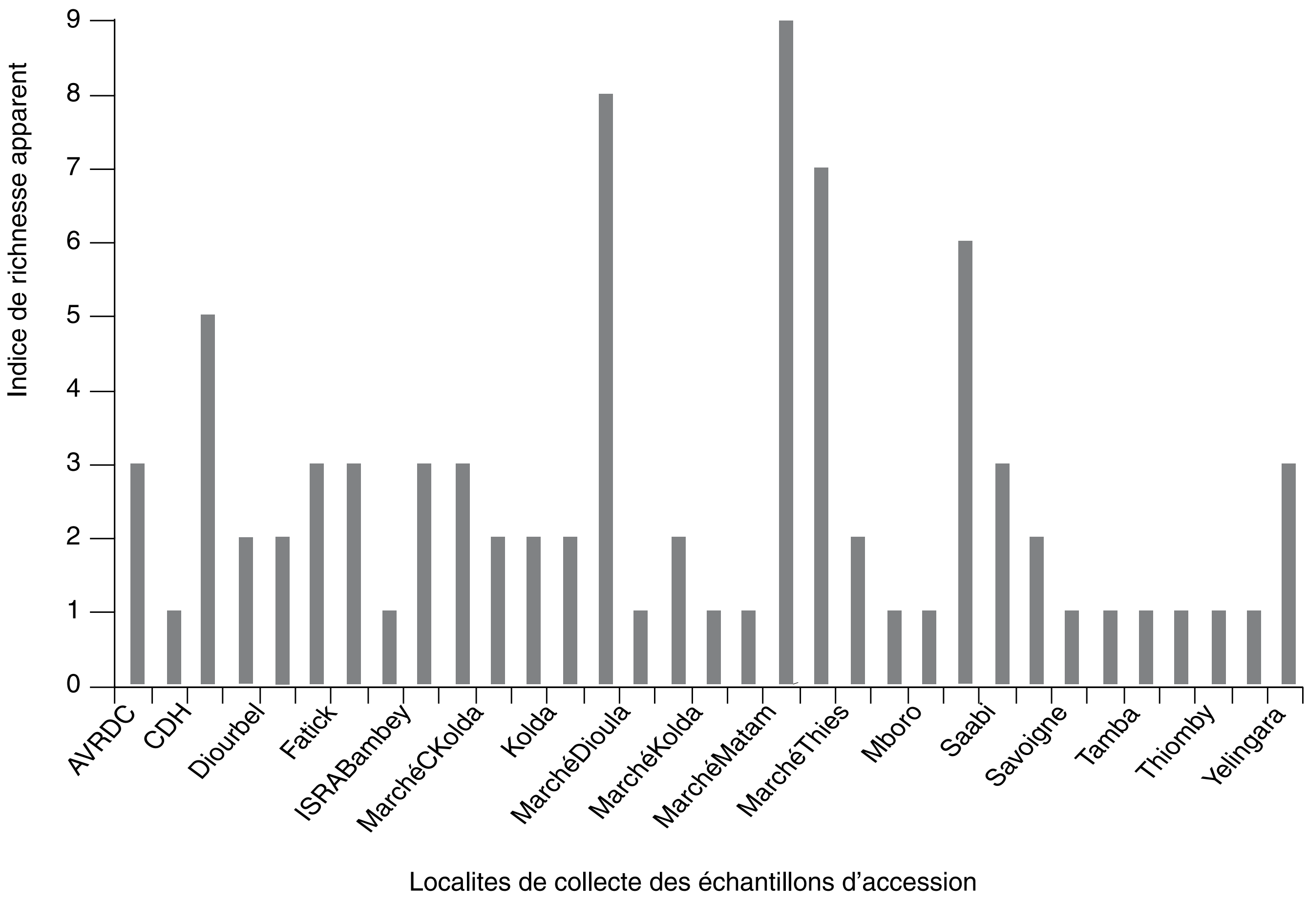

Figure 6: Diversité interspécifique dans les différentes localités visitées

de gènes (semences) a été observé dans le cas du bissap, du Nébéday et de l'amarante [16]. Pour ces trois espèces, des doublons d'échantillons de semences collectées sur des distances de 800 km (bissap), 600 km (Nébéday) et 100 km (amarante) ont été observés.

L'intérêt de la caractérisation du matériel collecté a été très important [3]. Les résultats ont montré que 55 % des localités sont sous haute menace d'érosion génétique. Ceci vient confirmer les besoins de caractérisation à des fins de conservation [3]. La caractérisation a permis d'identifier les doublons (bissap et niébé (37 %) et amarante et Nébéday (33%)) et de réduire la taille de l'échantillon à conserver et les coûts de conservation (*in situ* ou *ex situ*) [17].

Conclusion

La caractérisation agro-morphologique des accessions des 4 espèces de légumes feuilles traditionnels de type africain a permis de mieux connaître les phénotypes des échantillons de semences collectées et d'identifier les individus renfermant les caractères de préférence des femmes productrices. Cette caractérisation a aussi a mis en évidence la variabilité inter et intra-spécifique, mais également le mouvement de gènes par l'échange de semences intra et inter-localités sur des distances pouvant atteindre 800 km. Les marchés restent le principal lieu d'échange de semences. L'identification des doublons va aider à la mise en place d'une bonne stratégie de conservation *ex situ* des accessions. Cependant, il faut noter que cette caractérisation agro-morphologique devrait être complétée par des études plus approfondies notamment sur le plan biochimique et moléculaire pour permettre d'infirmer ou de confirmer nos résultats. L'accroissement du nombre d'accessions des différentes espèces et l'utilisation des différentes méthodes de caractérisation pourront contribuer à l'établissement de *core collection*, qui reste la meilleure stratégie de conservation du germoplasme.

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The diversity of cultivated African leafy vegetables in three communities in Western Kenya

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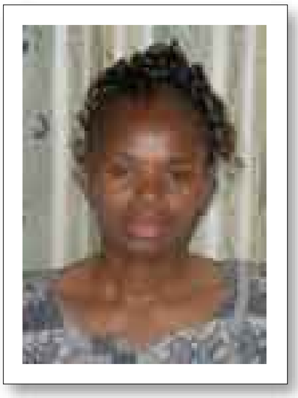

Mary Abukutsa-Onyango

Abstract
High poverty levels in western Kenya are manifested in malnutrition and poor health yet the region is endowed with high agricultural biodiversity like African leafy vegetables (ALVs). The vegetables have high micronutrient content, medicinal properties, several agronomic advantages and economic value yet their potential in alleviating poverty and ensuring household food and nutrition security in the rural areas has not been exploited.

Despite all the above advantages, these vegetables have been neglected and face several constraints hampering optimal production such that if the situation is left unchecked it may result in loss of this biodiversity. It is for these reasons that a study was conducted with the objectives of documenting the diversity of ALVs and to collect indigenous knowledge on production, agronomic and cultural practices in three communities of Western Kenya. A survey was conducted between January 2002 and March, 2003, in six districts in Western and Nyanza provinces representing the Luhya, Luo and Kisii communities.

A structured questionnaire was administered to 80 purposively sampled respondents distributed in the ratio of 30:20:30 for Luhya, Luo and Kisii communities respectively. One focus group discussion per community was held and two key informants per community were interviewed. Over 90% of the respondents indicated that there was an increase in the cultivation of ALVs. Ten ALVs were found in the three communities representing eight botanic families. All the communities cultivated the ALVs at a subsistence level in home gardens, with organic sources of manure and under an intercrop system. Broadcasting was practised by 20%, 40% and 60% of the respondents from the Luhya, Luo and Kisii communities respectively.

Harvesting was done by first uprooting at thinning, then ratooning. The major constraints facing production of ALVs included lack of quality seed, pests and diseases, drought, poor marketing strategies and lack of technical packages. In conclusion, the study showed that all the three communities studied had a high diversity of cultivated ALVs covering eight botanic families; respondents in all the communities cultivate ALVs in a subsistence, home gardening, intercrop system where the use of chemical fertilizers and chemicals was minimal and the major constraints of production of ALVs included poor quality seed, drought, poor marketing systems and infrastructure. The identified species should be promoted and improved as commercial crops.

Key words: diversity, cultivation, African leafy vegetables

Introduction
Over 50% of people in rural communities in western Kenya have been reported to be living below the poverty line, thus living on less than one dollar a day [1]. Poverty normally manifests mainly in malnutrition and poor health which can be ameliorated by consumption of African leafy vegetables (ALVs) [2] The poverty situation has been worsened by the prevalence of HIV/AIDS and data from National HIV/AIDS Control Council of 2004 indicate that 2.5 million Kenyans are infected with about 200,000 new infections per year and yet the region is endowed with agricultural biodiversity that includes ALVs [3, 4]. These vegetables could contribute significantly in the management of the HIV/AIDS infected and affected persons.

ALVs are African indigenous or traditional vegetables whose leaves, young shoots and flowers are consumed [5, 6]. These vegetables have been used by communities in western Kenya for a long time [7]. There has been a renewed interest in ALVs by the policy makers and the international community on the realization that these vegetables have a potential that has yet to be exploited [8]. There is empirical evidence that ALVs have several advantages and values that include high micronutrient content, medicinal properties, several agronomic advantages and contribute to food and nutrition security and income generation [9, 10].

ALVs contain high levels of vitamin A, vitamin C, iron, calcium and protein and are a valuable source of nutrition in rural areas where they contribute substantially to protein, mineral and vitamin intake [11]. They are compatible to use with starchy staples and represent affordable nutrition to the poor sector in the population. Fresh leaves of most ALVs like vegetable amaranths, Slenderleaf, Spiderplant, vegetable Cowpeas, pumpkin leaves and Jute mallow contain more than 100% of the recommended daily allowances for vitamins and minerals and 40% proteins for growing children and lactating mothers [12, 13].

Many ALVs especially the sour or bitter ones like Spiderplant, Slenderleaf and African nightshades have been reported to heal stomach-related ailments [9, 14]. Agronomic advantages of ALVs include: short growth period, where some of these vegetables are ready for harvest within 3-4 weeks; the ability to produce seed under tropical conditions; they respond well to organic fertilizers and can tolerate both biotic and abiotic stress [6, 15]. A market survey conducted in Kakamega municipal market showed that ALVs constituted 20% in value of the traded produce during the period of study [16]. Socio-economic surveys conducted in various parts of Africa indicate that ALVs are important commodities in household food and nutrition security [10].

Women are known to be actively involved in the cultivation, processing and marketing of ALVs. In a market survey conducted in 2001 in two rural and one municipal market in western Kenya, women constituted 95% and 70% of the respondents in the rural and municipal markets, respectively [16]. Despite the many advantages, ALVs have been neglected for a long time to the extent that some have become extinct and if this trend goes unchecked, there is a possibility that all could be lost. Promoting their production and utilization will ensure conservation by utilization, in which case if there is consumer demand for ALVs, then production will be sustained to meet the demand, thereby avoiding the threat to their extinction.

ALVs have not been fully exploited for food, nutrition and economic security, to alleviate poverty in Kenya and the Lake Victoria region. Some of the major constraints of production of ALVs include poor quality seed, lack of production and utilization packages, and poor marketing and processing strategies. ALVs normally face stiff competition with exotic vegetables like cabbage, spinach, exotic kale and lettuce, among others [17].

The cultivation of ALVs in many Western Kenyan communities has always been done at a subsistence level and their potential as commercial commodities has not been exploited [4, 18]. To address some of the Millennium Development Goals that pertain to poverty, health, food and nutrition security for the African continent, interventions must include the neglected African indigenous plants. Improving the quality and production of ALVs could be one of the powerful strategies to alleviate hunger, malnutrition and poor health in the region. It is, therefore, paramount to know the diversity of ALVs in the region and collect indigenous knowledge that could be useful in developing agronomic and utilization packages for improved production and utilization.

Objectives

- Document the diversity of African leafy vegetables in three communities in Western Kenya.
- Collect indigenous knowledge on production, agronomic and cultural practices of African leafy vegetables in three communities of Western Kenya.

Materials and methods

The study was conducted between January 2002 and March 2003, in six districts of two provinces that represent three communities in Western Kenya. The choice of study sites was on the basis that these communities have cultivated and consumed ALVs for long, yet they have not fully exploited their potential as an economic venture, despite people from these sites living in abject poverty. The six districts included Vihiga and Butere/Mumias districts in Western Province representing the Luhya community, Kisumu and Siaya districts in Nyanza Province representing the Luo community and Kisii and Nyamira districts also in Nyanza Province representing the Kisii community.

From these districts, respondents were purposively sampled on the basis of their growing the ALVs. Eighty structured questionnaires were administered to respondents in the various communities as follows: Luhya community – 30 respondents; Luo community – 20 respondents; and Kisii community – 30 respondents. Questionnaires were administered by research assistants who spoke the local languages.

The research assistants actually translated the questions into appropriate languages as they administered the questionnaire. In addition, one Focus Group Discussion (FGDs) was held in each community as was a discussion with two key informants per community from the two districts for each community. Key informants included agricultural extension officers and local community leaders.

Information captured in the questionnaire included crops grown and the percentage land allocated to ALVs, the list of ALVs cultivated by the respondents, the agronomic practices, farming system and location of the farm, any ALVs they ate in the past and is no longer available, the preferred ALVs and the major constraints in the production of ALVs. The focus group discussions and key informants were used to reconfirm what was indicated in the structured questionnaires.

Data collected from the study were analyzed by both qualitative and quantitative methods. The quantitative approach was used to discuss data from focused group discussions and key informants. Descriptive statistics were used to explain the quantitative part where percentages of the various responses were used and presented in the form of tables.

Results

Diversity of African leafy vegetables in three communities in Western Kenya

Tables 1, 2 and 3 show ALVs that are grown and consumed in Luhya, Luo and Kisii communities respectively. In each of the communities, respondents mentioned at least ten ALVs that were grown although the degree and intensity of cultivation varied with the community. The number of ALVs species grown and used by all (100%) respondents was six, nine and one for the Luhya, Luo and Kisii communities respectively (Tables 1, 2 and 3).

In some cases the same local name was used for the different species but of the same genus. Spiderplant (*Cleome gynandra*) was the only vegetable that was grown by all the respondents from the three communities as shown in Table 4. Table 4 also shows that the top 10 priority ALVs in the three communities studied were: *Cleome gynandra, Solanum villosum, Cucurbita moschata, Vigna unguiculata, Amaranthus blitum, Corchorus olitorius, Solanum scabrum, Crotalaria ochroleuca Crotalaria brevidens* and *Brassica carinata* representing seven botanic families: Amaranthaceae, Brassicaceae, Capparaceae, Cucurbitaceae, Fabaceae, Solanaceae and Tiliaceae.

Luhya and Luo communities had nine ALVs that were grown by 90% or more of the respondents while the Kisii community had only two in that category.

When asked to name any ALV that was consumed in the past but is no longer in use, no respondent enlisted such a vegetable in Kisii District. In the Luhya community 25% of the respondents listed four lost or rare ALVs as "indelema" (*Basella alba*), "linyolonyolo" (*Commelina africana*), "esirietso" (*Erythrococa atroviriens*) and "esitipa" (*Asytasia mysorensis*). Four lost or rare ALVs in the Luo community were identified by 20% of the respondents as "atipa" (*Asytasia mysorensis*), "achak" (*Launaea cornuta*), "onyulo" (*Sesamum calycinum*) and "odielo" (*Commelina africana*). When asked to name the ALVs that the respondent preferred, in the Kisii community, 65% of the respondents named Spiderplant (*Cleome gynandra*) and 35% named African nightshade (*Solanum villosum*). In the Luhya community, the preferred ALVs were Spiderplant (*Cleome gynandra*–30%), Cowpeas (*Vigna unguiculata*–30%), Slenderleaf (*Crotalaria brevidens/ochroleuca*–30%) African nightshades (*Solanum scabrum*–5%) and Jute mallow (*Corchorus olitorius*–5%), while the Luo community enlisted Cowpeas (*Vigna unguiculata*–35%), Spiderplant (*Cleome gynandra*–30%), Slenderleaf (*Crotalaria brevidens/ ochroleuca*–25%) and Jute mallow (*Corchorus olitorius*) and African nightshades (*Solanum scabrum*) (each 5%).

Indigenous knowledge on production, agronomic and cultural practices of African leafy vegetables in Western Kenya

In Luhya, Luo and Kisii communities, women made up 80%, 95% and 50% of the respondents. Land parcels owned by farmers varied from 0.5-5 hectares, 1.5-10 hectares and 0.5-5 hectares for the Luhya, Luo and Kisii communities respectively

Table 1: African leafy vegetables found in Vihiga and Butere/Mumias districts (Luhya community)

No.	Luhya name	Swahili name	Common English name	Scientific name	Percent
1	Tsisaka	Mgagani	Spiderplant	*Cleome gynandra*	100
2	Likhubi	Kunde	Cowpeas	*Vigna unguiculata*	100
3	Lisutsa	Mnavu	African nightshade	*Solanum villosum*	100
4	Emiro	Marejea	Slenderleaf	*Crotalaria ochroleuca*	100
5	Omurere	mlenda	Jute mallow	*Corchorus olitorius*	100
6	Lisebebe	Malenge	Pumpkin leaves	*Cucurbita moschata*	100
7	Lisutsa	Mnavu	African nightshade	*Solanum scabrum*	90
8	Libokoi	Mchicha	Vegetable amaranths	*Amaranthus blitum*	90
9	Emiro	Marejea	Slenderleaf	*Crotalaria brevidens*	90
10	Kanzira	-	African kale	*Brassica carinata*	50
11	Indelema	-	Vine spinach	*Basella alba*	03

Table 2: African leafy vegetables found in Kisumu and Siaya districts (Luo community)

No.	Luo name	Swahili name	Common English name	Scientific name	Percent
1	Dek	Mgagani	Spiderplant	*Cleome gynandra*	100
2	Alot-boo	Kunde	Cowpeas	*Vigna unguiculata*	100
3	Ododo	Mchicha	Vegetable amaranths	*Amaranthus blitum*	100
4	Osuga	Mnavu	African nightshade	*Solanum scabrum*	100
5	Osuga	Mnavu	African nightshade	*Solanum villosum*	100
6	Mitoo	Marejea	Slenderleaf	*Crotalaria brevidens*	100
7	Mitoo	Marejea	Slenderleaf	*Crotalaria ochroleuca*	100
8	Apoth	Mlenda	Jute mallow	*Corchorus olitorius*	100
9	Budho	Malenge	Pumpkin leaves	*Cucurbita moschata*	100
11	Kandhira	-	African kale	*Brassica carinata*	60

Table 3: African leafy vegetables found in Kisii and Nyamira districts (Kisii community)

No.	Kisii name	Swahili name	Common English name	Scientific name	Percent
1	Chinsaga	Mgagani	Spiderplant	*Cleome gynandra*	100
2	Rinagu	Mnavu	African nightshade	*Solanum villosum*	90
3	Omuongo	Malenge	Pumpkin leaves	*Cucurbita moschata*	45
4	Egesare	Kunde	Cowpeas	*Vigna unguiculata*	40
5	Emboga	Mchicha	Vegetable amaranths	*Amaranthus blitum*	40
6	Rinagu	Mnavu	African nightshade	*Solanum scabrum*	30
7	Omotere	mlenda	Jute mallow	*Corchorus olitorius*	25
8	Enderema	-	Vine spinach	*Basella alba*	06
9	Mitoo	Marejea	Slenderleaf	*Crotalaria ochroleuca*	06
10	-	Sukuma ya kiasili	African kale	*Brassica carinata*	00

Table 4: Ten priority African leafy vegetables in Luhya, Luo and Kisii communities in Western Kenya

No.	Name	Botanical families	Luhya	Luo	Kisii	Total
1	Spiderplant	Capparaceae	100	100	100	300
2	African nightshade *(S.villosum)*	Solanaceae	100	100	090	290
3	Pumpkin leaves	Cucurbitaceae	100	100	045	245
4	Cowpeas	Fabaceae	100	100	040	240
5	Vegetable amaranths	Amaranthaceae	090	100	040	230
7	Jute mallow	Tiliaceae	100	100	025	225
	African nightshade *(S.scabrum)*	Solanaceae	090	100	030	220
8	Slenderleaf *(C.ochroleuca)*	Fabaceae	100	100	006	206
9	Slenderleaf *(C. brevidens)*	Fabaceae	090	100	000	190
10	African kale	Brassicaceae	050	060	000	110

and the percentage of land allocated to ALVs varied from 5-30% (Table 5). The Kisii community had 20% of the respondents allocating 25% or more of land to growing ALVs.

All the respondents stated that they were growing the vegetables for both consumption and for sale. Over 90% of the interviewed farmers in all the communities studied observed that there had been an increase in the cultivation of ALVs as a result of increased demand and awareness campaigns. Although the increase in demand was noted, all the respondents were growing the vegetables in home gardens for ease of management and these were grown as intercrops with

Table 5: Land allocated to African leafy vegetables in three communities in Western Kenya

No	% land under ALVs	% of interviewed farmers		
		Luhya	Luo	Kisii
1.	30	-	-	10
2.	25	-	-	10
3.	20	10	-	25
4.	15	25	40	25
5.	10	45	30	18
6.	5	20	30	12
Total		100	100	100

cereals, legumes, root crops and in certain cases, fruit trees. The crops with which the ALVs were intercropped included maize, millet, sweet potatoes, kale, beans, avocado, cassava, groundnuts or bananas.

Land preparation, planting and weeding were effected using hand hoes and pangas. Planting was done by drilling in rows or broadcasting and thinning after 4-5 weeks. In Luhya, Luo and Kisii communities 20%, 40% and 60% respectively broadcasted the seeds during planting. All the respondents in all the three communities used farm yard manure as a source of macro and micro nutrients and used wood ash to control pests. It was only in the Luo and Kisii communities where one respondent in each case was using Diammonium Phosphate and Urea, respectively.

The planting was done twice a year in all the six districts during the long rains (March-July) and the short rains (September-December). Harvesting was reported to start 4-5 weeks after sowing, at thinning time and thereafter harvesting was done weekly by removal of young shoots resulting in subsequent ratoon crops. This type of harvesting could go on for a period of three months, then another two months for seed maturity. Most of the farmers depended on rainfall and only 20% of farmers from the Luo community practised irrigation using watering cans.

Major constraints facing production of African leafy vegetables in Western Kenya

The major constraints identified by respondents from the three communities included:

- Poor seed quality
- Pests and diseases
- Drought
- Poor marketing channels
- Transport to markers
- Lack of agronomic and utilization packages

Discussion

Diversity of African leafy vegetables in three communities in Western Kenya

Ten ALV species were found to be cultivated in the three communities in Western Kenya and these included *Cleome gynandra, Solanum villosum, Cucurbita moschata, Vigna unguiculata, Amaranthus blitum, Corchorus olitorius, Solanum scabrum, Crotalaria ochroleuca Crotalaria brevidens* and *Brassica carinata* representing seven botanic families namely Amaranthaceae, Brassicaceae, Capparaceae, Cucurbitaceae, Fabaceae, Solanaceae and Tiliaceae. This finding is in line with the market survey report which indicated that the top eight ALVs in Western Kenya were *Cleome gynandra, Solanum villosum, Cucurbita moschata, Vigna unguiculata, Amaranthus blitum, Corchorus olitorius, Crotalaria ochroleuca* and *Brassica carinata*. [10, 16].

Results from an earlier study in Kisii indicated that *Cleome gynandra* and *Solanum villosum* were the two ALVs with prominence followed by *Cucurbita carinata* and *Vigna unguiculata* which agrees with the findings of this study as the first four ALVs of importance in Kisii, although not in the same order [18].

Luhyas, Luos and Kisiis have been reported to have an extraordinarily high number of species used as vegetables, an indication of food production systems that evolved with emphasis on vegetable cooking [7]. Different communities display a combination of economic pursuits but one of them will be prominent and these pursuits include crop farming, pastoralism and hunting/gathering/fishing.

Luhyas, Luos and Kisiis have been placed on agricultural and mixed farming economic systems with medium to low dependence on wild plants and animals, and this explains why there is a high diversity in ALVs [7]. The lost or rare species of the African indigenous vegetables in the Luhya and Luo communities included *Basella alba, Commelina Africana, Erythrococa atroviriens*, *Asytasia mysorensis, Launaea cornuta* and *Sesamum calycinum*.

These are mainly species which were normally collected from the wild during periods of scarcity without any formal cultivation or occurred as weeds in cereal crops and taken advantage of [4, 18]. *Basella alba* was normally found in valleys where there were water sources or streams and small rivers, and since it is a perennial vine it has played a vital role in food and nutrition security, particularly during the dry periods [19].

As for the preferred ALVs in the three communities — Spiderplant, African nightshade, Cowpeas, Slenderleaf, and Jute mallow — the respondents argued that these vegetables were nutritious and made them strong. Spiderplant, African nightshades and Slenderleaf were said to have medicinal properties and could heal ailments relating to the stomach. These ALVs that have medicinal attributes are usually sour or bitter and have been reported to contain secondary metabolites like the alkaloids, oxalates and other phenolic compounds that could be responsible for not only the bitterness but also the healing properties [10, 12]

Indigenous knowledge on production, agronomic and cultural practices of African leafy vegetables in Western Kenya

ALVs were reportedly grown mainly in home gardens, mostly within the homestead. These are areas where the management practices are easier and the use of farm yard manure is facilitated [5]. Although in this study all the farmers indicated that they grow their ALVs in home gardens, the hardy species like Cowpeas and Slenderleaf could be grown in main cropping lands as intercrops as they have been shown to do well with nutrient-poor soils and with less water [20]. Another reason why farmers grow ALVs in homesteads is for protection from animals and thieves [4, 18].

Intercropping as a farming system is where two or more crop species are grown on the same piece of land [21]. Intercropping has several advantages that include having diversity of crops in a given season, and optimal utilization of resources like nutrients, water and light, especially if the intercrops have different growth patterns [22, 23]. Intercrops can be planted with crops that have different maturity dates. Farmers in the three communities have indigenous knowledge that agrees with the established fact that intercropping is advantageous.

However, to assess the benefits of intercropping, Land Equivalent Ratio (LER) for any pair of intercrops must be established. LER compares the yields from an intercrop with that from monocrop at the same level of management [22] and is calculated as follows LER= (intercrop1/monocrop1) + (intercrop2/monocrop2) if the LER>1 then the intercropping of the crops in question is suitable. Some work on intercropping ALVs with cereals has been reported. LER of intercrop of Slenderleaf (*Crotalaria brevidens)* and finger millet (*Eleusine coracana*) was greater than one, indicating that they are suitable intercrops. Other suitable intercrops reported include Spiderplant (*Cleome gynandra)* with maize (*Zea mays)* and African nightshade (*Solanum villosum)* with maize (*Zea mays)* [17].

It is amazing that all the farmers that were involved in the study were using organic manure as a source of nutrients and wood ash to control pests. The current global trend is to encourage the use of environmentally-friendly farming methods by avoiding the use of chemicals that are harmful not only to the environment but also to the consumers. The use of organic sources of manure like farmyard manure and wild sunflower (*Tithonia diversifolia*) leaves for growing ALVs found in Western Kenya has proven useful [17, 24]. Organic sources of manure, besides providing nutrients to the crop plants, also improve the structure of the soil and give residual effects on subsequent crops [25].

Major constraints facing production of African leafy vegetables in Western Kenya

Poor seed quality, pests and diseases, drought, poor marketing channels, transport to markets, and lack of agronomic and utilization packages are among the major constraints that hinder optimal production of ALVs. In addition to the above, Schippers lists perishability, neglect and lack of awareness of the merits of ALVs [10].

Seed quality is normally affected by the agronomic practices used, the time of harvest and seed processing procedures. Seeds of Spiderplant, African nightshades and Jute mallow have been reported to have poor germination compared to those of Cowpea and Slenderleaf due to dormancy characteristics [10, 20]. Seeds of most ALVs are processed through the dry method while African nightshades seed is normally treated by wet processing methods [26].

Proper treatment especially of the wet processed seeds is required to ensure complete removal of the flesh pulp that normally contains growth inhibitors. To promote sustainable production of ALVs, the above constraints have to be addressed holistically but quality seed is key to a successful promotion programme.

Conclusions

- The study showed that all the three communities studied had a high diversity of cultivated ALVs covering eight botanic families.
- Respondents in all the communities cultivate ALVs in subsistence, home gardening, and intercrop systems where the use of chemical fertilizers and chemicals was almost non-existent.

- The major constraints of production of ALVs included poor quality seed, drought, poor marketing systems and infrastructure, and lack of agronomic and utilization packages.
- The identified ALVs in Western Kenya which should be promoted and improved as commercial crops included Spiderplant, African nightshade, pumpkin leaves, Cowpeas, vegetable amaranths, Jute mallow, Slenderleaf and African kale.

Acknowledgement

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Conservation of African leafy vegetables in South Africa

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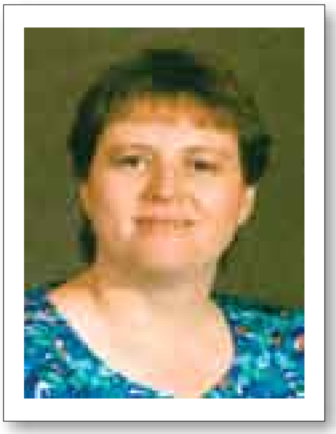

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Abstract

The nutritional and cultural importance of African leafy vegetables (ALVs) has become very important in South Africa in the past few years. Recent research has also confirmed these issues, leading to the incorporation of African vegetables into the core business of the Agricultural Research Council (ARC). The Agricultural Research Council Roodeplaat Vegetable and Ornamental Plant Institute (ARC-Roodeplaat) wants to improve the distribution and conservation status of ALVs. Geographical collection data on Amaranth, *Cleome gynandra*, *Corchorus olitorius* and *Vigna unguiculata* were obtained from the National Botanical Institute and analyzed with DIVA and Flora map. Ecogeographical distribution maps were drawn to predict the possible distribution of the species. Germplasm of ALVs was collected during routine visits and the conservation status was discussed with participants in the study areas of Arthurstone in Bushbuckridge, Watershed near Ladysmith and Mars/Glenroy near Polokwane. Germplasm of various species was also collected in collaboration with the Plant Genetic Resource Centre (NPGRC) of the Department of Agriculture in Arthurstone and Watershed.

The NPGRC included leafy vegetables in their mandate after this trip. Seed flow diagrams were used to discuss the Watershed community's seed exchange systems. It was clear when discussing ALVs in communities that their conservation and utilization are declining. Also looking at the trendlines of African vegetables availability and utilization, it is clear that the use and availability of ALVs are declining due to various reasons. Two major reasons are the negative image of the ALVs and the increased use of "exotic" vegetables like spinach and carrots. The active promotion, use and conservation of ALVs are important if we want to increase the production potential and potential contribution towards food security in South Africa. This will ensure that the status of these crops is enhanced, specifically their contribution towards sustainable nutrition as well as sustainable production. Results from promotion activities in the project (reported in another paper) indicated that the negative image of ALVs could be reversed and also had an effect on the roll-out of the project to other areas of research such as plant protection, nutritional analysis and food safety, crop science and indigenous knowledge systems.

Key words: Ecogeographical, conservation, leafy vegetable

Introduction

For centuries, African leafy vegetables (ALVs) were part of the daily livelihoods of the African people. Unfortunately, they were taken for granted and the people believed that they would always be part of their lives as they were growing wild and harvested for free. Old women who passed the responsibility and knowledge on to younger generations safeguarded seed of certain species. Unfortunately, as a result of various social, political and economic reasons, these systems do not exist in many places any more. As part of a project funded by Bioversity International (former IPGRI), the Agriculture Research Council Roodeplaat Vegetable and Ornamental Plant

Institute (ARC-Roodeplaat) investigated the distribution and conservation status of certain ALV species in South Africa.

Ecogeographical study

An ecogeographical investigation of Amaranth, *Chenopodium album*, *Cleome gynandra*, *Vigna unguiculata* and cucurbits was carried out. Geographical collection data were obtained from herbarium sheets of the National Botanical Institute in Pretoria, South Africa. A total number of 1446 entries, collected between 1877 and 2000, were extracted from the Pretoria Computerized Information System (PRECIS). These collections were done in South Africa, Botswana, Namibia, Swaziland and Lesotho. The grid references of some entries were given in the following format: 3318CD. It indicated a specific square south east of the intersection of 18° E and 33° S as indicated in Figure 1.

These grid references, of the point in the centre of each of the 16 squares, are converted to decimal fractions in Table 1. Thus 3318CD will be converted to 33.875°S and 18.375°E.

Table 1: Grid references converted to decimal fractions

Grid reference	Longitudinal fraction	Latitudinal fraction
AA	0.125	0.125
AB	0.375	0.125
AC	0.125	0.375
AD	0.375	0.375
BA	0.625	0.125
BB	0.875	0.125
BC	0.625	0.375
BD	0.875	0.375
CA	0.125	0.625
CB	0.375	0.625
CC	0.125	0.875
CD	0.375	0.875
DA	0.625	0.625
DB	0.875	0.625
DC	0.625	0.875
DD	0.875	0.875

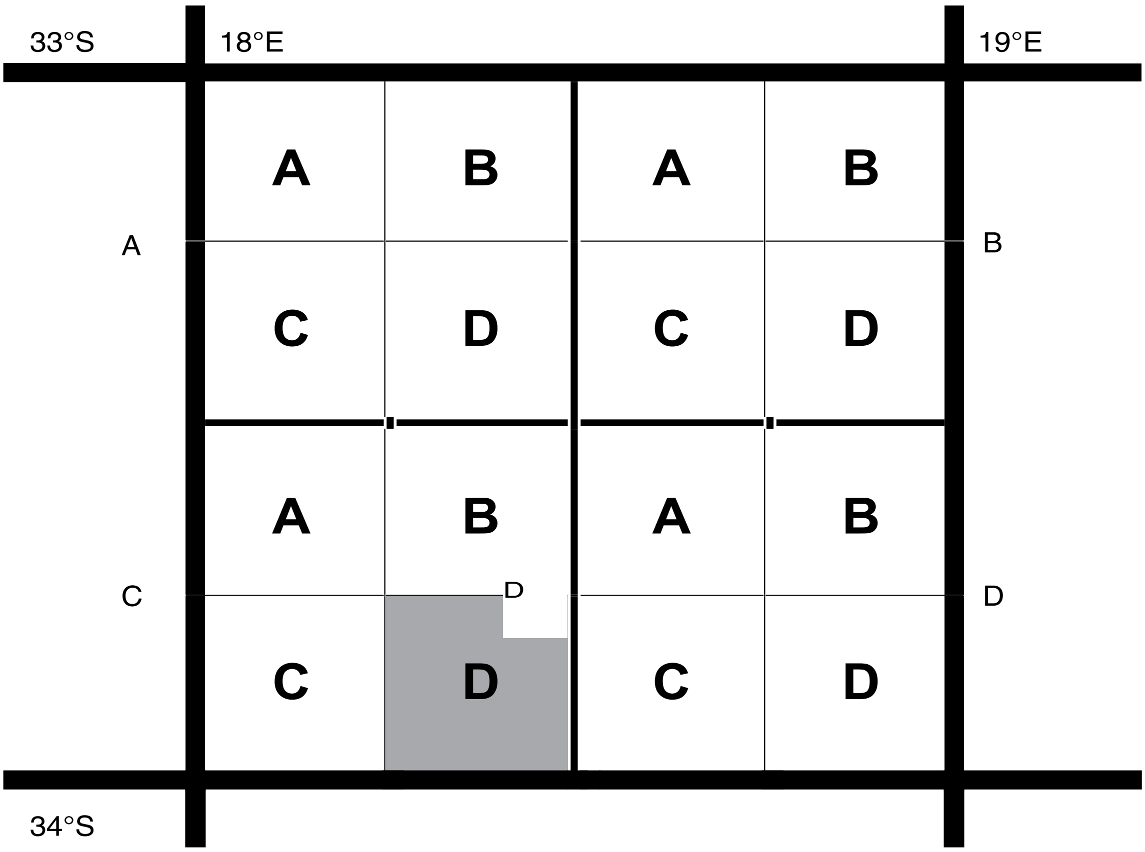

Figure 1: The location of 3318CD

The data were converted to DBASE using DIVA [1]. Distribution maps of the collection sites were drawn with the DIVA as well. Predictions of diversity and distribution were made with FloraMap. All the entries of a specific group were clustered together in one group, using Wart analysis, and these groups were used in the probability analysis to predict the possible distribution of the different groups.

1. Amaranthus *spp.* (*Amaranthaceae*)

A total of 469 entries of *Amaranthus* spp. were considered as follows:

A. thunbergii (159 entries)
A. spinosus (62 entries)
A. deflexus (47 entries)
A. hypochondriacus
A. viridus (27 entries)
A. hybridus subspecies – (*A. hybridus* subsp. *cruentus* – 19 entries: *A. hybridus* subsp. *hybridus* var. *erythrostachys* – 18 entries, *A. hybridus* subsp. *hybridus* – 158 entries)

Amaranthus spp. are normally wild and weedy, growing widespread in Southern Africa except in the more arid south-western areas as seen in Figure 2. It is not widely cultivated but is collected in the wild and in cultivated fields.

2. Chenopodium album (*Chenopodiaceae*)

Chenopodium album (181 entries)
Chenopodium is a wild weedy plant collected by the women in the fields all over South Africa. There is no evidence that *Chenopodium* is cultivated in South Africa. It is widely distributed but is more prevalent at higher altitudes (Figure 3).

3. Cleome gynandra (Gynandra gynandrum) (*Capparaceae*)

Cleome gynandra (184 entries)
Cleome gynandra is mostly a wild weedy plant collected by women in the fields in the northern parts of South Africa. It is unknown in KwaZulu-Natal although some plants were collected there (Figure 4). There is no evidence that *Cleome* is cultivated in South Africa.

4. Vigna unguiculata (*Fabaceae*)

Vigna unguiculata subsp. *dekindtiana* var. *dekindtiana* (45 entries)
Vigna unguiculata subsp. *dekindtiana* var. *huillensis* (14 entries)
Vigna unguiculata subsp. *protracta* (23 entries)
Vigna unguiculata subsp. *stenophylla* (82 entries)
Vigna unguiculata subsp. *tenuis* var. *ovata* (1 entry)
Vigna unguiculata subsp. *unguiculata* (236 entries)

Cowpeas (*Vigna unguiculata*) are cultivated for dry beans in various areas in South Africa. It is also found in the wild in the eastern areas of KwaZulu-Natal, Mphumalanga and the Limpopo Province (Figure 5).

5.Cucurbit leaves
Citrullus lanatus (167 entries) and *Citrullus rehmii* (13 entries)

Pumpkins, melons and squash (*Cucurbita maxima*, *C. pepo* and *C. moschata*) are widely cultivated in South Africa for their fruit and by some farmers for the leaves. Leaves of all cucurbits are used for leafy vegetables. The collections are from species that grow in the wild in the more arid areas of western and central Southern Africa (Figure 6).

Collection

A collection trip in collaboration with the National Gene bank (National Department of Agriculture) was made during May 2002. A total of 225 accessions were collected (Table 2) in Arthurstone (an area within Bushbuckridge), Watershed near Ladysmith and Mars/Glenroy near Polokwane. Only the local names of certain accessions are known and these accessions have to be identified. The base collection of these accessions is stored at the National Gene Bank. A working collection will be stored at ARC-Roodeplaat. Material of landraces of other crops not used as leafy vegetables was also collected for the National Gene Bank.

The accessions were collected from farmers in the community as seed. The seeds are saved from one season to the next in containers, mostly glass or airtight plastic containers. Ash is added in some instances to discourage pests.

Seed of selected species was multiplied by ARC-Roodeplaat and the seeds were made available to community members to enhance the availability of seed.

Conservation

Conservation and seed systems of African vegetables were discussed with the Arthurstone, Mars/Glenroy and Watershed communities. In many areas, seed systems are in a poor state. An old woman of high social status used to be the custodian of the seed for the community, but the role has been lost due to various social and economic reasons. The increased significance of “exotic” or “modern” vegetables and the commercial availability of the seed also played a role in the demise of the role of seed custodians. The community members tend to keep their own seed now or buy from dealers. This leads to scarcity and even loss of some crops that are not part of the formal seed sector. Revival of the role of seed custodians within communities is critical for the conservation and preservation of genetic diversity of the crops that are not part of the mainstream seed sector.

The introduction and promotion of “exotic” or “modern” vegetables has had a negative effect on the use of traditional vegetables in communities. The preferences of people have changed to the exotic vegetables such as cabbage. Preparation

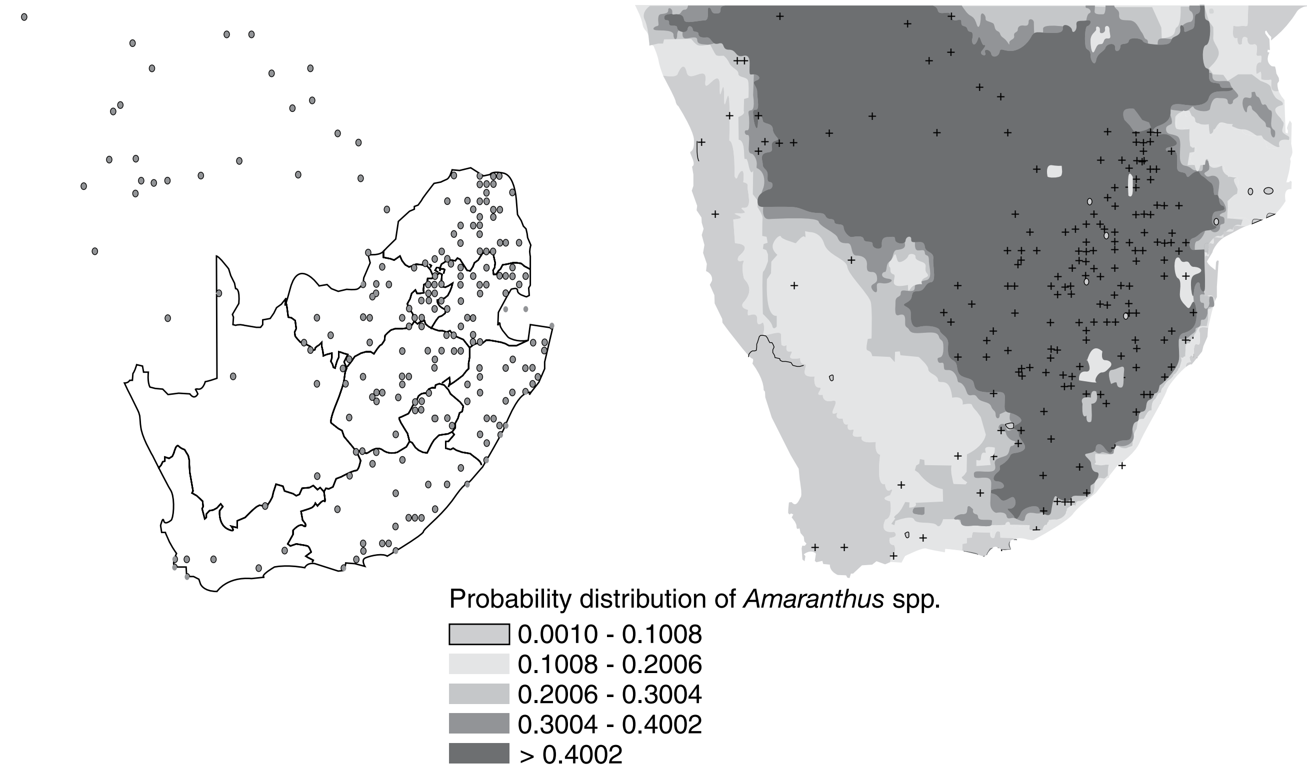

Figure 2 a: Distribution of the sites where *Amaranthus* spp. were collected. b. Predicted distribution of the mentioned *Amaranthus* spp. in Southern Africa as predicted by Floramap.

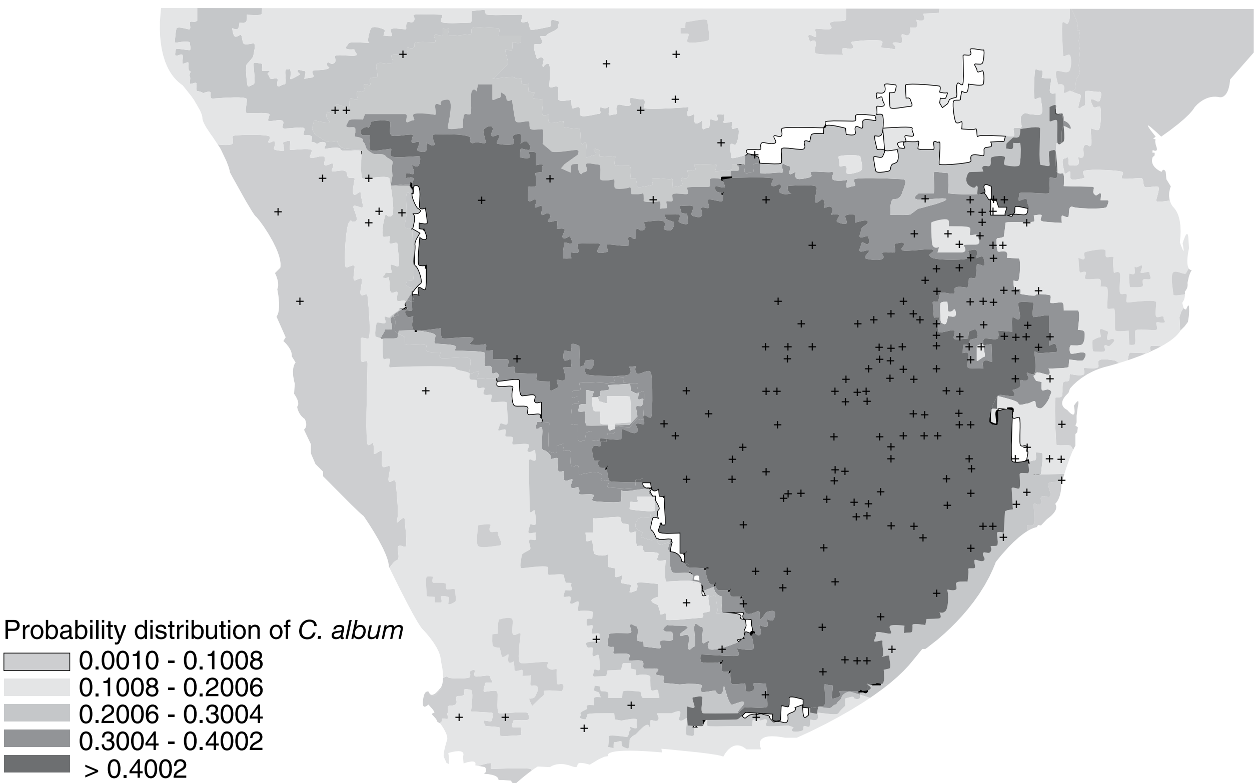

Figure 3 a**:** Distribution of the sites where *Chenopodium album* was collected. b. Predicted distribution of *Chenopodium album* in Southern Africa as based on map drawn by Floramap.

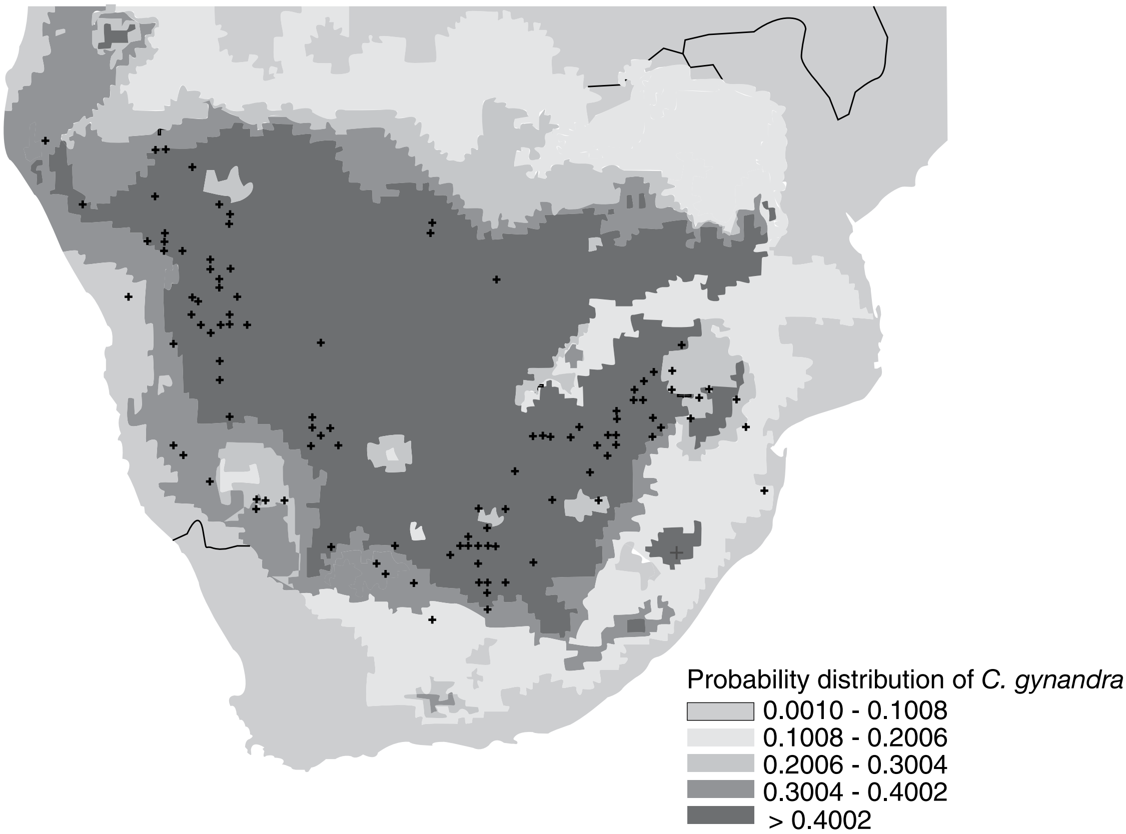

Figure 4 a: Distribution of sites where *Cleome gynandra* was collected in Southern Africa. b: Predicted distribution of *Cleome gynandra* in Southern Africa based on Floramap.

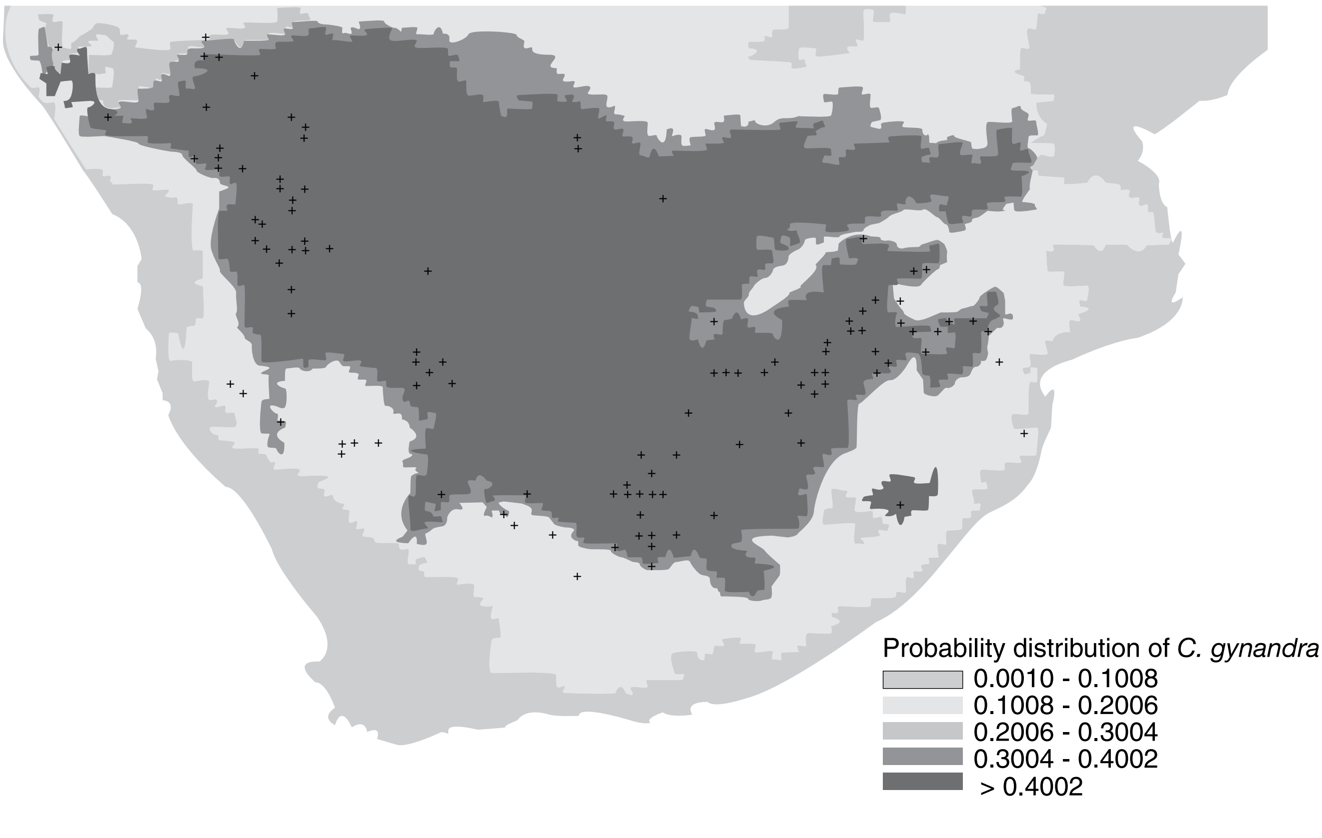

Figure 5 a: Distribution of the collection sites of *Vigna unguiculata*. b: Predicted distribution of the mentioned *Vigna unguiculata* sub species in Southern Africa as based on map drawn by Floramap.

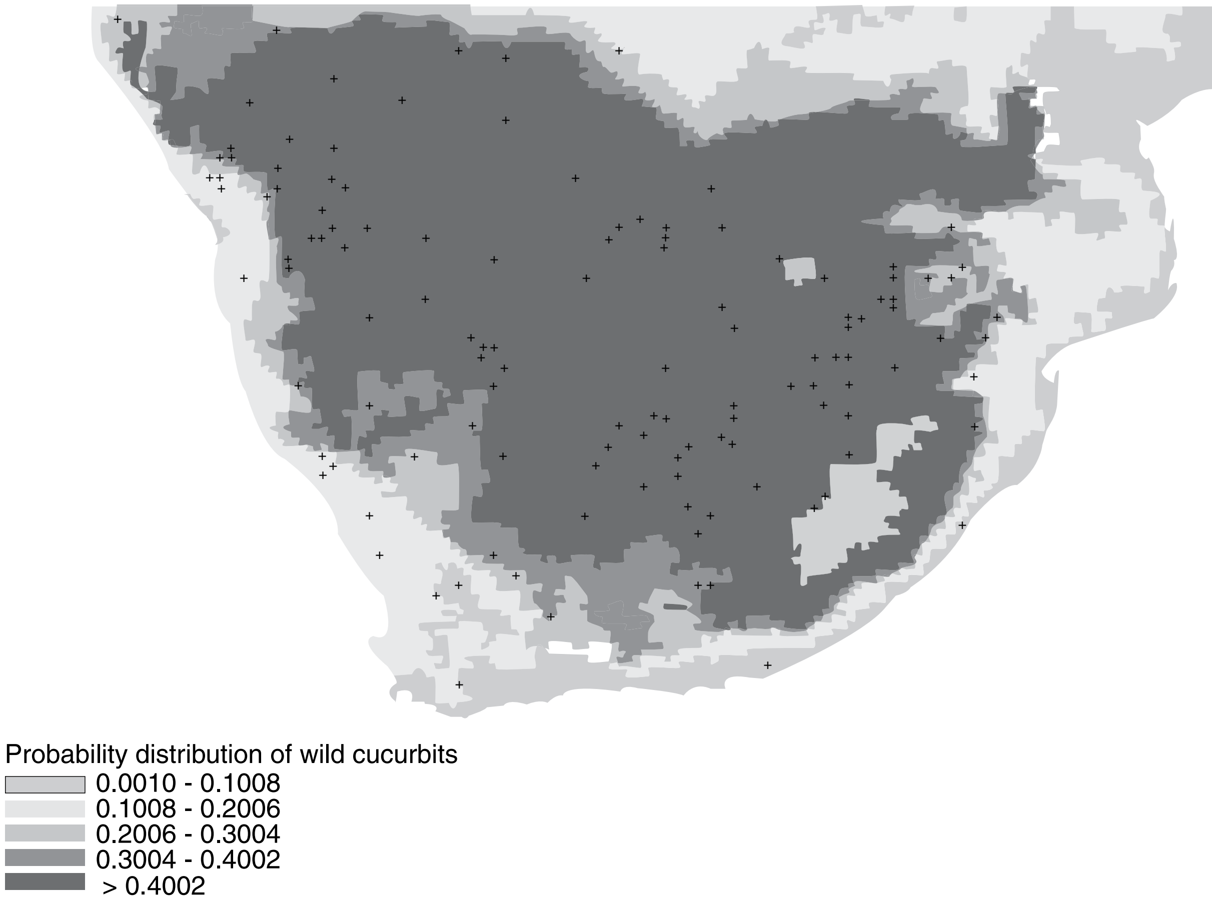

Figure 6 a: Distribution of sites where *Citrullus lanatus* and *C. rehmii* were collected in Southern Africa. b: Predicted distribution of *Citrullus lanatus* and *C. rehmii* based on map drawn by Floramap.

Table 2: Accessions collected

Scientific name	Arthurstone (Bushbuckridge) and Mars/ Glenroy (Polokwane)	Watershed
Abelmoschus esculentus	14	0
Allium cepa	0	1
Amaranthus sp.	8	3
Arachis hypogaea	18	0
Citrullus lanatus	4	1
Cleome gynandra	16	0
Corchorus tridens and *C. olitorius*	6	0
Cucurbita pepo and *C. maxima*	28	8
Ipomoea batatas	1	0
Lagenaria siceraria	2	1
Momordica sp.	7	0
Pennisetum sp.	3	0
Phaseolus sp.	1	9
Sorghum bicolor	0	2
Vigna subterranea	17	1
Vigna unguiculata	24	1
Zea mays	28	5
Other species	16	0
Total	193	32

methods and changing taste preferences of the youth also have a negative influence on the utilization and indirectly on conservation of traditional vegetables. Climate and rainfall patterns also have an influence on conservation. Drought has led to over harvesting of the plants, thus depleting seed banks. Heavy rains and thunderstorms (especially after droughts) cause soil erosion and the loss of valuable topsoil as well as the seed in the soil.

The case of 'Phara'

'Phara' (a local variant of *Cucumis melo*) is a popular traditional leafy vegetable in the northern parts of South Africa. During discussion with the Mars/Glenroy communities, the women realized that it was becoming rather scarce. The women decided to collect all the seeds they could in the coming season, and to distribute them to a few other women, thus ensuring that the risks were spread. The following season was very dry and unfortunately livestock invaded the gardens so all the plants that survived the drought were destroyed, leaving no 'phara'. Families from villages nearby were contacted and the 'phara' seed was re-introduced into the community. The community women immediately appointed other women in each community to look after 'phara' and ensure its survival in the community [2].

Discussion

It was clear when discussing ALVs in communities that their conservation and utilization are declining. The women remembered that the ALVs were more abundant during their childhood. The older women in particular would say that 'morogo' (the local name for ALVs collectively) was abundant in their childhood and that they could not find some of the species any more. The trendlines on the availability and utilization of African vegetables clearly shows that the use and availability of ALVs are declining. Two major reasons for this decline are the negative image of the ALVs and the promotion and increased use of "exotic" vegetables like spinach and carrots.

In South Africa, 'morogo' is regarded as poor man's food or famine food, especially by the youth. The younger generation of South Africans are used to the taste and textures of the more fatty foods popularized by the media. This perception is, however, changing. Results from promotion activities in the project (reported in another paper) indicated that the negative image of ALVs can be reversed and also had an effect on the roll-out of the project to other areas of research such as plant protection, nutritional analysis and food safety, crop science and indigenous knowledge systems. From the 1960s, modern vegetables such as carrots, cabbage, green beans and so forth were actively promoted by agricultural research and extension services.

Conclusion

Crops such as cabbage and spinach have almost completely replaced the African leafy green vegetables in areas where extension was active. Furthermore, extension services actively discouraged the selective weeding practised by many farmers and advised the farmers to remove the "weeds". The active promotion, use and conservation of ALVs in food security needs to be addressed in South Africa. The ALVs must be promoted as a healthy alternative to the modern vegetables. The African vegetables must also be recognized as an extremely important part of our African heritage. This will ensure that the status of these crops is enhanced, specifically their contribution towards sustainable production and nutrition. The recognition of the role that African vegetables play in food security and nutrition will also help to increase their conservation status.

Acknowledgement

The National Botanical Institute is thanked for the use of data from the National Herbarium, Pretoria (PRE) Computerized Information System (PRECIS).

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Sélection participative de nouveaux cultivars de quatre espèces de légumes feuilles (*Hibiscus sabdariffa* L., *Amaranthus* L. spp., *Vigna unguiculata* (L.) Walp et *Moringa oleifera* Lam) au Sénégal

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Résumé

Les légumes - feuilles traditionnels peuvent contribuer jusqu'à 100 % du revenu des ménages. Parmi les principales contraintes limitant le développement de leur culture, nous avons l'accès à des semences de qualité et en quantité. Il a été rapporté que les méthodes conventionnelles de sélection sont confrontées à un sérieux problème d'adoption des nouvelles obtentions variétales. Elles souffrent d'une insuffisance de prise en compte des critères des paysans guidant le choix des écotypes locaux. C'est pourquoi, malgré les nombreux acquis de la recherche sur le plan variétal, le taux d'adoption est toujours faible, les revenus des producteurs sont restés bas et le problème de la pauvreté ne fait que s'accroître. C'est dans le souci d'améliorer le niveau d'adoption des nouvelles variétés de légumes-feuilles traditionnels qu'une session de sélection participative a été organisée à l'Institut Sénégalais de Recherches Agricoles-Centre pour le Développement de l'Horticulture (ISRA-CDH). Cette sélection s'est faite avec une forte implication des femmes utilisatrices. La méthode de notation matricielle ou *scoring matrix* a été utilisée. Les trois meilleures variétés pour chacune des quatre espèces sont par ordre décroissant pour le bissap : L24, L7 et ACCM, le niébé : Kolda1, YélingaraGF et AVRDC, l'amarante : AVRDC, Tamba7 et Missira5 et Nébéday : MAVRDC, MCDH et MKOTHIARY. Le choix des utilisatrices de ces espèces de légumes feuilles traditionnels recoupe dans la plupart des cas les résultats obtenus par la recherche. En effet, dès le début du processus de sélection les préoccupations des femmes utilisatrices ont été prises en compte. Etant donné que les variétés ont été classées par ces dernières, l'adoption doit être maximale si elles gardent toujours la même performance en milieu paysan. C'est ainsi que ces variétés vont faire l'objet d'évaluation multilocale pour confirmer ou infirmer leur performance en station.

Mots-clés: espèce, sélection participative, cultivar, variété, préférence

Introduction

La culture des légumes-feuilles traditionnels est une activité essentiellement réservée aux femmes [1, 2]. Les femmes ont un savoir et un intérêt spécial sur les légumes- feuilles traditionnels. Les données sur la gestion de ces ressources en matière de revenu et de sécurité alimentaire doivent être sauvegardées. Elles assurent à la fois les besoins et la survie de la communauté tout en contribuant à la conservation et à l'utilisation durable des espèces locales.

A cet effet, la sous-estimation de la contribution importante des populations locales dans les stratégies de conservation et la gestion des ressources phytogénétiques a affaibli leur portée. En effet, les méthodes de sélection modernes sont confrontées à un sérieux problème d'adoption des nouvelles obtentions variétales. Elles souffrent d'une insuffisance de prise en compte des critères guidant le choix des écotypes locaux dont d'une part, leur grande adaptabilité aux conditions environnementales locales et, d'autre part, leurs qualités organoleptiques hautement appréciées dans la confection des mets locaux [3]. C'est pourquoi, malgré les nombreux acquis de la recherche sur le plan variétal, le taux d'adoption est toujours faible, les revenus des producteurs sont restés bas et le problème de la pauvreté ne fait que s'accroître.

L'intégration de ce savoir traditionnel, constitue de fait une étape importante pour l'adoption des nouvelles variétés et pour le développement d'une stratégie de gestion durable des ressources naturelles dont les légumes feuilles traditionnels. C'est dans le souci d'améliorer le niveau d'adoption des nouveaux cultivars de légumes-feuilles traditionnels qu'une session de sélection participative a été organisée à la station de recherche de l'ISRA-CDH. Cette sélection s'est faite avec une forte implication des femmes productrices, commerçantes et consommatrices des légumes feuilles mais également les principaux partenaires de la recherche tels que les Organisations Non Gouvernementales (ONGs).

Matériels et méthodes

Trente et huit espèces de légumes-feuilles traditionnels ont été recensées au Sénégal. Parmi celles-ci, l'oseille de guinée communément appelée bissap (*Hibiscus sabdariffa* L.), le nébéday (*Moringa oleifera* Lam.), l'amarante (*Amaranthus* L. spp.) et le niébé (*Vigna unguiculata* (L.) Walp.) sont les plus consommées [1]. Ces quatre espèces prioritaires font l'objet de la présente étude. Les missions de prospection et de collecte qui ont été effectuées à travers le Sénégal ont permis de collecter des échantillons de semences des différents écotypes locaux de ces quatre espèces de légumes-feuilles traditionnels. Au cours de ces missions, les critères de sélection et les caractéristiques des idéotypes définis par les femmes productrices de légumes feuilles ont été recueillis [1, 2, 4].

Les échantillons de semences collectés au Sénégal et ceux introduits ont été mis en régénération à la station de recherche de l'ISRA-CDH et de nouveaux cultivars ont été sélectionnés en se basant aussi bien sur les critères définis par les productrices que ceux conventionnels d'ordre agro-botanique [5]. Les meilleurs cultivars sélectionnés dans ces quatre espèces ont été semés à la station de recherche de l'ISRA-CDH en vue de la session de sélection participative. Le matériel comprenait respectivement 3, 4, 9 et 9 cultivars de Nébéday, amarante, niébé et bissap. Le semis a été fait le 19 mai 2004 sur une parcelle ayant comme précédent cultural le bissap. Les écartements utilisés pour le bissap, le niébé, l'amarante et le Nébéday sont respectivement : (0,5 m x 0,5 m) x 1 m; (0, 5 m x 0,50 m) x 1,50 m, (0,5 m x 0,5 m) x 1,5 m et (0,5m x 0,5 m) x 1 m. De la poudre d'arachide et de l'engrais minéral NPK (10 10 20) ont été utilisés conformément aux recommandations des fiches techniques du bissap et de l'amarante de l'ISRA-CDH [6]. Les recommandations de la fiche technique de production du niébé du CNRA de l'ISRA-Bambey ont été utilisées pour la fertilisation minérale et organique [7]. Lors de la régénération du Nébéday de la poudre d'arachide (1 kg/m^2) et de l'engrais minéral NPK (10 10 20)(20 g/m^2) ont été utilisés comme fumure de fond et de couverture. Pour chacune des accessions, l'irrigation était quotidienne (5 mm) jusqu'au stade de première récolte et s'est poursuivie à la dose de 10 mm tous les deux jours jusqu'à la récolte. Les ennemis des cultures ont été contrôlés régulièrement suivant les recommandations des fiches techniques de culture de chacune des espèces [6, 7].

La séance de sélection participative a été organisée à la station de recherche de l'ISRA- CDH. La méthodologie utilisée a consisté tout d'abord à identifier des acteurs de la filière. Ils provenaient de trois sites pilotes (Mboro (Thiès), Thiomby (Kaolack) et Ndiane (Khombole)) où les organisations féminines sont fortement impliquées dans la production, la consommation et la commercialisation des légumes feuilles [1, 8]. Chacune de ces organisations a envoyé deux représentantes. Il y a eu aussi la participation du GIE (Groupement d'Intérêt Economique) de commerçantes de légumes-feuilles et des détaillantes des mêmes légumes d'un marché de Dakar et de l'ONG Sahel 3000 qui est un partenaire au développement. Ces derniers ont été représentés par deux personnes chacun. Un nombre total de 10 femmes, toutes actrices de la filière légumes-feuilles traditionnels ont pris part à cette séance.

Les différents critères notés lors des missions de terrain ont d'abord été soumis à l'appréciation des participantes, puis discutés et leur sens dans la langue locale défini (Tableau 1). Au terme de ces échanges, elles ont bien voulu définir de façon consensuelle des critères de sélection pour chacune des espèces cibles. A cet effet la couleur et la largeur de la feuille ont été retenues pour les quatre espèces. En plus de ces deux critères, la forme de la feuille, la capacité de régénération ou rapidité de rejet de la plante, l'acidité, le rendement et la facilité de vente ont aussi été adoptés pour le bissap ou oseille de Guinée. S'agissant de l'amarante et du niébé, la longueur du cycle et la tendresse des feuilles (temps de cuisson) sont aussi choisies en plus du port dans le cas du niébé. Quant au nébéday ou Moringa, elles ont en plus opté pour le rendement et la tendresse des feuilles.

Une fois qu'un compromis a été trouvé sur les termes, la méthodologie a été expliquée et une démonstration faite sur le terrain. La méthode de notation matricielle ou *scoring matrix* a été utilisée [9]. Elle consiste à déposer des pots auprès de la parcelle de chaque cultivar. Chaque participante avait un petit pot rempli de graines de haricot blanc. Les participantes passent devant les différents cultivars de chacune des 4 espèces et donnent librement une note qui correspond aux nombres de graines déposées dans chaque pot placé en face de chaque cultivar. Le système de notation adopté affecte des notes suivant une échelle allant de 0 à 5 par caractère. Zéro (0) lorsque le cultivar n'est pas intéressant pour le caractère ciblé et cinq (5) si ce dernier est jugé très intéressant. Les notes 1,

Tableau 1: Critères de sélection des cultivars des différentes espèces

Espèces	Critères de sélection
Hibiscus sabdariffa L.	- couleur de la feuille - largeur de la feuille - forme de la feuille - capacité de rejets - rendement - facilité de vente - acidité
Vigna unguiculata (L.) Walp.	- couleur de la feuille - largeur de la feuille - longueur du cycle - tendresse des feuilles (temps de cuisson) - le port
Amaranthus L. spp.	- couleur de la feuille - largeur de la feuille - longueur du cycle - tendresse des feuilles (temps de cuisson)
Moringa oleifera Lam.	- couleur de la feuille - largeur de la feuille - tendresse des feuilles (temps de cuisson) - rendement

2, 3 et 4 selon que le caractère est plus ou moins intéressant. Après le passage de toutes les participantes, le nombre de graines pour chaque cultivar est compté et consigné dans une feuille préparée à cet effet. Le processus est ainsi répété pour tous les caractères de chaque cultivar qui ont été définis par les participantes. Le cumul des points obtenu pour chaque cultivar de l'espèce a été calculé et le classement effectué. Le même travail a été effectué pour tous les cultivars de chacune des quatre espèces de légumes feuilles. Les données des différentes variables ont été saisies dans EXCEL et analysées avec le logiciel d'analyses statistiques multivariées R [10]. Les résultats obtenus sur chacun des quatre cultivars ont été représentés sous forme de dendrogrammes.

Résultats

Bissap ou oseille de Guinée (Hibiscus sabdariffa *L.*)

En se basant sur un total de sept critères de sélection (acidité, largeur feuilles, forme feuilles, couleur feuilles, facilité de vente, capacité de régénération après récolte et rendement), le cultivar L24 est jugé plus intéressant pour cinq critères à savoir la largeur comme la forme des feuilles, la facilité de vente, le rendement et la capacité de régénération après récolte. A l'opposé, le cultivar Koor est le moins apprécié pour les 4 premiers critères ci-dessus en plus de la couleur de ses feuilles qui n'est pas du tout attrayante. L24 reste parmi les cultivars testés le plus attrayant pour les deux autres critères (couleur et acidité des feuilles). Les résultats de l'analyse de l'acidité ont montré la dominance de 4 cultivars à savoir VCDH, L22, L24 et ACCM.

Il en est de même pour la couleur des feuilles où ACCM, L7, L24 et L22 sont préférés. Ainsi, le classement des cultivars suivant la méthode de notation matricielle consacre de loin L24 comme le cultivar préféré des actrices de la filière légumes-feuilles traditionnels ; il est suivi respectivement de : L7, ACCM, L22, VCDH, L28, Vimto, VF et Koor. S'agissant du rendement, L24 présente une très forte performance contrairement aux autres cultivars qui ont des rendements moyens à très faibles (Figure 1). Il a été rapporté que les femmes productrices de feuilles préfèrent les cultivars de type vert à larges feuilles (Diouf et al. 2004). Au regard des neuf cultivars qui ont fait l'objet de la session de sélection participative, les cinq premiers sont de type vert et les quatre derniers de type rouge, comme l'atteste la Figure 1. Cette distinction est très nette sur le daisydendrogramme sur lequel on observe deux sous-ensembles très distincts. L'un est composé de types verts (L24, L22, VCDH, L7 et ACCM) qui correspondent aux cinq premiers cultivars selon le classement obtenu par la méthode de notation matricielle et un autre sous-ensemble renfermant des types rouges (Koor, Vimto, VF et L28) qui sont les quatre derniers (Figure 2).

Mieux on observe sur cette figure 2 que L24 qui est classé premier se détache des autres cultivars du même sous-ensemble. Le coefficient de dissimilarité entre L24 et le premier doublon (L7 et ACCM) est de 0,14 et s'élève à

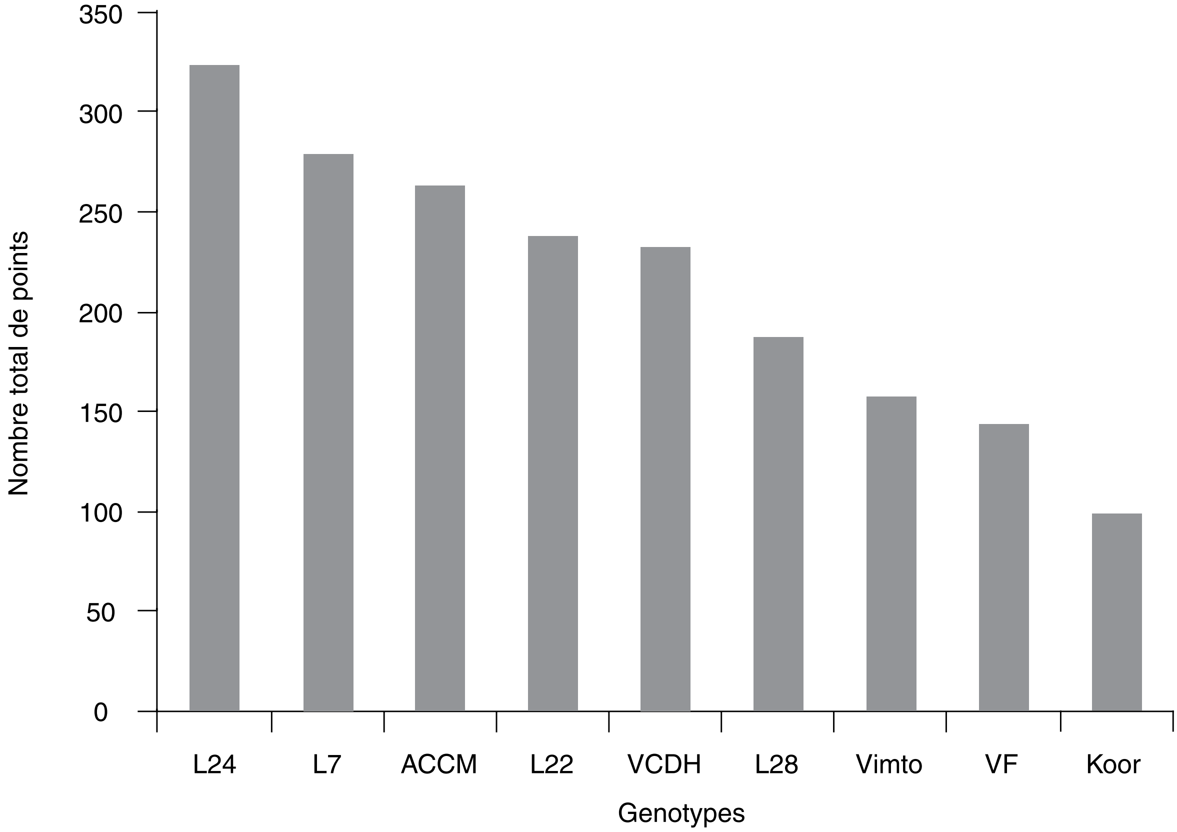

Figure 1: Classement des cultivars de bissap suivant le nombre total de points

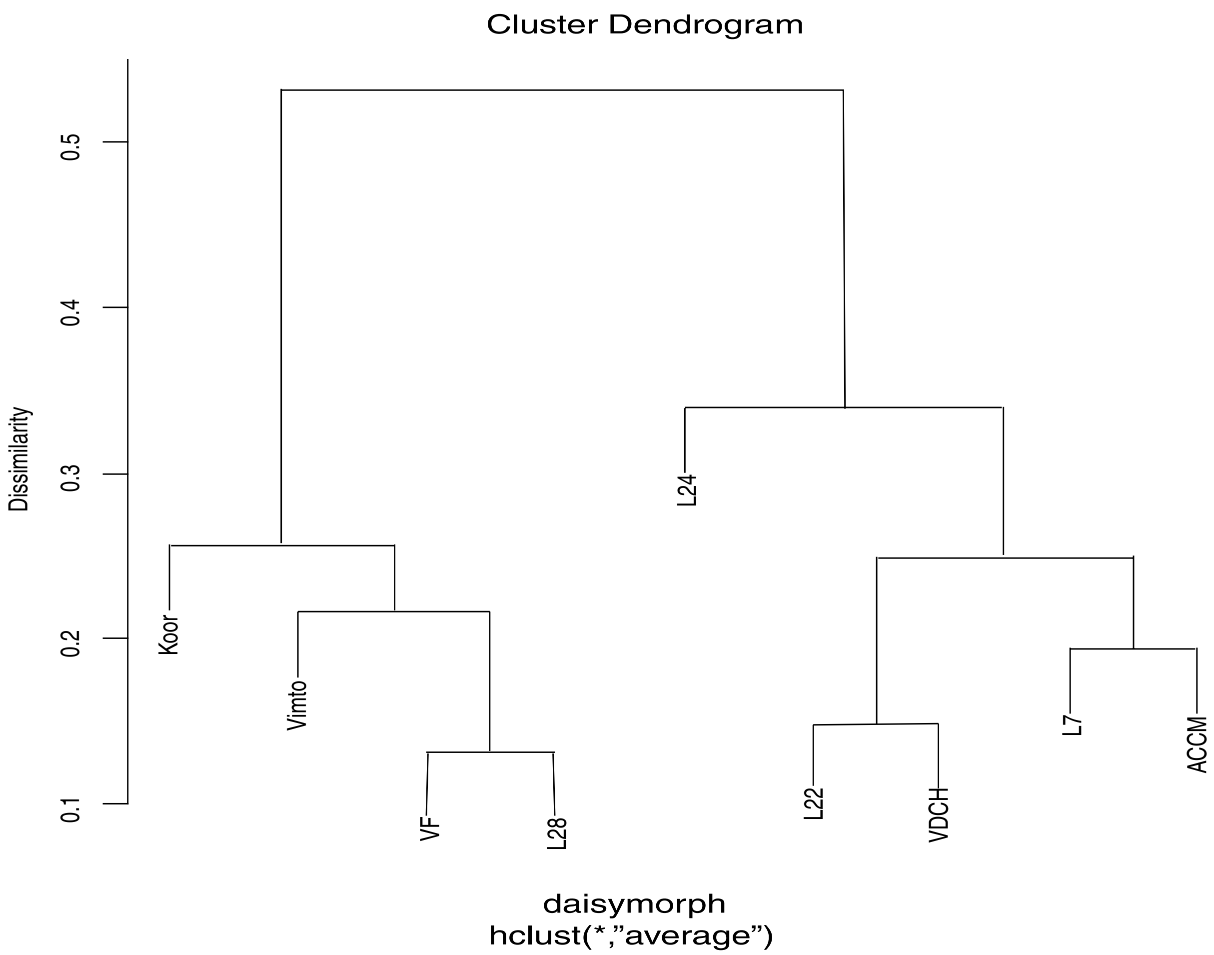

Figure 2: Daisydendrogramme des cultivars de bissap

0,20 entre L24 et le deuxième doublon (L22 et VCDH). Mais il faut noter que la méthode de notation matricielle utilisée durant la session de sélection participative a permis de classer par ordre de préférence des femmes utilisatrices les trois doublons de cultivars de bissap observés sur le daisydendrogramme ((L7 et ACCM), (L22 et VCDH) et (VF et L28)) qui statistiquement ne présentent aucune dissimilarité (coefficient de dissimilarité étant égale à zéro) (Figure 2). Ces résultats viennent confirmer ceux de Diouf et al., rapportant la préférence des femmes sur les feuilles de bissap de type vert [5].

Niébé (Vigna unguiculata (*L.*) *Walp*)

Les cultivars Kolda1, YélingaraGF et Fatick9 sont respectivement les plus tardifs. Les meilleurs cultivars du point de vue tendresse ou temps de cuisson des feuilles sont respectivement AVRDC, Kolda1, YélingaraGF et Fatick9. Les cultivars Fatick9 et Kolda1 ont une couleur de feuilles plus attrayante que les autres, ils sont suivis du YélingaraGF et de l'AVRDC. S'agissant du port de la plante, le cultivar Kolda1 semble être préféré. Sur l'ensemble des 5 critères de sélection, le cultivar Kolda1 est très bien apprécié pour sa tardiveté, la longueur de ses feuilles et pour son port contrairement à Mougne qui est très peu apprécié sur presque l'ensemble des critères retenus.

Ainsi, les quatre meilleurs cultivars selon leur classement suivant la méthode de notation matricielle, à partir des notes attribuées par les femmes qui interviennent dans la valorisation de ces espèces, sont respectivement Kolda1, YélingaraGF, AVRDC et le génotype Fatick9 (Figure 3). Ces quatre meilleurs cultivars (Kolda1, YélingaraGF, AVRDC et Fatick9) constituent un sous-groupe bien distinct sur le daisydendrogramme, avec Kolda1 (premier) qui se détache des autres (Figure 4).

Le cultivar Mougne est le moins apprécié suivi de Bambey21 (Figure 3) pour la consommation des feuilles. Pourtant ce dernier fait partie des cultivars les plus prisés pour la production de gousses. Les trois meilleurs cultivars (Kolda1, YélingaraGF et Fatick9) sont les plus tardifs, ont les plus larges feuilles et sont à port érigé ; ce qui confirme les résultats des études précédentes portant sur ces mêmes critères de préférence [5]. La méthode de sélection participative a permis non seulement de classer tous les cultivars par ordre de préférence mais par la même occasion à hiérarchiser les deux doublons ((YélingaraGF et AVRDC) et (YélingaraPF et ZIPPER)) observés sur le daisydendrogramme qui statistiquement ne présentent aucune dissimilarité (Figure 4).

Amarante (Amaranthus *L. spp.*)

Au regard des critères de sélection de l'amarante (largeur et couleur des feuilles, tardiveté et temps de cuisson), le cultivar AVRDC est de loin toujours préféré à tous les autres et, est à chaque fois suivi de Tamba7. Ainsi, la méthode de notation matricielle adoptée, classe successivement les cultivars AVRDC, Tamba7, Missira5 et Tamba4 comme les plus performants (Figure 5). La préférence des femmes aux variétés tardives de type vert et à larges feuilles a été rapportée [5]. Les deux doublons de cultivars de l'amarante ((AVRDC et

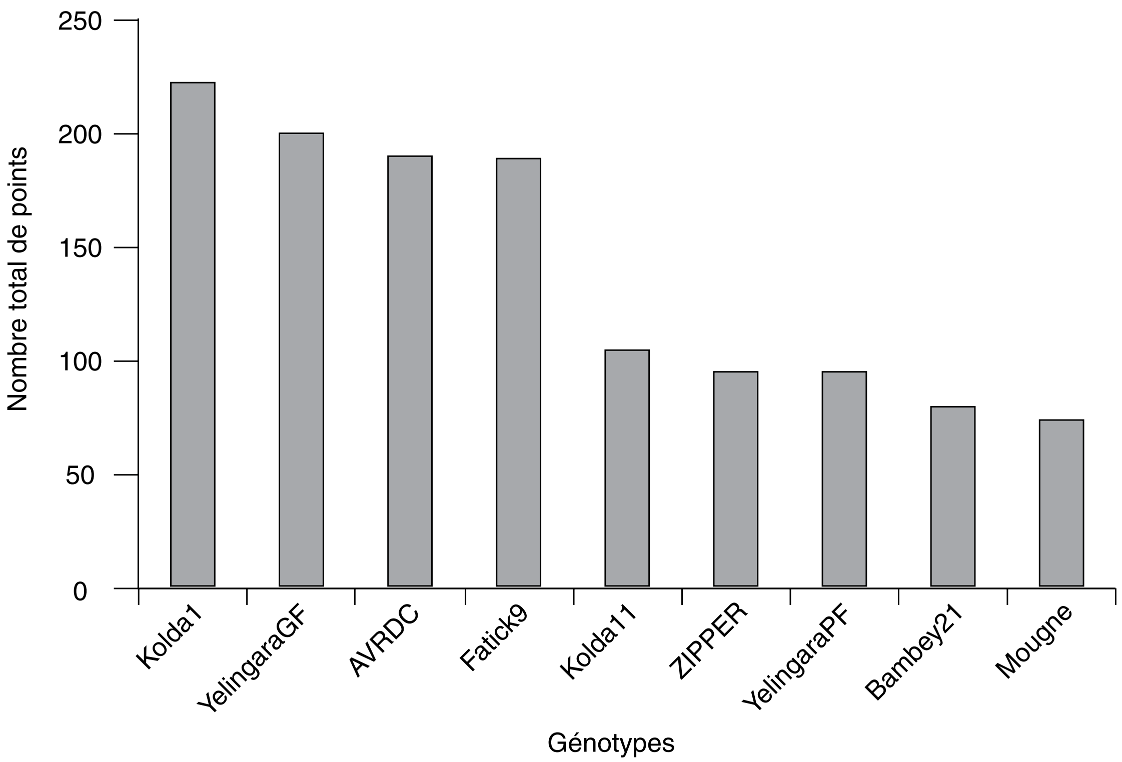

Figure 3: Classement des cultivars de niébé suivant le nombre total de points

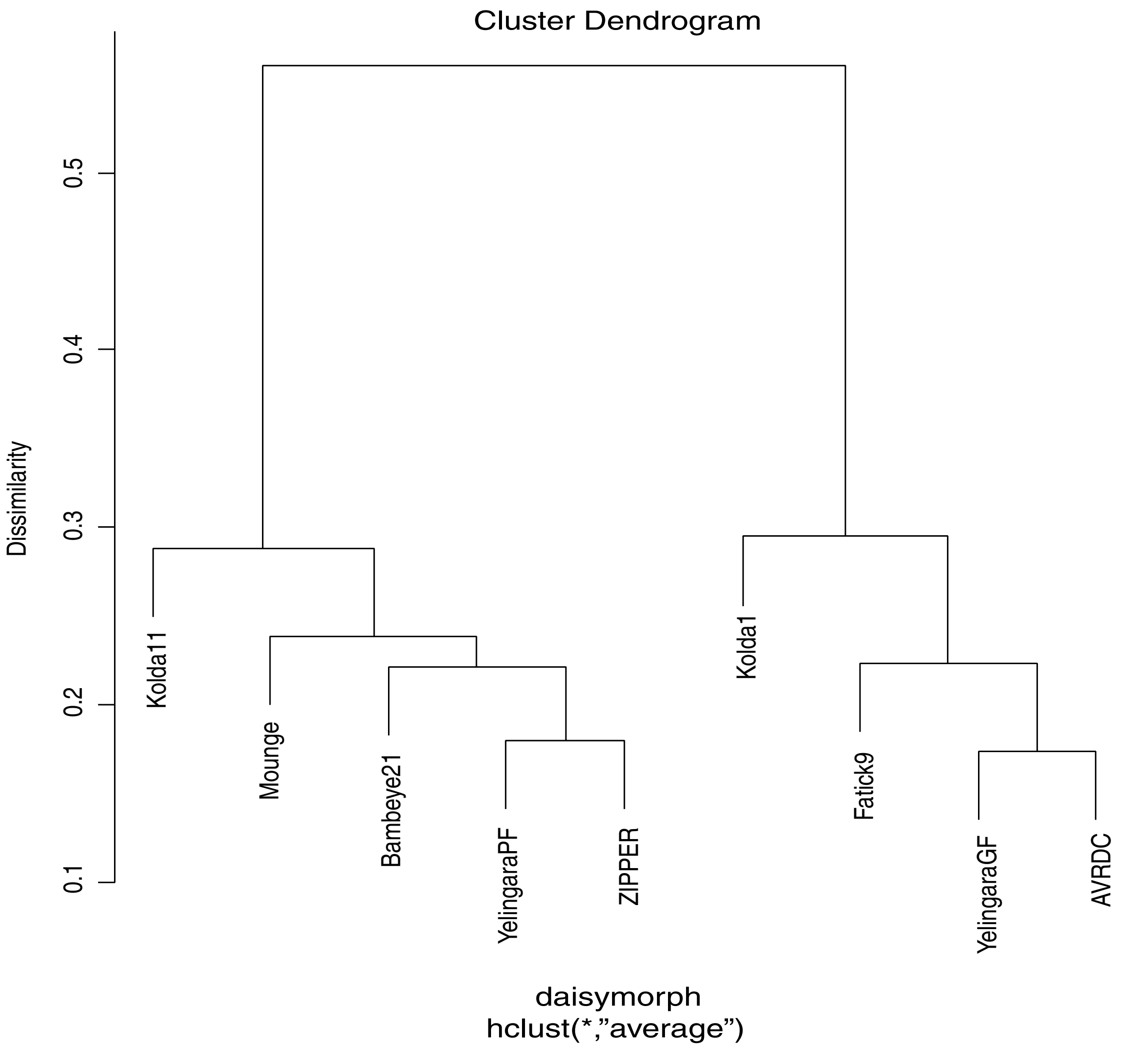

Figure 4: Daisydendrogramme des cultivars de niébé

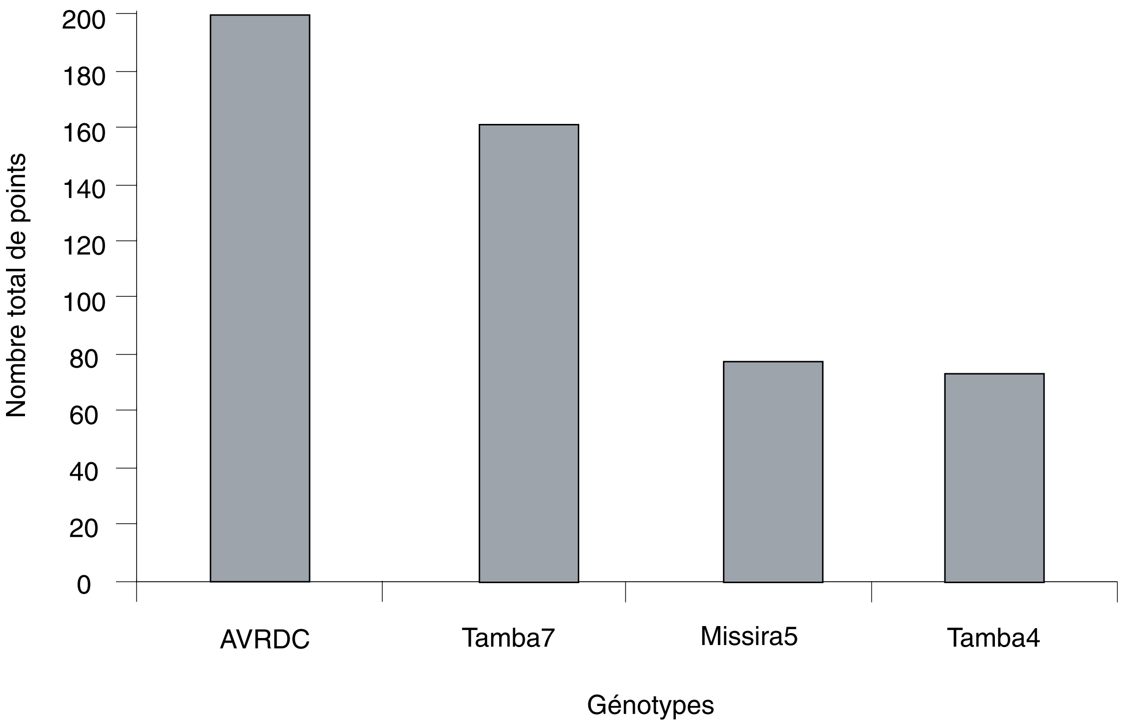

Figure 5: Classement des cultivars d'amarante suivant le nombre total de points

Tamba7) et (Missira5 et Tamba4)) (Figure 6) ont été également classés grâce à la méthode de sélection participative.

Nébéday **(Moringa oleifera *Lam*)**

En considérant les quatre critères (largeur feuilles, couleur feuilles, productivité et temps de cuisson) de choix du Nébéday, le cultivar MAVRDC apparaît toujours comme étant le préféré. Le classement des cultivars suivant la méthode de notation matricielle s'établit de façon décroissante comme suit : MAVRDC, MCDH et MKOTHIARY (Figure 7). Lors de nos différentes missions de prospections, aucun critère de distinction variétale ou de préférence n'a été rapporté [5] et pourtant elles sont arrivées à classer les génotypes suivant les quatre critères définis de commun accord. C'est pour cette raison qu'il a été rapporté que les agriculteurs «traditionnels» sont une source incroyable de connaissances empiriques et théoriques des plantes, des semences et du rendement potentiel de chaque variété [3]. Le classement des cultivars MCDH (2ème) et MKOTHIARY (3ème) qui statistiquement ne présentent aucune dissimilarité (Figure 8) vient confirmer les travaux précédents [3].

Discussion

Les légumes feuilles sont fortement consommés (23 g $pers^{-1}$ j^{-1}) et peuvent contribuer jusqu'à 100% dans le revenu de certains ménages sénégalais [1]. Les femmes sont les principaux acteurs de la production. Le développement de la production des légumes feuilles est cependant limité par un certain nombre de contraintes dont l'accès à des semences de qualité et en quantité reste crucial. L'accessibilité aux semences passe par la sélection de nouvelles variétés dont le support méthodologique serait l'approche participative afin d'accroître le taux d'adoption. C'est pour cette raison que le matériel qui a servi de support à la sélection provient de plusieurs missions de collecte avec comme outil méthodologique l'approche participative. Les rencontres avec ces femmes ont permis de déterminer les principales caractéristiques morphologiques distinctives des accessions mais également les critères de préférences des femmes utilisatrices se rapportant à la morphologie et/ou au goût des feuilles après cuisson [5]. L'approche participative utilisée vise à montrer que la meilleure implication des paysans se manifeste par leur participation dans le processus de sélection [11]. La capacité des populations locales à améliorer la diversité génétique (c'est à dire chercher, sélectionner et échanger) est un élément important dans l'agriculture durable [11]. La sélection des nouvelles lignées dans les descendants des douze accessions de bissap a été faite en se référant aux caractéristiques agro-morphologiques organoleptiques et biochimiques des feuilles afin de prendre en compte les préoccupations les femmes utilisatrices. En effet, les méthodes de sélection modernes souffrent d'une insuffisance de prise en compte des critères des paysans guidant le choix des écotypes locaux dont d'une part, leur grande adaptabilité aux conditions environnementales locales et, d'autre part, leurs qualités organoleptiques hautement appréciées dans la confection des mets locaux [3]. C'est pourquoi, malgré les nombreux acquis de la recherche sur le plan variétal, le taux d'adoption est toujours faible. Les différents cultivars ont été classés par

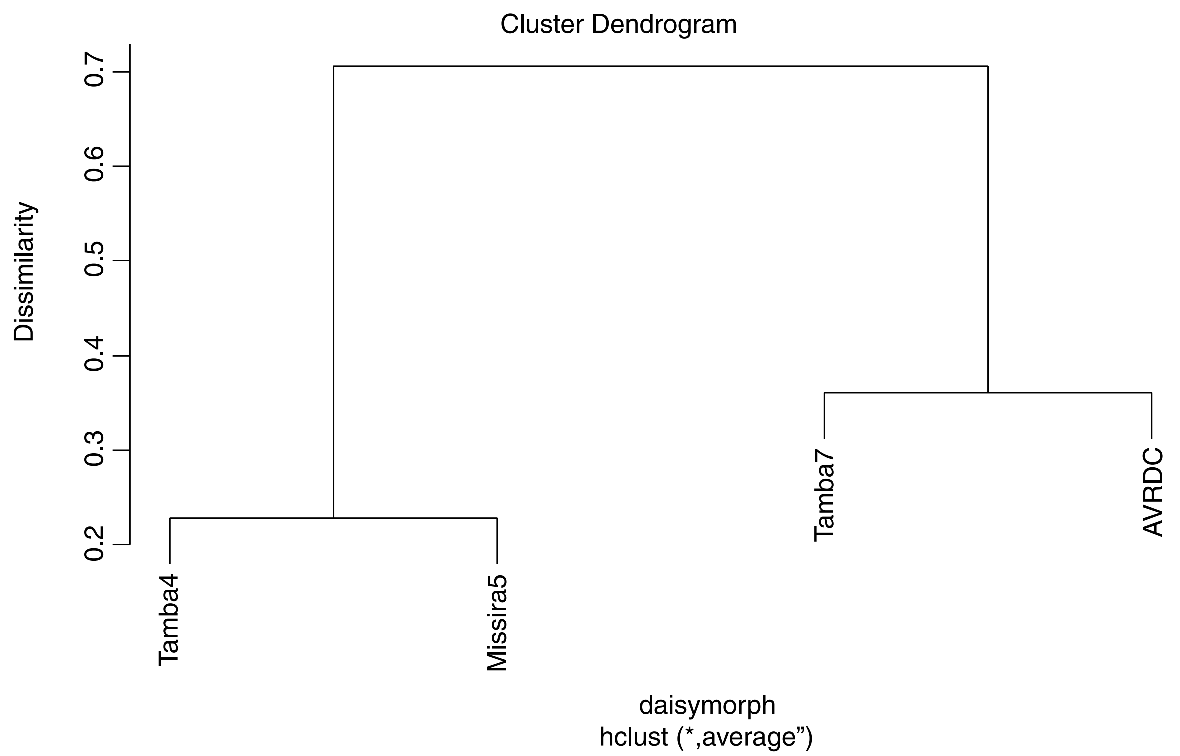

Figure 6: Daisydendrogramme des cultivars d'amarante

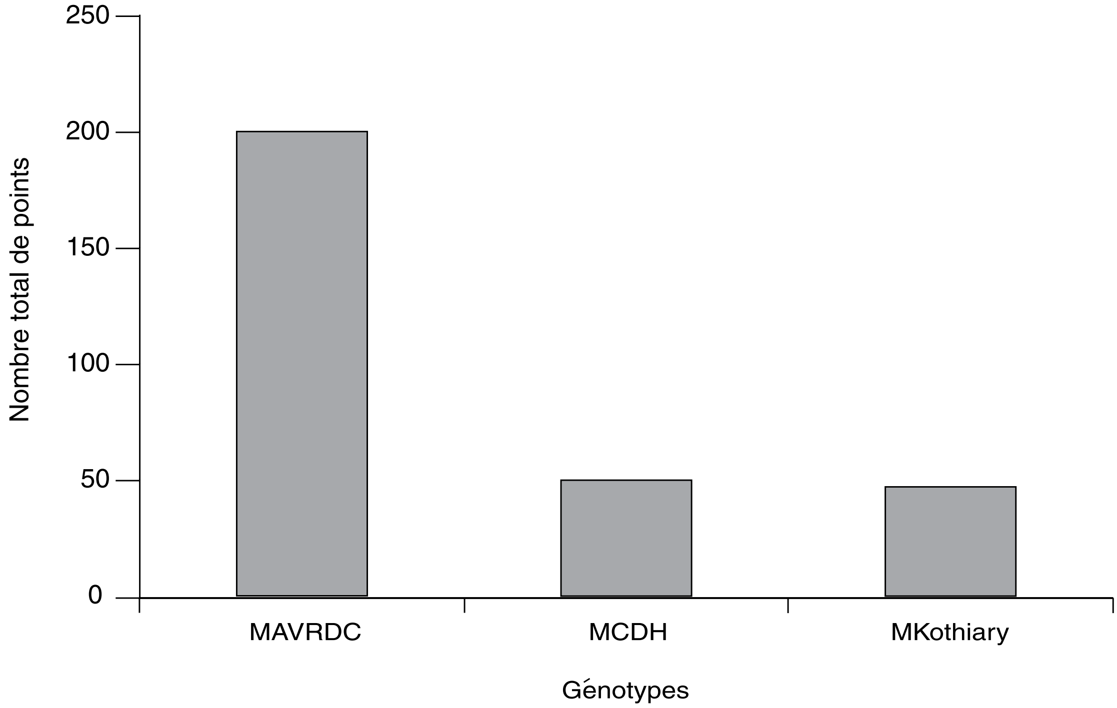

Figure 7: Classement des cultivars de Nébéday suivant le nombre total de points

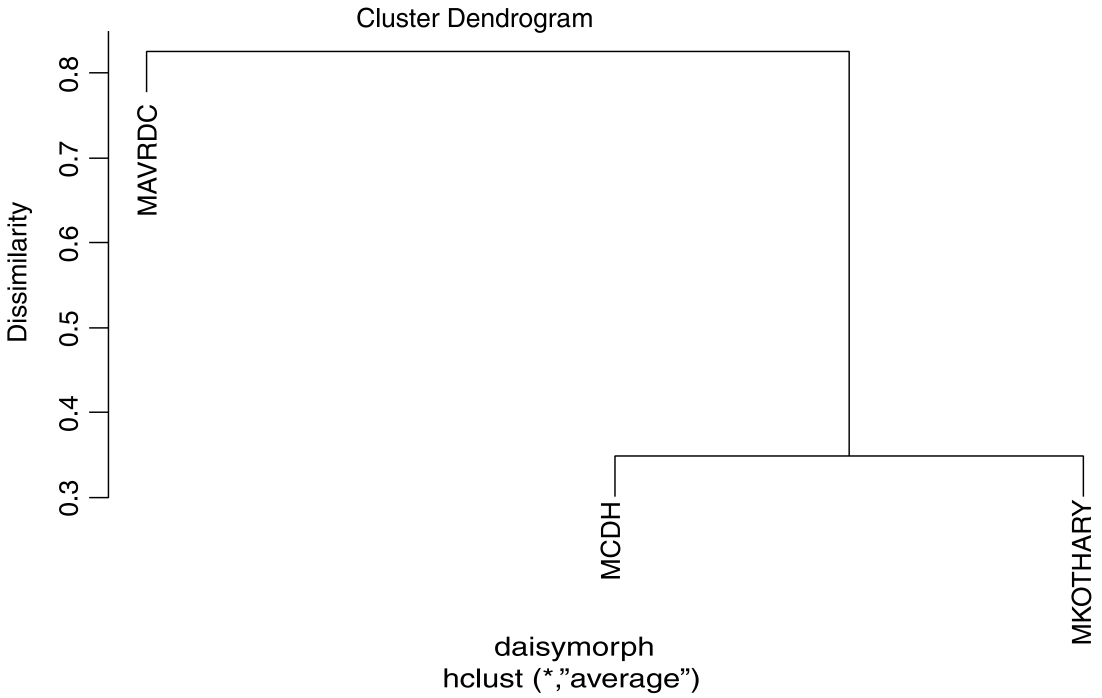

Figure 8: Daisydendrogramme des cultivars de Nébéday

les utilisatrices en fonction de leur critère de préférence et de fait l'adoption devrait être totale si les cultivars gardent les mêmes performances en milieu paysan.

Conclusion

Cette session de sélection participative a permis d'affiner les critères de préférence des cultivars des différentes espèces des utilisatrices rapportés lors des différentes misions de prospection et collecte. La caractérisation participative a permis également de classer des variétés sans différence statistiquement significative. A cet effet, les trois meilleurs cultivars pour chacune des quatre espèces sont par ordre décroissant : bissap (L24, L7 et ACCM), niébé (Kolda1, YélingaraGF et AVRDC), amarante (AVRDC, Tamba7 et Missira5) et Nébéday (MAVRDC, MCDH et MKOTHIARY). Le choix des utilisatrices de ces espèces de légumes feuilles traditionnels recoupent dans la plupart des cas les résultats obtenus par la recherche. Etant donné que les cultivars ont été classés par ces dernières, l'adoption serait maximale s'ils gardent toujours les mêmes performances en milieu paysan.

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Seed production and support systems for African leafy vegetables in three communities in Western Kenya

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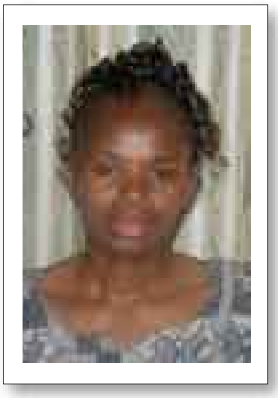

Mary Abukutsa-Onyango

Abstract

Communities in western Kenya have utilized several species of African leafy vegetables (ALVs) for food and valued them for their taste, nutritional qualities and medicinal properties. With increasing demand for these vegetables, there is dire need for a formal reliable source of quality seed and a need to study and develop seed support systems in communities in Western Kenya.

The objectives of the study were: to determine the current seed support systems; to collect, evaluate and multiply germplasm; to establish seed support systems, and; to determine effects of seed treatments on seedling emergency of priority ALVs in three communities in Western Kenya. A survey was conducted by administering structured questionnaires to 30, 20 and 30 households in the Luhya, Luo and Kisii communities respectively, between January 2002 and March 2003.

Germplasm collection, evaluation and multiplication of the priority ALVs were effected. Multiplied germplasm was used to establish a seed support system at Maseno University botanic garden and with 70 farmers in the three communities. Seed treatments for Spiderplant, nightshades and Jute mallow were conducted between June and August 2004. Treatments included T_1=No treatment or control, T_2=Dipped seed in boiling water for 10 seconds, T_3=Soaked seeds in water for 24 hrs and T_4= Soaked seed in 95% acetone for 30 minutes.

Current seed support systems for ALVs are informal and constitute production from farmers' own fields or from the village markets. Seven ALV species were selected from 42 accessions collected on the basis of seed weight, germination percentage and seed moisture content. These included *Cleome gynandra, Crotalaria brevidens, Crotalaria ochroleuca, Solanum scabrum, Vigna unguiculata, Amaranthus blitum* and *Corchorus olitorius*. Seed yields of the above species ranged from 1036-1320 kg/ha with 1000 seed weight of 1.1 to 100g.

A total of 70 contact farmers in six districts of Western Kenya were provided with seed and technical information on production and processing of seed, 13% of whom had started producing quality seed for their use or sale. A seed support system was set up at Maseno University botanic garden to avail seed of the seven ALVs to farmers in the region and beyond. Seed treatments had a significant effect on the seedling emergence of Spiderplant and African nightshade but not on Jute mallow. It is recommended that agronomic, processing and utilization packages be developed for the identified species.

Key words: African leafy vegetables, seed systems

Introduction

African leafy vegetables (ALVs) are important for food and as a source of income in many western Kenya communities [1]. A survey conducted in three markets in Western Kenya indicated that ALVs contributed 10% of the income generated by commodities in the markets during the study period [1].

The most important species include Spiderplant (*Cleome gynandra*), African nightshades *(Solanum villosum* and *Solanum scabrum*), pumpkin leaves *(Cucurbita moschata*), Cowpeas (*Vigna unguiculata*), vegetable amaranths (*Amaranthus* *blitum*), Jute mallow (*Corchorus olitorius*),), Slenderleaf (*Crotalaria ochroleuca* and *Crotalaria brevidens*) and African kale (*Brassica carinata*), representing seven botanic families, namely Amaranthaceae, Brassicaceae, Capparaceae, Cucurbitaceae, Fabaceae, Solanaceae and Tiliaceae [1].

ALVs are valued by different communities in Western Kenya for their taste, nutritional qualities, medicinal and culinary properties [2]. These vegetables are easily adapted to the environmental conditions they grown in and are easy to grow and manage [3]. A market survey conducted in Kakamega municipal market and two rural markets (Kiboswa and Chavakali) indicated that ALVs contributed 20% of the total value of commodities traded during the study period [1].

Studies have also shown that for a very long time these vegetables were collected from the wild but as the pressure on land increased, they were domesticated and the need for quality seed set in [3, 4]. Normally, ALVs are grown as a subsistence crop and only the surplus is sold to the markets while farmers prepare and preserve their own seed which in most cases is of poor quality [3]. With increasing demand for this commodity, there is need for increased production and this calls for good quality seed for increased yields to meet the demand for these vegetables, particularly in urban and peri-urban areas [4].

The seed production system of Spiderplant, Slenderleaf and African nightshades in Kakamega District of Western Kenya was found to be an informal one [2]. Farmers were found to produce and store their own seed and distribute it among themselves. Farmers lack adequate knowledge on how to grow and process seed optimally and therefore need to be trained on these aspects [5]. This will be a short term solution as mechanisms are put in place for formal breeding programmes for ALVs [2]. Some farmers in Kisii District have already been trained on seed production and processing methods, with the aim of commercializing production of ALV seed. [6].

It has been established that proper processing of seed determines the seed quality, for example, sun-drying of Spiderplant seeds was reported to improve the mean germination time, seedling vigour and overall germination percentage compared with shade-dried seeds [7].

Temperature and light have been shown to have a significant influence on germination of Spiderplant, where best conditions for seed germination are 20-30^{0}C in darkness. Spiderplant seeds are negatively photosensitive and the effects of photo-inhibition increases at temperatures lower than 20^{0}C and germination is also influenced by physiological maturity [8].

Other ALV species that have shown poor germination and dormancy problems include African nightshades and Jute mallow [3]. Poor germination and dormancy problems are normally attributed to the presence of growth inhibitors, the physical hardness of the seed and fruit coats, and damage by insects. Slenderleaf and Cowpea normally do not have problems with germination, and Slenderleaf (*Crotalaria brevidens*) has been reported to maintain germination percentages of over 90% even after five years of seed storage [9].

Among the constraints that hinder optimal production of ALVs, seed quality has been the major one, among others [1]. It was, therefore, essential to study the current seed support and supply systems in three communities in Western Kenya, and develop and suggest ways and means of improving them.

Objectives

- Determine the current seed support systems of ALVs in three communities of Western Kenya
- Collect, evaluate and multiply germplasm of priority ALVs in three communities of Western Kenya
- Establish seed support systems of priority ALVs in three communities of Western Kenya
- Determine the effect of seed treatments on seedling emergency of three priority ALVs in three communities of Western Kenya.

Materials and methods

Current seed support and supply systems in Luhya, Luo and Kisii communities

A survey was conducted between January 2002 and March 2003 in six districts of two provinces that represented three communities in Western Kenya. The six districts included Vihiga and Butere/Mumias districts in Western Province representing the Luhya community, Kisumu and Siaya districts in Nyanza Province representing the Luo community and Kisii and Nyamira districts representing the Kisii community.

From these districts, households were purposively sampled on the basis of their growing ALVs. A structured questionnaire was developed and administered to 80 households in the three communities as follows: Luhya community – 30 households, Luo community – 20 households and Kisii community – 30 households. The total numbers of households in the three communities were 170,000, 90,000 and 140,000 households for Luhya, Luo and Kisii communities respectively.

Germplasm collection, evaluation and multiplication of the collected priority African leafy vegetable species in Western Kenya

Germplasm collection of vegetable amaranths (*Amaranthus blitum*), Spiderplant (*Cleome gynandra*), Jute mallow *(Corchorus olitorius),* Slenderleaf *(Crotalaria brevidens* and *Crotalaria ochroleuca*), African nightshade (*Solanum* *scabrum)* and Cowpeas *(Vigna unguiculata)* was effected during the survey and evaluated in the laboratory by weighing and determining moisture content and germination percentages of the selected accessions which were then regenerated and multiplied in the field.

Seed regeneration and multiplication of the above selected ALV species was conducted from May to December 2003 at Maseno University botanic garden in plots measuring 10m x 10m for each vegetable. All the seven vegetables except *Solanum scabrum* were direct seeded by drilling in rows 30 cm apart, and then thinned to intra-row spacing of 30 cm two weeks later. *Solanum scabrum* was first raised in the nursery then transplanted at the 4-6 leaf stage. At planting time, farm yard manure at the rate of 20 tonnes per hectare was applied into the plots. The seeds were harvested and processed to moisture content of about 8-10%, then weighed and seed yield determined.

Establishment of seed support system in three communities in Western Kenya

Seed production varied with the species. The seven species were bulked, packaged in varying farmer-friendly quantities of 10, 20, 50 and 100g in plastic bags, sealed and made available at Maseno University botanic garden. In addition, contact farmers were selected from those from whom germplasm was collected. Distribution of 100g of seed at the rate of two species per farmer and seed production packages were distributed in, Vihiga, Butere-Mumias (Luhya community), Kisumu, Siaya (Luo community) Kisii and Nyamira (Kisii community) districts between January and June 2004. This was done with an aim of establishing seed support systems in those areas to ensure local availability of quality seed. After June 2004, a follow up was made to establish which of the contact farmers had succeeded in producing the seeds provided and as advised.

Seed treatments for three African leafy vegetables in Western Kenya

A study was conducted between June and August 2004 at Maseno University in the Department of Botany and Horticulture laboratory and shade house. Seeds of *Cleome gynandra, Corchorus olitorius* and *Solanum scabrum* from the selected seed lots were first subjected to germination tests. These were selected on the basis that farmers in the three communities had identified them as species that normally have germination problems (Table 1). Fifty seeds of each vegetable were placed in a Petri dish lined with a wetted filter paper and kept moist throughout the experiment, which was replicated three times. Daily measurements on a number of germinated seeds were made and percentage germination was determined.

Plastic pots of 21 cm diameter and 21 cm height were filled with solarised sandy soil from Maseno University farm and shallowly sowed with 10 seeds of three ALV species after subjecting them to various seed treatments. The experiment was set up in Completely Randomized Design with four treatments replicated three times. The treatments included T_1=No treatment or Control, T_2=Dipped seed in boiling water for 10 seconds, T_3=Soaked seeds in water for 24 hrs and T_4= Soaked seed in 95% acetone for 30 minutes. Parameters measured included seedling emergence, plant height, number of leaves, and leaf area at 15 days after sowing.

Data analysis for the surveys was done by using descriptive statistics and cross tabulation, and calculating and presenting percentages in tables. Data from the laboratory and shade house study were analyzed statistically using analysis of variance (ANOVA) to establish if the treatment effects were significant at 5%, 1% or 0.1%. Separation of means was done only for those parameters where the ANOVA was significant, using Least Significant Difference at 5% level ($LSD_{5\%}$.).

Results

Current seed support and supply systems of African leafy vegetables in Luhya, Luo and Kisii communities

In Luhya, Luo and Kisii communities, women made up 80%, 95% and 50% of the respondents respectively. Land parcels owned by farmers varied from 0.5-5 hectares, 1.5-10 hectares and 0.5 -5 hectares for the Luhya, Luo and Kisii communities respectively, and the percentage of land allocated to ALVs varied from 5-30%. All the respondents stated that they were growing the vegetables for both consumption and sale. The most profitable ALVs were identified as Spiderplant (*Cleome gynandra*), Slenderleaf (*Crotalaria* spp.) African nightshade *(Solanum* spp.), Cowpea (*Vigna unguiculata*), vegetable amaranths (*Amaranthus blitum*) and Jute mallow (*Corchorus olitorius*) starting with the highly profitable ones. Table 1 shows percentage of farmers' responses on various aspects of seed support systems for ALVs.

Most of the farmers preferred to produce their own seed (94%) or purchase them from the village market (72%) than to source from other places. The main mechanisms of distributing seed was by selling (29%) or given out as a gift (21%). Over 50% of the respondents did not participate in distribution of seed of ALVs.

Eighty percent of the households interviewed process seed on their farms either by dry (92%) and/or by use of wet (71%) processing methods. Seed selection was normally done either randomly (19%), choosing healthy plants (56%) or by maturity of pods (24%). Seed was stored in plastic pots after treatment with wood ash (63%), in tins with wood ash (27%), in bottles with wood ash (9%), or in polythene bags with wood ash (2%). In this form, seed would store for a period of 6-24 months depending on the species or prevailing environmental conditions.

Table 1: Farmers' response (%) on seed support systems for African leafy vegetables in three communities in Western Kenya

Practice	Luhya	Luo	Kisii	Mean
*Source of seed (%) not mutually exclusive				
Own seed	82	100	100	94
Village market	86	100	30	72
Outside village	10	0	0	3
Distribution				
Sell	21	15	50	29
Gift	19	25	10	18
None	60	60	40	53
Seed selection				
Random	21	12	25	19
Healthy	54	65	50	56
Maturity	25	23	25	25
*Seed processing	74	76	86	80
Sundry, thresh and winnow	75	100	100	92
Squeeze and sundry	50	80	44	58
Squeeze and dry in shade	0	0	40	13
Seed storage method				
Bottle with wood ash	12	0	6	9
Plastic pot with wood ash	54	65	70	63
Tins with wood ash	34	35	12	27
Polythene with wood ash	0	0	6	2
Longevity of seed				
6 months	10	20	0	10
1 year	54	64	50	56
2 years	20	10	20	20
Not known	16	6	30	14
Seeds with germination problems				
African nightshade	12	20	40	24
Spiderplant	70	45	60	58
Jute mallow	18	35	0	18

*Percentages not mutually exclusive

Germplasm collection, evaluation and multiplication of priority African leafy vegetables in Western Kenya

Germplasm collection and evaluation of seven ALVs from three communities are shown in Table 2. A total of 42 accessions were collected as follows: seven vegetable species, in two seed lots per species for each of the three communities. The selected accessions for each vegetable species based on the weight, germination % and moisture content are also shown in Table 2. Except for Spiderplant (*Cleome gynandra*) and African nightshade (*Solanum scabrum*) laboratory germination was high (>70%) and correlated very well with field germination (>80%). The selected accessions were to have a weight of not less than 15g per accession to allow for multiplication while the other accessions with lower seed weight were discarded. Moisture content for all the accessions ranged between 9.5 and 11.2%.

The results of the seed yields of the multiplied germplasm are shown in Table 3.

Seed yields per hectare varied slightly with the vegetable species but ranged from 1036 (*Corchorus olitorius*) to 1320 (*Amaranthus blitum*) kg/ha. The 1000 seed weight of the seven species was also determined and this also varied with species as shown in Table 3. *Cleome gynandra*, *Solanum scabrum*, *Corchorus olitorius* and *Amararanthus blitum* had 1000 seed weights of 1.4, 1.2, 1.9 and 1.1g respectively. *Crotalaria brevidens* had 1000 seed weight of 5.8g and *Crotalaria ochroleuca* had 5.6g while *Vigna unguiculata* had 1000 seed weight of 100g.

Setting up seed support systems

A seed support system was set up at Maseno University botanic garden where seed of the seven selected species were

Table 2: Selected accessions from a total of 42 African leafy vegetables from Western Kenya

ALVs	Collection number	Weight (g)	% Germination (lab)	% Germination (field)	Moisture content (%)
Cleome gynandra	7	40.6	30	90	11.2
Solanum scabrum	34	15.6	50	85	11.0
Corchorus olitorius	13	22.1	75	80	10.2
Crotalaria brevidens	8	20.8	100	95	9.5
Crotalaria ochroleuca	10	22.3	100	99	9.5
Amaranthus blitum	22	34.0	85	86	9.6
Vigna unguiculata	2	30.7	100	90	10.9

Table 3: Seed yields of seven African leafy vegetables

Vegetable	Yield (kg/ha)	1000 seed weight (g)
Cleome gynandra	1100	1.4
Solanum scabrum	1124	1.2
Corchorus olitorius	1036	1.9
Crotalaria brevidens	1272	5.8
Crotalaria ochroleuca	1172	5.6
Amaranthus blitum	1320	1.1
Vigna unguiculata	1120	100

produced during the long and short rains each subsequent year after the study to support the existing seed support systems like Rural Outreach Program (ROP). Optimal appropriate seed processing is done and seed tested for moisture content and germination percentage, and packed in 10, 20, 50 or 100 kg plastic bags and sealed ready for distribution. These seeds are available throughout the year.

A total of 70 farmers in six districts were provided with seed and technical information on the production and seed processing of seven ALVs, with community distribution of 25, 29 and 16 for the Luo, Luhya and Kisii communities, respectively as shown in Table 4. Table 5 shows the follow-up made on nine farmers representing only 13% of the total number of contact farmers that were given seeds. Eighty percent of the monitored farmers were women. All the farmers visited were producing their own seed and 22% of them (all women) were selling the surplus to the village market.

Seed treatments for three African leafy vegetables in Western Kenya

Laboratory germination percentages for Spiderplant, Scabrum nightshades and Jute mallow were 20, 28 and 86 %, respectively. Table 6 shows the seedling emergence of the three species of ALVs at 15 days after sowing. Results indicate that seed treatment significantly ($p \leq 0.05$) affected seedling emergence of Spiderplant (*Cleome gynandra*) and African nightshade (*Solanum scabrum*) but had no significant ($p>0.05$) effect on Jute mallow (*Corchorus olitorius*). Seeds of both Spiderplant and nightshades that were not treated had significantly lower seedling emergence than those soaked in water for 24 hours and those soaked in 95% acetone. Treatment effects on plant height, number of leaves and leaf area per plant were not significant ($p>0.05$) at 15 days after sowing for all the three species.

Discussion

Current seed support and supply systems of African leafy vegetables in Luhya, Luo and Kisii communities

In many communities in Kenya, especially from the western part, the growing, processing and marketing of leafy vegetables is normally done by women [1, 10]. The results from this study showed that this was the case for Luhya and Luo communities but not for the Kisii community, where gender distribution was 50%.

This observation in Kisii District could be attributed to the fact that as a crop develops from subsistence status to a commercial commodity, men tend to become more involved [4] as is the case of ALVs in Kisii District. Results on priority ALVs identified

Table 4: Seed distribution and technical advice and outreach on African leafy vegetables (given 50 g of seed of their choice and technical leaflets in Kiswahili or English)

District/Community represented		Number of farmers /groups per district	Number per community
Kisumu	Luo	14	25
Siaya	Luo	11	
Vihiga	Luhya	24	29
Butere-Mumias	Luhya	05	
Kisii	Kisii	11	16
Nyamira	Kisii	05	
Total		70	70

Table 5: Follow-up of farmers given seed done between 10 Oct 2004 and 11 Oct 2004

District	Number given seed	Number followed	Gender	Comments
Kisumu	14	2	FF	Both produce own seeds (22%)
Siaya	11	-	-	
Vihiga	24	2	MM	Produce own seed, the other gets from neighbours (22%)
Butere-Mumias	05	2	FF	Both farmers produce own seed and even sell the surplus – gave us samples (22%)
Kisii	11	1	F	Produces own seed (12%)
Nyamira	05	2	FF	Produce own seed (22%)
Total	70	9 (13%)	80%F	

Table 6: Effect of seed treatment on percentage seedling emergence of three African leafy vegetables 15 days after sowing

Treatments	Spiderplant	Nightshades	Jute mallow
T1	27	33	88
T2	45	56	77
T3	72	74	88
T4	76	82	94
LSD5%	10*	9*	ns

T_1=No treatment or Control, T_2=Dipped seed in boiling water for 10 seconds, T_3=Soaked seeds in water for 24 hrs and T_4= Soak seed in 95% acetone for 30 minutes

in this study that included *Cleome gynandra, Crotalaria* spp., *Solanum* spp., *Vigna unguiculata, Amaranthus blitum* and *Corchorus olitorius* agree with reports of other workers who identified the same ALVs species as priority in western Kenya in terms of production, consumption and marketability [1, 4]. These vegetables have been reported to be highly nutritious, containing 100% of the recommended daily allowance for vitamin A and C, iron and calcium and 40% for protein in their fresh leaves [11].

The identified species also have medicinal properties and mature very fast, producing seed under tropical conditions unlike the temperate species [3, 12]. Their ability to withstand drought, low soil fertility and pests and diseases makes them popular with the resource-poor farmers. Because of their many advantages, these vegetables should be improved so that they develop into commercial crops for both the local and export markets to help alleviate poverty and improve the food and nutrition situation of communities in the study areas.

Commercialization should focus on both leaf and seed production. In most cases no proper selection is conducted to choose the best plants and fruits for seed production on farmers' fields [6], which agrees with our finding that some farmers just picked seed at random. No community disparities were observed in this study with regard to source of seed, distribution, seed processing and storage, longevity of seed, and seeds with germination problems. As has been reported by other workers, ALVs are still largely subsistence crops and deliberate efforts have to be made to commercialize them [3, 4 & 14].

Germplasm collection, evaluation and multiplication of priority African leafy vegetables in three communities of Western Kenya

Laboratory germination for the selected germplasm ranged from 30% to 100% and except for *Cleome gynandra* and *Solanum scabrum,* the laboratory germination correlated very well with the field germination. It has been advanced that the differences between laboratory and field germination could possibly be due to photo inhibition that has been observed in Spiderplant [8]. Spiderplant and nightshades with laboratory germination of 30% and 50% respectively, have been reported to have inherent dormancy problems especially if the seeds were not properly harvested and processed [3, 12] and low germination of 15% (Spiderplant) and 5.3% (African nightshade) from farmers' fields have been reported [13] .

Photo-inhibition of Spiderplant seeds has been reported to occur as temperature progressively decreased and was evident at 20ºC[8]. During this inhibition the seeds are not able to germinate as they are in a state of suspended germination. Moisture content did not vary significantly within and between species where the observed range was from 11to 2.5%. Moisture content of seed has a great influence on seed viability and seedling vigour, where for small seeds moisture content of 5-10 % is optimal, while for larger seeds it is 11-14% moisture content for longer storage and maintenance of quality [12, 14].

Seed yields and quality of ALVs will depend not only on the management of the crop in the field but also on the harvesting and processing of the seed [7]. Seed yields of 500-900kg/ha for Spiderplant, African nightshades, Jute mallow, Slenderleaf and vegetable amaranths have been reported in Kenya [7, 13].

Setting up seed support systems

Success of a crop is determined by use of quality seed, and for ALVs, quality seed production technology at farmers' own field is a basic input and primary pre-requisite for vegetable growing [5, 6]. Although this did not come out directly from this study, but from published sources of secondary information, there are indications of the existence of ALVs' seed support initiatives that are operating in the three communities studied.

Seed production at the farm level by farmers is still the most common source of seeds for ALV farmers in Western Kenya and more often than not, seeds produced are of poor quality [2, 5, 6] and some of the initiatives are addressing the problem of poor seed quality for ALVs. Under the Soil Management Project (SMP) and Integrated Pest Management (IPM) concepts for seed production, more than 500 farmers in Kisii District are participating in *Cleome gynandra* and *Solanum villosum* seed production as an alternative means of income generation [6].

Another seed production initiative is by a community-based organization in Siaya District, where Technology Adoption Through Research Organization (TATRO) is committed to this venture after receiving training from national and international research organizations on growing and seed processing of ALVs [5]. TATRO is involved in and committed to seed production, processing, storage and distribution of *Cleome gynandra*, *Crotalaria brevidens*, *Crotalaria ochroleuca*, *Corchorus olitorius* and *Solanum scabrum*. Although there was no direct response from farmers on the existing seed support initiatives in the study area, such initiatives do exist.

The initiatives include Rural Outreach Programme (ROP) in Butere/Mumias District, an initiative that is involved in the production, processing and distribution of *Cleome gynandra*, *Crotalaria brevidens*, *Crotalaria ochroleuca*, *Corchorus olitorius*, *Amaranthus blitum, Brassica carinata, Cucurbita moschata* and *Solanum scabrum* seed to the farmers in the district and its environs. Efforts of this study and seed support system at Maseno University botanic garden collaborate with and complements the existing initiatives in the three communities. There is a great need to increase and strengthen ALV seed support systems at the farm, village, community, institutional, national and regional level.

Seed treatments for three African leafy vegetables in Western Kenya

Spiderplant *(Cleome gynandra),* African nightshades *(Solanum scabrum)* and Jute mallow (*Corchorus olitorius)* were identified to have dormancy problems in this study and this observation agrees with the report that germination of Spiderplant, nightshades and Jute mallow is usually uneven due to seed dormancy [3]. Seed treatments had no significant effect on the seedling emergency of Jute mallow. Fresh and sometimes old Jute mallow seeds show dormancy caused by impermeability of seed coat and to suppress the dormancy, it is recommended that seed is tied in a piece of cloth and immersed for five seconds in almost boiling water or is scarified with sand paper [15].

Germination percentages observed do not agree with what is reported in literature [8, 9] and there may be other physiological aspects that could be contributing to the dormancy besides the physical hardness of the seed coat. In Spider plant, dormancy is much reduced with time and this could be due to reduction of growth inhibitors [16].

For African nightshades, low germination is caused by improper seed extraction and therefore inadequate removal of sugars and germination inhibitors present in the fruit [17]. It is therefore understandable that the soaking treatments enhanced seedling emergence, possibly by their effect on the leaching out germination or growth inhibitors in the seed. The low seedling emergence in the parboiled treatment in all the three species could be explained by the fact that there is a possibility of killing the embryo during the process [8].

Conclusions

The current seed support systems for ALVs in the three communities studied were informal and constituted mainly production from farmers' own farms (94%) or from the village market (72%) although the existence of seed support system initiatives like ROP and TATRO were noted.

Germplasm of seven priority ALV species was collected from three communities in Western Kenya, evaluated and multiplied. The identified and selected priority species included: *Amaranthus blitum, Cleome gynandra, Corchorus olitorius, Crotalaria brevidens, Crotalaria ochroleuca, Solanum scabrum* and *Vigna unguiculata* based on seed weight, germination percentage and moisture content.

A total of 70 contact farmers in six districts of Western Kenya were provided with seed and technical information on production and processing of seed, 13% of whom were already producing quality seed for their own use or sale. A seed support system was set up at Maseno University botanic garden to avail seed of the seven ALVs to farmers. This was to complement the already existing initiatives like TATRO and ROP.

Seed treatment significantly increased seedling emergence of Spiderplant and African nightshade but had no effect on Jute mallow.

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Pratiques culturales et teneur en éléments anti-nutritionnels (nitrates et pesticides) du *Solanum macrocarpum* au sud du Bénin

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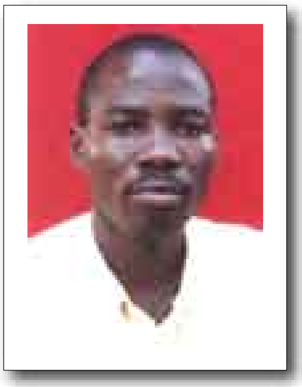

Prudent Anihouvi

Résumé

La pression foncière en région urbaine et périurbaine amène beaucoup de producteurs maraîchers à adopter des pratiques culturales qui ne garantissent pas la qualité sanitaire des produits récoltés. Cette étude a analysé les pratiques de fertilisation et de traitements phytosanitaires sur les légumes feuilles traditionnels les plus consommés afin d'identifier ceux à risque. Six échantillons composites de feuilles de *S. macrocarpum*, répétés deux fois, issus de parcelles ayant reçu des doses de 20, 40 et (20+10+10) t/ha de fientes de volaille et de graines de coton, sur un sol ferralitique faiblement dessaturé au sud du Bénin, ont été analysés au cours des deux premières coupes pour la recherche de nitrates par colorimétrie. Dans la zone de décrue, l'identification et le dosage des pesticides organochlorés par chromatographie en phase gazeuse couplée à un système de détection à capture d'électrons ont été effectués sur dix échantillons de feuilles et un échantillon composite de sol (mélange de trois échantillons de sols) prélevés de façon aléatoire dans les champs maraîchers. Le diagnostic approfondi des pratiques de fertilisation et de traitements phytosanitaires a montré que de fortes doses d'engrais organiques et surtout d'engrais minéraux sont appliqués sur les légumes feuilles dans les zones prospectées. Les taux de nitrate dans les feuilles et dans les sols sont faibles (<50mg/kg de matière fraîche) mais ces taux ont augmenté de la 1ère à la 2ème coupe. Les teneurs en pesticides organochlorés totaux sont comprises entre 0,320 et 2,225 μg/g de légumes secs. En dehors de l'endosulfan et du lindane retrouvés dans les échantillons de légumes, à faibles teneurs (respectivement 0,07 et 0,1 μg/g de légumes), les autres pesticides comme le DDT, l'endrine, l'heptachlore, l'aldrine, le dieldrine présentent des teneurs supérieures aux normes Codex appliquées pour le contrôle de la qualité des aliments. Les mêmes pesticides se retrouvent dans les échantillons de sol.

Mots - clés: Pratiques culturales, fientes, pollution, pesticides organochlorés

Introduction

Le Bénin, comme beaucoup d'autres pays africains, a connu ces dernières années un développement de l'agriculture urbaine et périurbaine à la suite d'une forte croissance démographique induisant un accroissement des besoins alimentaires. C'est une activité génératrice de revenus et d'emplois, pratiquée par les couches vulnérables des régions urbaines et périurbaines [1, 2, 3]. Au Bénin, la production maraîchère et surtout celle des légumes feuilles a pris une part importante dans cette agriculture dans les villes du Sud Bénin [4]. En effet, en matière de cultures maraîchères, les légumes feuilles occupent la deuxième place dans le Sud-Bénin derrière la tomate, avec une superficie de 1496 ha et une production totale de 10600 T [5]. Parmi les cultures maraîchères produites au Bénin, les légumes feuilles sont les plus consommés (62,5%) et les légumes feuilles traditionnels en y constituent la grande part (89%). Ces légumes feuilles traditionnels rentrent dans l'alimentation quotidienne de presque tous les Béninois [6].

Le développement de ce type d'agriculture s'est accompagné de plusieurs contraintes dont les plus importantes sont la pression foncière avec pour conséquence la surexploitation des terres et les attaques de ravageurs de toutes sortes occasionnant ainsi d'énormes pertes de productions [7, 8]. Au vu de ces contraintes, il est évident que les conditions de culture de ces légumes feuilles ne soient pas des meilleures : sur-fertilisation organique et/ou minérale, utilisation abusive ou inappropriée de pesticides, etc. Des doses d'engrais organiques (> 40T/ha) et minéraux (> 600 kg/ha) sont fréquemment apportées sur Solanum macrocarpum et les ordures ménagères sont également utilisées avec les risques de contamination des sols aux métaux lourds (plomb, cadmium, mercure etc.) [9, 10, 11, 12]. De même l'usage des pesticides □coton□ comme l'endosulfan, qui sont interdits sur les cultures vivrières et maraîchères, a été signalé sur les légumes [4, 13, 14]. Tous ces facteurs ne garantissent pas la qualité sanitaire des légumes produits. C'est pourquoi la présente étude a été initiée et vise de façon générale à analyser à travers les pratiques culturales et phytosanitaires, la qualité des légumes feuilles traditionnels les plus cultivés et les plus consommés au Bénin.

Les objectifs spécifiques sont les suivants :

- Analyser les pratiques de fertilisation et de traitements phytosanitaires en cours sur les légumes feuilles.
- Identifier et évaluer les éléments antinutritionnels (résidus de pesticides et nitrates) présents dans ces légumes feuilles.

Matériel et méthodes

L'étude a été conduite dans la ville de Cotonou et dans six autres villes du sud du Bénin. La région du sud du Bénin bénéficie d'un climat bimodal à deux saisons de pluie et à deux saisons sèches. A Cotonou, la température moyenne varie entre 33 et 28°C. L'humidité relative mensuelle moyenne varie entre 75 et 90 %.

Sites d'enquête et échantillonnage des producteurs

Les zones enquêtées ont été retenues sur la base du niveau de production en légumes feuilles et les recherches documentaires sur les systèmes maraîchers au Sud-Bénin [4, 11, 12, 14, 15]. Ainsi le centre et la périphérie des villes ci-après ont été identifiés pour l'enquête : Cotonou, Ouidah, Porto-Novo, Sèmè, Adjohoun (Vallée de l'Ouémé), Grand-Popo et Athiémé. Un regroupement en zones a été fait non seulement sur la base des caractéristiques écologiques, édaphiques et climatiques mais aussi en tenant compte du zonage effectué par PADAP [14] dans le sud du Bénin qui intègre la pression de l'urbanisation, les surfaces cultivées, la disponibilité en eau et les infrastructures etc. Les localités qui entrent dans les trois grandes zones constituées sont les suivantes:

- zone du Cordon littoral située aux abords de la mer: Grand-Popo centre, Sèmè
- zone de décrue: Adjohoun, Athiémé, Grand-Popo rural
- zone intra et périurbaine: Cotonou, Porto-Novo, Ouidah

L'enquête a été effectuée auprès de 101 producteurs (une trentaine par zone), sélectionnés de façon aléatoire dans les différentes localités ci-dessus citées qui cultivent prioritairement la morelle et/ou l'amarante qui sont des légumes les plus consommés dans le sud du Bénin. Le questionnaire administré a mis l'accent sur les systèmes de culture intégrant les légumes feuilles traditionnels, les pratiques paysannes en matière de fertilisation et de protection phytosanitaire.

Test agronomique

Le test a été conduit sur la station d'Agonkanmey dans le Sud-Bénin qui est caractérisé par un sol ferrallitique faiblement dessaturé, très sableux en surface (60 % de sable) et un climat de type subéquatorial avec une pluviométrie annuelle moyenne comprise entre 1000 et 1200 mm. La plante test est la morelle (*Solanum macrocarpum*). Deux types d'engrais organiques ont été utilisés: les fientes de poulet (FP) et les graines de coton (GC). Les traitements appliqués sont les suivants :

- Apport unique 20T/ha (FP1 et GC1)
- Apport unique 40T/ha (FP2 et GC2)
- Apport fractionné 40T/ha (20-10-10) soit (FP3 et GC3).

Les deux types d'engrais organiques ont été appliqués selon les trois traitements répétés quatre fois. Les parcelles élémentaires ont une superficie de 6 m^2. Les variables mesurées concernent les rendements en feuilles fraîches et les teneurs en nitrates.

Analyse des sols et des feuilles

Les prélèvements ont été faits à deux niveaux :

- Des prélèvements de feuilles issus des tests en milieu contrôlé sur la station d'Agonkanmey pour la recherche de nitrate.
- Des prélèvements aléatoires sur les sites maraîchers de sols et de feuilles pour la recherche de nitrate

(Cotonou) et de résidus de pesticides (Vallée de l'Ouémé). En effet, ces options ont été faites à cause des pratiques paysannes recensées lors des enquêtes : les apports en fertilisants azotés dépassant les normes à Cotonou et l'utilisation des pesticides tout venant dans la vallée de l'Ouémé.

Pour les analyses de nitrates en station, six échantillons composites de feuilles, répétés deux fois, issus de parcelle ayant reçu des doses de 20, 40 et (20+10+10) T/ha de fientes de volaille et de graines de coton, ont été analysés au cours des deux premières coupes. La récolte du *S.macrocarpum* a été faite par coupes successives. Les enquêtes ont révélé que le nombre moyen de coupes est de 3 avec des extrêmes de 12 dans la vallée de l'Ouémé.

Au laboratoire, 5g de feuilles lavées à l'eau déminéralisée sont traités après broyage avec de l'acide acétique (2%). Le filtrat après homogénéisation est conservé au réfrigérateur pour dosage des ions nitrates. Les ions nitrates (NO_3^-) ont été dosés par colorimétrie avec la méthode de salicylate de sodium après extraction dans une solution d'acide acétique à 2% pour les échantillons de feuilles et dans une solution de 0,1N de sulfate de potassium pour les échantillons de sols.

Pour les analyses de résidus de pesticides, dix (10) échantillons de feuilles de S. macrocarpum ont été prélevés sur les plants matures, emballés dans du papier aluminium et conservés au frais dans une glacière jusqu'au laboratoire. Un (1) échantillon composite de sols (mélange de trois échantillons de sols pris au hasard sur un site maraîcher de la vallée de l'Ouémé), a été prélevé à une profondeur de 0-30 cm.

L'extraction des résidus de pesticides a été réalisée à l'extracteur Soxlhet avec le pentane comme solvant. La chromatographie en phase gazeuse couplée à un système de détection à capture d'électrons (CPG/ECD) a été utilisée pour le dosage.

Analyse des données

Pour les données d'enquête, l'analyse descriptive a été utilisée pour le calcul des moyennes, d'écart type et de pourcentage. Pour le test agronomique, les facteurs analysés sont : les déchets, les doses et les effets doses (effets directs et en arrière effets). Les effets doses sont mesurés par la première coupe et les arrière-effets qui se décomposent comme suit :

- effet direct + arrière effets pour les apports fractionnés
- arrière effet simple pour les apports uniques.

Ainsi au total, six traitements ont été comparés. L'analyse de variance a été faite avec le logiciel SAS. La Plus Petite Différence Significative (PPDS) a été utilisée pour comparer les moyennes au seuil de 5%.

Résultats

Résultats d'enquête

Au cours de l'enquête effectuée dans la région sud du Bénin une analyse des pratiques paysannes de fertilisation et de protection phytosanitaire sur les légumes feuilles a été faite.

Légumes feuilles les plus cultivés

Solanum macrocarpum (morelle ou "Gboma" en langue locale Fon) et *Amaranthus hydridus* (amarante ou 'Fotètè') sont les deux légumes feuilles identifiés comme étant les plus cultivés dans la région sud du Bénin. Ces légumes feuilles sont produits par 95% et 58% des producteurs enquêtés. *Celosia argentea* (célosie ou 'Soma'), *Corchorus olitorius* (crincrin ou 'Ninnouwi') et le *Vernonia amygdalina* (vernonie ou 'Amavivè') sont produits respectivement par 30%, 22% et 10% des maraîchers enquêtés.

En considérant l'ensemble des exploitations maraîchères enquêtées au cours de l'année 2003, les superficies moyennes emblavées sont de 643 m^2 pour la morelle et de 328 m^2 pour l'amarante. Les résultats d'enquête ont en outre montré qu'environ 60% des producteurs consacrent plus de 50% de leurs superficies à la production de ces deux légumes feuilles alors que 17% des producteurs leur réservent moins de 25%. Tout ceci démontre l'importance que revêtent ces deux légumes feuilles dans les systèmes de culture maraîchère du Sud-Bénin.

Pratiques culturales sur les légumes feuilles

Fertilisation organique et / ou minérale

Le recours à la fertilisation organique et minérale est systématique dans les zones intra urbaines, périurbaines et du Cordon littoral alors qu'il demeure très marginal dans les zones de décrue. En effet, 16 et 17% des producteurs de la zone de décrue utilisent respectivement les engrais minéraux et organiques.

Trois types d'engrais organiques sont identifiés comme étant les principales sources de matière organique utilisées par les maraîchers du Sud-Bénin dans la production des légumes feuilles: fientes de poulet (71,4% des producteurs enquêtés), bouse de vache (17,5%) et ordures ménagères (11,1%). L'application directe sans compostage de ces différents types d'engrais organiques est la pratique la plus observée.

Les doses et fréquences d'apport des engrais organiques et minéraux sont présentées dans le tableau 1. Ces valeurs ne concernent que les fientes de poulet et la bouse de vache. Les ordures ménagères n'ont pas été prises en compte du fait de la grande difficulté au cours de l'étude à estimer les quantités utilisées. En effet, les quantités apportées dépendent de la main d'œuvre utilisée (âge et sexe), le lieu d'entreposage, les bols et bassines utilisés etc. L'analyse de ce tableau montre que la morelle bénéficie plus d'amendement organique que l'amarante. L'engrais organique est apporté en moyenne 1,1 fois à l'amarante et 1,3 fois à la morelle. Par ailleurs, les doses d'engrais organiques les plus élevées sont enregistrées en zones du Cordon littoral (28,85 t/ha) et de l'intra et périurbain (26,47 t/ha). Les doses d'engrais organiques appliquées sont presque partout supérieures à celle recommandée par la recherche (20 t/ha) quel que soit le type de légume feuille.

L'urée est l'engrais minéral le plus utilisé sur les légumes feuilles. Soixante dix-neuf pour cent (79%) des producteurs l'utilisent seul et 21% l'utilisent en mélange avec le NPK surtout pour la production de la morelle. L'urée est apportée de façon fractionnée en moyenne deux fois pendant tout le cycle de culture quelle que soit la zone.

La morelle bénéficie plus d'apport d'urée que l'amarante. En effet, les doses d'urée apportées à la morelle font en moyenne deux fois celles appliquées à l'amarante quelle que soit la zone. Les doses d'application d'urée les plus élevées sont observées sur le Cordon littoral (1150 kg/ha) et les plus faibles dans la zone de décrue (360 kg/ha) (tableau 2). Quelle que soit la zone, les doses d'urée sont supérieures à celle recommandée par la recherche nationale sur les légumes feuilles (75 - 150 kg/ha) [16]. Les enquêtes ont révélé des applications dépassant 5 fois la dose recommandée.

La distribution des producteurs suivant les doses d'urée apportées est présentée au tableau 3. Ce tableau montre que près de 83% des producteurs de morelle et 50% des producteurs d'amarante apportent des doses d'urée six fois supérieures à la dose recommandée. Les doses les plus appliquées sont comprises entre 300 et 600 kg/ha pour la morelle (34% des producteurs de morelle) et 150 et 600 kg/ha pour l'amarante (70% des producteurs d'amarante). Des doses dix fois supérieures à la dose recommandée sont enregistrées chez environ 34% des producteurs de morelle et 6% des producteurs d'amarante.

Pratiques phytosanitaires sur les légumes

Les problèmes phytosanitaires constituent l'une des contraintes qui limitent la production de légumes feuilles dans le Sud-Bénin. Tous les maraîchers enquêtés ont signalé des attaques de ravageurs (acariens, chenilles) et maladies (pourriture dues au *Sclerotium*, nématodes) sur les légumes feuilles. La lutte chimique est la principale méthode utilisée par les maraîchers quelle que soit la zone.

Les pratiques en matière d'utilisation de pesticides sont des plus dangereuses. En effet, les maraîchers pulvérisent le plus souvent les légumes avec une diversité d'insecticides et de fongicides à des doses inappropriées. La liste des produits de synthèse les plus utilisés par zone, le pourcentage de producteurs utilisant chaque type de produit ainsi que les doses et fréquences moyennes d'applications sont présentés dans le tableau 4. Dans la zone de décrue, les insecticides coton comme Dursban (chlorpyriphos-éthyl), Cotalm (cyperméthrine + diméthoate),

Tableau 1: Dose et fréquence moyennes d'apport de l'engrais organique par zone sur la morelle et l'amarante

Zones	Morelle		Amarante	
	Dose (t/ha)	Fréquence d'apport	Dose (t/ha)	Fréquence d'apport
Cordon littoral	28,8 (13)	1,1	22,4 (4)	1,0
Intra et périurbain	26,4 (34)	1,4	15,9 (33)	1,1
Décrue	23,3 (8)	1,4	23,3 (6)	1,3
Sud-Bénin	26,6 (55)	1,3	17,5 (43)	1,1

(): Effectif des producteurs utilisant les fientes de poulet ou la bouse de vache par zone

Tableau 2: Dose et fréquence moyennes d'apport de l'urée par zone

Zones	Morelle		Amarante	
	Dose (t/ha)	Fréquence d'apport	Dose (t/ha)	Fréquence d'apport
Cordon littoral	1151,5 (15)	2,1	420,8 (4)	1,0
Intra et périurbain	636,6 (39)	2,4	361,1(39)	1,4
Décrue	361,9 (7)	2,1	206,7 (5)	1,2
Sud-Bénin	439,0 (61)	2,3	210,0 (48)	1,3

(): Effectif des producteurs utilisant l'urée par zone

Tableau 3: Distribution des producteurs suivant les doses d'urée apportées

Dose d'urée (kg/ha)	Morelle		Amarante	
	Effectif	Pourcentage (%)	Effectif	Pourcentage (%)
75 - 150	3	4,92	7	14,58
150 - 300	7	11,47	17	35,42
300 - 600	21	34,43	17	35,42
600 - 750	9	14,75	4	8,33
750 - 1125	13	21,31	3	6,25
> 1125	8	13,12	0	0
Total	61	100	48	100

Tableau 4: Doses et fréquences moyennes d'application des pesticides les plus utilisés par zone

Zones	Produits phytosanitaires	Dose moyenne (g ou l/ha)	Fréquence d'application	Dose recommandée
Cordon littoral	Topsin-M	2186,0 g/ha (416-4956)	3,5 (3-4)	1400,0 g/ha
	Orthène	1,025 l/ha (0,05-2)	4,0 (3-5)	0,8 l/ha
	Banko plus	1855,0 g/ha (1250-2460)	3,5 (2-5)	500,0 g/ha
Décrue	Cotalm	1,3 l/ha (0,05-3)	5,5 (3-8)	1,0 l/ha
	Dursban	1,2 l/ha (0,06-3)	5,0 (3-7)	1,0 l/ha
	Orthène	1,0 l/ha (0.05-2)	4,0 (3-5)	0,8 l/ha
Intra et périurbain	Manèbe	2041,9 g/ha (208-8680)	3 (2-4)	1600,0 g/ha
	Decis	4,9 l/ha (0,125-20,8)	3 (1-5)	1,0 l/ha

( ) : Min-Max

endosulfan, etc., interdits sur les légumes sont beaucoup utilisés par un nombre élevé de producteurs.

Les doses appliquées varient d'un producteur à l'autre. La majorité des producteurs appliquent différentes doses jusqu'à obtenir la dose efficace. Le nombre d'applications est variable selon les expériences des producteurs. Pour certains, le traitement se fait à chaque fois qu'il y a apparition d'insectes sur la plante ; pour d'autres il faut traiter tous les trois jours sans attendre l'apparition des insectes.

Les doses de pesticides appliquées par traitement sont en général supérieures à celles recommandées quel que soit la zone ou quel que soit le pesticide (tableau 4). Les doses les plus élevées sont enregistrées au niveau des zones intra et périurbaines et littorales. Les doses moyennes appliquées dans lesdites zones sont comprises entre 1,5 et 5 fois celles recommandées. Les doses notées au niveau des zones de décrue sont au contraire proches de celles qui sont recommandées pour les quelques produits autorisés (TopsinM, orthène, etc.). Cependant les fréquences d'application les plus élevées sont notées dans la zone de décrue (5 fois en moyenne) avant la première coupe soit en deux mois et demi.

Résultats du test agronomique

Sources de matière organique et rendements en feuilles de la morelle

Les analyses statistiques ont montré qu'au seuil de 5%, les interactions entre doses et types d'engrais organiques ne sont pas significatives, c'est-à-dire que les deux facteurs considérés sont indépendants. Le tableau 5 présente les effets (doses et types d'engrais organiques). Les résultats obtenus entre la première coupe (effet) et la deuxième coupe (arrière - effet) sont significativement différents au seuil de 5%, quel que soit le paramètre mesuré, toutes doses et tous types d'engrais organiques confondus. Les constats sont :

- Les premières applications d'engrais organiques contribuent à l'élargissement des feuilles
- Les arrières effets permettent une augmentation du nombre des feuilles mais celles-ci sont plus petites
- Les arrières effets donnent les rendements les plus élevés.

Dose d'engrais organique et teneurs en nitrates

La figure 1 présente l'effet des sources de matière organique

Tableau 5: Effet direct et arrière effet des facteurs déchets et doses sur la croissance des plants de morelle

Effets	Paramètres mesurés			
	Hauteur plant (cm)	Largeur feuille (cm)	Nombre de feuilles	Rendements des feuilles fraîches
Effet direct	26,99±4,63 b	15,88±1,48 a	33,44±5,36 b	14,68±5,99 b
Arrière effet	33,17±4,12 a	11,92±1,72 b	47,20±8,62 a	20,32± 4,03 a

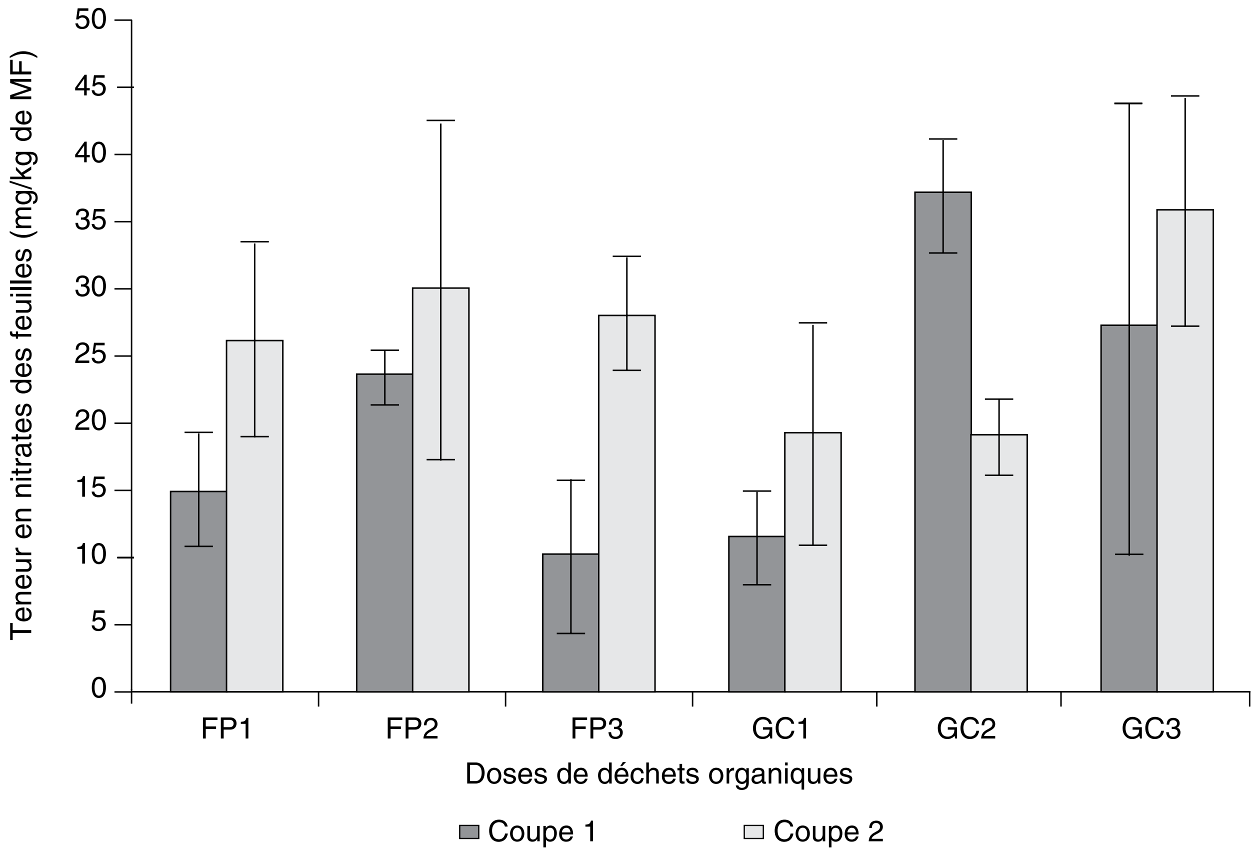

Figure 1. Influence des apports organiques sur la teneur en nitrate des feuilles en milieu contrôlé

et des doses sur la teneur en nitrates des feuilles de morelle. La comparaison des teneurs en nitrates des feuilles du point de vue statistique, montre qu'il n'y pas eu de différence significative entre les traitements aussi bien à la première qu'à la deuxième coupe.

Les doses et mode d'apport de fientes n'ont pas influencé la teneur en nitrates des feuilles de *Solanum macrocarpum* pour les deux coupes effectuées.

Les teneurs en nitrate même si elles sont faibles, ont augmenté lorsqu'on passe de 20 à 40 T/ha. L'apport fractionné de 40T/ha a donné des teneurs statistiquement égales à l'apport unique de 40T/ha mais avec des tendances à la baisse beaucoup plus prononcées pour les fientes que pour les graines de coton.

A l'instar des rendements, la concentration en nitrates des feuilles d'une manière générale a augmenté quels que soient les traitements de la première à la deuxième coupe surtout dans le traitement pour les fientes de poulets.

Doses de résidus de pesticides dans les feuilles et le sol

Nitrates

Les échantillons de sol prélevés dans la Vallée de l'Ouémé présentent des concentrations en nitrates plus élevées que ceux prélevés à Cotonou (respectivement 16,16 et 3,91 NO^-_3 mg/kg). Les échantillons de feuilles prélevés présentent des teneurs en nitrates variables. La teneur moyenne est de 13,92 mg/kg de feuilles fraîches dans la Vallée de l'Ouémé et de 16,89 mg/kg à Cotonou. Tous les échantillons de feuilles ont accumulé des nitrates, mais à des taux inférieurs aux normes admises par l'OMS/FAO (500 mg/kg) [17].

Résidus de pesticides

Les analyses de feuilles et de sols révèlent une contamination par les pesticides organochlorés comme nous le montrent les tableaux 6 et 7.

Les pesticides organochlorés détectés dans les légumes sont le DDT, l'Endrine, l'Heptachlore, l'Aldrine, l'Endosulfan, le Dieldrine et le Lindane. Les mêmes pesticides se retrouvent dans l'échantillon composite de sol.

Le DDT, l'endosulfan et l'heptachlore ont été détectés dans tous les échantillons de légumes. En dehors de l'endosulfan et du lindane retrouvés dans les échantillons de légumes, à faibles teneurs, les autres pesticides présentent des teneurs supérieures aux normes Codex appliquées pour le contrôle de la qualité des aliments.

Discussion

Les résultats ont montré que les pratiques de fertilisation varient suivant les zones. Alors que l'apport d'engrais organique et minéraux est systématique dans les zones du Cordon littoral et de l'intra et périurbain, il est peu fréquent en zones de décrue. En effet, avec la crue, beaucoup d'éléments fertilisants sont transportés et déposés au niveau des sols. Après le retrait de l'eau, les sols alluvionnaires des zones de décrue sont pourvus d'une richesse en éléments fertilisants. Cette fertilisation naturelle justifie la faible proportion de producteurs s'adonnant à la pratique de fertilisation.

Dans la zone intra et périurbaine où les ordures ménagères sont encore utilisées, le triage de ces ordures, souvent mal exécuté, augmente les risques de pollution des espaces cultivés par les matières non biodégradables et de contamination des légumes par les métaux lourds [18].

Quelle que soit la zone, la morelle bénéficie de plus d'apports organique et minéral que l'amarante. Ceci s'explique par le fait que le nombre de coupes pratiquées sur la morelle est supérieur à celui de l'amarante.

Les doses de fertilisation les plus élevées sont observées dans les zones du Cordon littoral et de l'intra et périurbain. En effet, les sols très sableux de ces zones sont pauvres en matière organique. De même, les besoins d'intensification dus à la pression foncière, exigent des apports élevés en intrants pour une augmentation de la productivité. Enfin, ces types de sols favorisent une lixiviation rapide des éléments nutritifs vers les horizons inférieurs.

Ces pratiques de surdosage observées surtout au niveau des zones de l'intra, périurbain et du Cordon littoral mettent en évidence les risques de sur-fertilisation azotée et d'accumulation de nitrates dans les feuilles de morelle et d'amarante. En effet, la sur-fertilisation azotée peut conduire à une accumulation de nitrates dans les feuilles, surtout celles utilisées comme épinard et laitue [19, 20]. Ce qui ne saurait rester sans conséquences sur la santé des consommateurs. En effet, une partie des nitrates ingérés peut être transformée en nitrites responsables des troubles respiratoires surtout chez les jeunes enfants avec pour conséquence la méthémoglobinémie [21, 22]. Des études ont prouvé de façon irréfutable que les nitrates se combinent aux amines pour former des composés cancérogènes appelés nitrosamines [23]. Cependant les résultats d'analyse de nitrates au niveau des feuilles ont révélé des taux très faibles comparés aux normes admises par l'OMS (500 mg/kg). Certains auteurs ont déjà fait état de faibles taux de nitrates au niveau des légumes produits à Cotonou [24, 25].

Tableau 6: Teneurs en pesticides organochlorés (µg/kg) dans les échantillons de feuilles

	Pesticides organochlorés (µg/kg de légumes)						
	DDTs	Endosulfan	Aldrine	Dieldrine	Endrine	Heptachlore	Lindane
Moyenne sites	0,224	0,356	0,115	0,301	0,112	0,07	0,11
Normes Codex*	0,1	2	0,1	0,1	0,02	0,05	0,5

Normes Codex Alimentarius : FAO, 2001

Tableau 7: Concentrations en pesticides organochlorés (µg/g) dans l'échantillon composite de sol

Echantillon	Pesticides organochlorés (µg/g)						
	Aldrine	P,p'-DDT	Endosulfan	Dieldrine	Endrine	Heptachlore	Lindane
Sol	0,496	4,8	7,975	2,15	3,568	0,725	2,457

Les légumes produits dans le Sud-Bénin présentent donc très peu de risques d'intoxication en nitrates. Néanmoins les risques de pollution de la nappe phréatique par les nitrates sont probables à cause des sols très filtrants observés dans le sud du Bénin.

Les résultats d'enquête ont montré que les risques de contamination des légumes par les pesticides sont plus grands dans les zones de décrue. En effet, en se référant à l'Index Phytosanitaire, il ressort que la plupart des pesticides utilisés en zones de décrue (Cotalm, Dursban) notamment dans la vallée de l'Ouémé sont des insecticides « coton » à forte toxicité, prohibés sur les cultures vivrières [26]. De même, les fréquences de traitement les plus élevées sont notées au niveau de cette zone. Par contre les pesticides les plus utilisés en zones littorales (Topsin-M, Orthène, Banko Plus) et en zones intra et périurbaines (Manèbe, Decis) font partie de ceux recommandés en maraîchage.

Les paramètres mesurés en plein champ : la largeur des feuilles, le nombre de feuilles, les rendements en matière sèche et fraîche, ont évolué différemment selon qu'on considère les effets directs ou les arrières effets. Les feuilles les plus larges sont obtenues à la première coupe quel que soit le type d'engrais organiques. Ce qui suppose que l'azote contenu dans les engrais organiques a été surtout utilisé pour un bon développement des feuilles. En effet, l'azote est un facteur essentiel de croissance des plantes surtout au niveau des feuilles et des tiges [27]. Après la première coupe, le nombre de ramifications augmente avec aussi une augmentation du nombre de feuilles. Malheureusement toutes ces feuilles ne peuvent pas bénéficier d'une bonne photosynthèse ; leur développement est donc limité. Le nombre de feuilles ayant augmenté, le rendement augmente également d'où le résultat que l'arrière effet donne des rendements supérieurs à l'effet direct quels que soient les doses et les types d'engrais organiques. Le rendement élevé obtenu au niveau de l'arrière effet de la dose fractionnée de 40 T/ha peut être expliqué par la mise à disposition progressive des éléments nutritifs à des moments où la plante en a besoin, la reconstitution du stock organique par l'apport répété de matières organiques au fur et à mesure que les eaux d'irrigation contribuent au lessivage des éléments nutritifs et le mulch permanent occasionné par les apports successifs de déchets organiques. Ce mulch maintient l'humidité du sol et la diminution du lessivage au niveau de ces parcelles [28].

Les doses et mode d'apport de déchets n'ont pas influencé la teneur en nitrates des feuilles de *Solanum macrocarpum*. En examinant les taux de nitrates dans les feuilles, on peut déduire que les plants suivant les doses de matières organiques apportées, n'utilisent pas de la même manière les nitrates prélevés dans le sol. D'autres facteurs incontrôlables peuvent être à l'origine de cette variabilité comme le démontre les écarts enregistrés: ensoleillement, développement de la plante, état du sol, etc.

Comme les rendements, la concentration en nitrates des feuilles d'une manière générale a augmenté de la première à la deuxième coupe. Cela peut être dû à la décomposition des matières organiques, qui libère progressivement l'azote minéral prélevé par la plante.

Les fortes doses (40T/ha) n'ont pas induit des teneurs élevées en nitrates des feuilles par rapport aux faibles doses. Ceci laisse supposer que la décomposition des matières organiques n'est pas encore totale compte tenu de la quantité apportée. Ainsi, la plante utilise la majeure partie de l'azote minéral absorbé pour son développement. Les rendements ont donc augmenté de la première à la 2ème coupe. Cependant l'accumulation des nitrates dans les feuilles des parcelles ayant reçu 40T/ha, pourrait être accentuée au moment où les plants auraient atteint un stade de développement maximal et que la décomposition serait avancée. En effet, lorsque les rendements finissent par atteindre un seuil malgré l'apport d'azote, la teneur en nitrates des légumes continue d'augmenter. A ce stade, les végétaux au lieu d'utiliser les nitrates à des fins structurales ou les incorporer à la chlorophylle et à d'autres composés, ils les gardent en réserve dans leurs tissus foliaires sous forme de nitrates [20, 23].

Les résultats d'analyses de résidus de pesticides des échantillons de sols et feuilles prélevés dans la vallée de l'Ouémé montrent l'existence des risques de contamination par les produits phytosanitaires. Cependant ces risques existent également dans les zones du Cordon littoral et de l'intra et périurbain à cause du surdosage observé même si les produits utilisés sont recommandés en maraîchage. D'autres études ont déjà fait mention d'une utilisation inappropriée ou abusive de pesticides en maraîchage dans le Sud-Bénin [4, 13, 14]. Le DDT, l'endosulfan et l'heptachlore ayant été détectés dans tous les échantillons de légumes, on pourrait conclure une utilisation généralisée de ces trois types de pesticides au niveau de tous les sites. Ces trois pesticides pourraient constituer de bons indicateurs de suivi de pollution par les pesticides organochlorés dans la vallée de l'Ouémé.

En dehors de l'endosulfan et de la lindane retrouvés dans les échantillons de légumes, à faibles teneurs, les autres pesticides présentent des teneurs supérieures aux normes Codex appliquées pour le contrôle de la qualité des aliments. Les analyses étant effectuées sur des échantillons de légumes à l'état brut; les risques d'intoxication des consommateurs par les produits de maraîchage de la vallée de l'Ouémé sont réels.

Conclusion

La morelle (*Solanum macrocarpum*) et l'amarante (*Amaranthus cruentus*) sont les deux principaux légumes feuilles traditionnels les plus cultivés au Sud-Bénin. Cette étude a permis de montrer que les pratiques actuelles sur ces légumes feuilles participent non seulement à détériorer leur qualité nutritionnelle mais aussi à la dégradation de l'environnement. En effet, des pratiques de sur-fertilisation (organique et/ou minérale) et d'utilisation abusive ou inappropriée de pesticides sur ces légumes feuilles notées lors des enquêtes, ne sont pas de nature à garantir la qualité nutritionnelle de la morelle et de l'amarante.

Pour la production de feuilles dans les sols sableux du sud du Bénin, les doses de 20 et 40 T/ha et la fréquence d'apport des fientes ou des graines de coton ont peu influencé les rendements et les teneurs en nitrates des feuilles. Bien que des études récentes aient montré que la consommation des légumes riches en nitrates pourrait améliorer certaines réactions immunitaires de l'organisme à des agents pathogènes [21], il est important de tenir compte de l'augmentation de ces taux dans les feuilles consommées dans les coupes successives, pratiques souvent observées dans la gestion des légumes feuilles.

Les concentrations en pesticides organochlorés dans les feuilles sont supérieures aux normes Codex appliquées pour le contrôle de la qualité des aliments. Les risques d'intoxication des consommateurs par les pesticides sont grands et réels. Une action conjuguée des différents acteurs en agriculture urbaine est indispensable pour une sécurité alimentaire durable au sud du Bénin.

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Response of Slenderleaf (*Crotalaria brevidens* Benth) to inorganic nitrogen application

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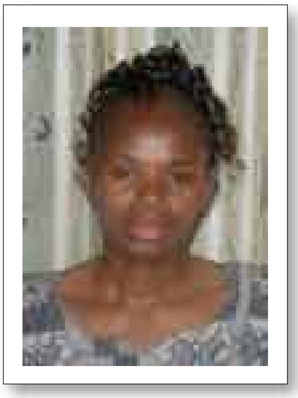

Mary Abukutsa-Onyango

Abstract

Slenderleaf is one of the African leafy vegetables (ALVs) that has been grown and consumed in Kenya for a long time. Its young leaves and shoots are used as a cooked vegetable. Slenderleaf acts as an agent to promote suicidal germination of Striga, a parasitic plant that is a major problem weed for maize and millet growers. One of the major constraints in its production has been poor quality seed and lack of technical packages for optimal production. Although Slenderleaf has a high germination percentage that occurs within five days, there is hardly any information on nitrogen nutrition and the longevity of Slenderleaf seed and factors affecting them.

The objectives of this study therefore were: to investigate the effect of nitrogen rates on growth, leaf and seed yield of *Crotalaria brevidens;* and to study the effect of storage period on germinability of *Crotalaria brevidens*. Seeds of Slenderleaf were obtained from Maseno University botanic garden and subjected to germination tests, then planted in the field in a well prepared seed bed at Maseno University experimental plots at a spacing of 30 x 30cm.

The design of the experiment was RCBD with six treatments and three replications; each plot measured 1.5 x 2m. The treatments included six nitrogen rates (0, 10, 20, 40, 80 and 100 kg N per hectare). Measurements on plant height, number of leaves, number of branches and number of flowering plants were taken regularly. Seeds were harvested, processed and seed yield determined. The seeds from the various treatments were kept in airtight containers and stored at room temperature in September 2003.

Germination tests were carried out by placing 50 seeds from each treatment randomly selected into a Petri-dish lined with a wet filter paper every six months commencing September 2003 for a period of two years, and germination percentage determined. Results indicated that nitrogen rates did not have a significant ($p>0.05$) effect on growth, leaf and seed yields. Seed yields varied from 0.42 to 0.59 kg/m^2. Nitrogen rates had no significant ($p>0.05$) effect on the germination percentage in the period of storage. In September 2003, the mean germination percentage was 96.8% while in September 2005 it was 95%. The findings of this study indicate that nitrogen application may not always be necessary for growing Slenderleaf and seed can be stored for two years without loss of germinability and viability.

Key words: Slenderleaf, nitrogen, growth, yields

Introduction

Plants in the C*rotalaria* genus belong to the family Fabaceae/ Leguminaceae [1, 2]. The genus *Crotalaria* includes about 500 species of herbs and shrubs of which 400 species can be found in Africa [1].The two African species used as a vegetable are *Crotalaria ochroleuca* and *Crotalaria brevidens*. The former has a mild taste whereas the latter has a bitter taste, but both species are commonly called Rattle pod, Rattle box, Sunhemp or Slenderleaf. *Crotalaria ochroleuca* has bright green leaves, and grows to a height of 250 cm. The flowers are pale yellow or creamish in colour and the seeds are normally but not always light yellow and the pods are wider in diameter and big [1]. *Crotalaria brevidens* has bluish green leaves, and grows to a height of 210 cm and has bright yellow flowers and the seed colour normally contains anthocyanin and is light brown in colour and the pods are small and narrow in shape.[2]. The main distinguishing features of the two species is the taste and pod size. The centre of diversity of both species is believed to be Africa and the two C*rotalaria* vegetable species are commonly cultivated and consummed throughout East Africa and to a limited extent in West Africa.

Slenderleaf (*Crotalaria brevidens*) is one of the important African indigenous vegetables whose young leaves and shoots are consumed and contributes 100% of the daily dietary requirement for vitamin A, vitamin C, iron, calcium and 40% of proteins when 100g of the fresh weight are consumed [3, 4]. Slenderleaf has medicinal applications where it has been implicated in treating stomach-related ailments and malaria.[2, 5]. Slenderleaf has been reported to have several agronomic advantages that include: ability to produce seed under tropical conditions, performs well in nitrogen-stressed soils due to its ability to fix atmospheric nitrogen, drought tolerance and intercropping suitability [2, 7]. It has been used as a fodder crop and as green manure.

Slenderleaf also causes suicidal germination of striga weed (*Striga hermonthica*), an obnoxious cereal crop weed, and has potential use in reduction of *Striga* seed population in the soil [2]. The bitter taste of Slenderleaf could be attributed to the presence of alkaloids and phenolic compounds[1]. A market survey conducted in three markets in western Kenya revealed that Slenderleaf was among the top ten priority African indigenous vegetables in the region [6] and in Kenya [7].

Studies have been carried out on *Crotalaria brevidens* plant density, harvesting heights and intercropping, and hardly any on nitrogen rates [7]. It has been reported [8] that at a plant density of 17 plants/m^2, and optimal harvesting height of 15 cm, *Crotalaria brevidens* gave the highest leaf yield of 8 tonnes per hectare. *Crotalaria brevidens* has been found to be a suitable intercrop for *Eleusine corocana* with land equivalent ratio (LER) of greater than one [8].

Despite the many advantages that have been attributed to Slenderleaf, its potential has not been fully exploited. One of the major constraints of production has been poor quality seed. Farmers normally produce their own seed from their farms and may store them for as long as three years. Although according to work done earlier, Slenderleaf exhibits high germination percentage (>90%) compared to other African indigenous vegetables(<50%) [2], there is hardly any work reported on the storability and longevity of seeds of Slenderleaf and factors affecting it, or on effects of nitrogen application. This study set out to investigate the effects of nitrogen rates on growth, leaf and seed yield, and the effect of storage period on germinability of *Crotalaria brevidens*.

Materials and methods

Effect of nitrogen rates on growth, leaf yield and seed yield of Crotalaria brevidens

The study was conducted at Maseno University in the Department of Botany and Horticulture between January 2003 and December 2005. Seeds of Slenderleaf were obtained from Maseno University botanic garden and subjected to germination tests. Fifty seeds of Slenderleaf were placed on individual Petri dishes lined with a wet filter paper replicated four times. Water was added to the Petri dish regularly to ensure that the filter paper is kept moist throughout the experimental period. Daily measurements of the number of germinated seeds were recorded for one week, and then percentage germination calculated at the end of the experiment. Seed germination protocol used was according to International Standards for testing Seed Vigour [9].
Soil sampling was done in the experimental plots before the seeds were planted, to determine the soil nutrient status at the time the experiment commenced. The soil samples were then air dried and passed through a two millimetre sieve. The fraction which passed through the sieve was used to analyze total nitrogen, exchangeable cations, organic carbon, available P and pH using described analytical methods [10, 11, 12] and available nitrogen analysis was determined using fresh soils. Seeds were then planted on 20 April 2003 by drilling in rows 30 cm apart in the field in well prepared seed beds at Maseno University experimental plots.

The seedlings were then thinned two weeks later to a spacing of 30 x 30 cm. The experimental plots were kept weed free throughout the experimental period and Triple super-phosphate at the rate of 200 kg per hectare were applied at planting time. The design of the experiment was Randomized Complete Block Design (RCBD) with six treatments and three replications and each plot measuring 1.5 x 2m. The treatments included six nitrogen rates (0, 10, 20, 40, 80 and 100 kg N per hectare).

Parameters measured included plant height, leaf number, number of branches, number of flowering plants per plot, leaf yield and seed yield. Non-destructive measurements were taken weekly, commencing two weeks after planting and destructive measurements on leaf area and leaf yields were taken only twice just before onset of flowering (eight weeks after sowing) and one week later. Plant height was taken by selecting two plants per plot and tagging them and their heights measured using a ruler from the soil surface to the apical bud. The number of emerged leaves and number of branches per plant of the tagged plants were counted. The number of flowering plants per plot were counted and then the percentage of flowering plants in each plot determined. Leaf yield per plant was determined by harvesting two plants per pot and cutting off the edible parts, including leaves, young branches and shoots, and weighed on a balance. Seeds were harvested when mature but before drying up and shattering, they were dried, threshed, winnowed and seed yield determined at 8% moisture content. The germination percentage of the seed lot was also determined. The same procedure was repeated during the short rains when sowing was done in the field on 20 September 2003.

Storage period on germinability of Crotalaria brevidens

Seeds from the long rains crop for various treatments were kept in airtight containers and stored at room temperature (24±3). In September 2003, seed storage and germinability studies were started by placing 50 seeds randomly selected from each treatment, into a Petri-dish lined with a wet filter paper every six months for a period of two years and germination percentage determined. Each time the germination was done it was replicated three times.
Data obtained were subjected to Analysis of Variance (ANOVA) to determine whether treatment effects were significant at 5, 1 and 0.1% and separation of means was done by Least Significance Difference ($LSD_{5\%}$) for those parameters where the treatment effects were significant.

Results

Soil analysis results

The results of the soil chemical and physical properties are shown in Table 1. The pH of the soils was 6.3 which is within the optimal pH for most vegetable crops of 5.5- 6.8 [14]. Available phosphorus was 1.6 ppm and available nitrogen 0.12 ppm with balanced clay, sand and silt distribution. The table also shows exchangeable cations, potassium, magnesium, calcium and aluminium.

Effect of nitrogen rates on growth, leaf yield and seed yield of Crotalaria brevidens

The germination percent was 100% and correlated positively with the field seedling emergence which was over 95% in all the plots. Nitrogen rates had no significant (p>0.05) effect on all growth parameters, leaf and seed yield of *Crotalaria brevidens*. At eight weeks after sowing, the following ranges were observed: plant height varied from 45 cm to 60 cm, number of leaves, 39-55, number of branches, 11-16 and % number of flowering plants per plot were 15-35%. Leaf yields varied from 26 to 30 g/plant (Table 2).

Effect of nitrogen rates on germination% of stored Slenderleaf seeds

Nitrogen rates had no significant (p>0.05) effect on germination percentage of Slenderleaf seeds that were stored for two years at room temperature (Table 3).
The mean germination percentage for September 2003, March 2004, September 2004, March 2005 and September 2005 were 96.8, 95.2, 94.7, 93.5 and 95, respectively. pH of 6.3 falls within the optimal range for vegetable growing of 5.5-6.8 [14].

Effect of nitrogen rates on growth and leaf yield of Crotalaria brevidens

The failure of Slenderleaf (*Crotalaria brevidens*) to respond to nitrogen rates agrees with other previous studies that have shown lack of response even to nitrogen rates as high as 150kg/ha [16] .The observed ranges of growth parameters like plant height, leaf and branch number are within what has been reported by Chweya [7]. Seed yields of 0.42-0.59 kg/m^2 are slightly lower than those reported earlier of 0.77kg/ m^2 [16]. It was reported that there was no response to nitrogen rates of 0, 60, 80 and 100 kg of N per hectare by cowpeas (*Vigna unguiculata*) [18].

Table 1: Soil chemical and physical properties at Maseno University

Soil variable	Long rains 2003
pH (water)	6.3
Soil organic carbon (%)	1.20
Available P (mg/kg)	1.60
Available N (mg/kg)	0.12
Ex K (meq/100g)	0.12
Ex Mg.(meq/100g)	0.50
Ex Ca (meq/100g)	2.24
Ex Al (meq/100g)	1.07
% clay	34.3
% sand	36.5
% silt	29.3

Table 2: Effect of nitrogen rates on seed yields of Slenderleaf

Treatment (kg of N per hectare)	Mean seed yields (kg/m^2)
0	0.42
10	0.44
20	0.50
40	0.58
80	0.46
100	0.59
Significance	Not significant (p>0.05)
LSD	-

This observation could be attributed to the ability of leguminous plants to which Slenderleaf and Cowpea belong, to fix atmospheric nitrogen through root-rhizobium symbiosis. It has been reported that most legumes can get 80-90% of their total nitrogen requirements through symbiotic fixation. Quantities of symbiotically-fixed nitrogen in Cowpea are reported to range between 150-354 kg of nitrogen per hectare [15]. It is envisaged that Slenderleaf in this study being a leguminous plant fixed adequate amounts of nitrogen and utilized it in the production of dry matter. The accumulated dry matter was then re-translocated to the seeds during seed formation.

Effect of nitrogen rates on germination % of stored Slenderleaf seeds

Nitrogen rates had no significant (p>0.05) effect on germination percentage of Slenderleaf seeds that were stored for a period of two years at room temperature. The mean germination percentage at the onset of the experiment in September 2003 was 96.8% and two years later in September, 2005 it was 95%. This shows that Slenderleaf has not only high germination percentage but is able to maintain that germinability for two years or even longer.

The observed germination percentage was very high (over 90%) for the stored seeds. The minimum acceptable germination percentage for a seed lot is normally 85% [19]. Although this indicates that the germinability of the stored Slenderleaf seed remains high for two years, it is imperative to check the vigour of the seedlings. Other important measurements that could be undertaken are the electrical conductivity and tetrazolium tests [19].

High germination % of over 90% is in line with earlier reports [19]. High germinability corroborates with reports indicating that germination percentage for both farmers' and researchers' Slenderleaf seeds had a germination percentage of 92% [4]. The most important factor that influences the potential longevity of seed is moisture content [19] and this could have contributed to the Slenderleaf seeds under the current study that were stored at 8% moisture content. However, it is important to note that germination test alone may be of limited ability in detecting physiological quality differences in stored seed.

A small difference in percentage germination represents a large difference in the progress of seed deterioration and a seed may be viable but still fail to germinate under stressful conditions. Slenderleaf is a promising vegetable crop since it can grow under nutrient-deficient soils and can withstand some stress conditions like drought [2]. In addition its seeds can maintain viability for at least two years and has no dormancy problems. Further investigations relating to its optimal production are suggested.

Conclusions

- Nitrogen rates had no significant effect on growth, leaf and seed yield of Slenderleaf.
- Nitrogen rates had no significant effect on germination percentage of stored Slenderleaf seeds.
- Slenderleaf seeds can be stored for a period of two years without significantly affecting its germination percentage.

Table 3: Effect of rates on germination percentage on stored Slenderleaf seeds

Treatment (kg N/Ha)	% Germination in September and March of each year					
	Sept 2003	March 2004	Sept 2004	March 2005	Sept 2005	Mean
0	95	94	94	95	95	94.6
10	100	99	100	95	96	98.0
20	94	93	92	94	97	94.0
40	99	92	93	94	95	94.6
80	93	94	92	93	92	92.8
100	100	99	97	90	95	96.2
Mean	96.8	95.2	94.7	93.5	95	95.0
Significance	ns	ns	ns	ns	ns	ns
$LSD_{5\%}$	-	-	-	-	-	-

- Further research is needed on the effect of storage on seedling vigour and longevity of the seeds and other aspects like use as green manure, medicinal value and control of striga weed in cereals and its suitability as an intercrop.

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Re-creating awareness of traditional leafy vegetables in communities

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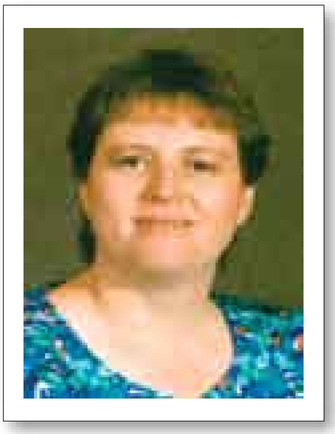

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Abstract
Research and extension in South Africa has been labelling traditional leafy vegetables as weeds since the 1960s when they started encouraging households to produce food seen in the shops. This negative perception has led to an unwillingness to use and conserve these 'poverty foods', as many community members have labelled them. The status of these crops needed to be improved to help people realise their importance in their daily diet. Awareness activities in six communities made use of production training sessions in seven schools and eight community gardens, discussion groups, garden competitions, cooking competitions, recipe collection, awareness days, local resource collection activities, participatory selection and a radio talk. Discussions about use and conservation status of these crops during the data collection phase stimulated discussions on various aspects of the crops and caused an increased awareness about the poor conservation status within the communities, leading to the appointment of keepers of specific seed. The local resource collection efforts and gene bank actions encouraged community members to appreciate their natural resources more and emphasised the vulnerability of the crops, and their important role in keeping the biodiversity available for them and for future generations. In an effort to create awareness of the traditional plants at all levels within the community, schools (where possible) and community gardens were targeted during the training and awareness campaigns. The awareness campaigns culminated in a school garden and community garden competition, as well as a cooking competition. Participatory selection was used to expose the community members to new crops and to variations in the crops that they know. Community evaluation of these crops created a better understanding for researchers and community members, leading to improved cooperation. A noticeable increase in demand for seed and training on production methods was the result of the awareness activities within the communities.

Key words: Leafy vegetables, awareness, biodiversity, use

Introduction
In South Africa, local people formerly ate a diet of meat, milk, wild cereals and wild plants, but the Pedi proverb "Meat is a visitor, but 'morogo' a daily food" (morogo are traditional leafy vegetables) has become a reality for most [1]. The use of traditional leafy vegetables in rural communities has reached a low point, as many have labeled their dishes as 'poverty food'. This unfortunate label has stigmatized these healthy crops with, especially, the youth. The women are the custodians of leafy vegetables, as they are responsible for all aspects of these crops. The constant reminders from both research and extension from the 1960s to the present day to remove the 'weeds' (usually African leafy vegetables) from their crops has attached a 'backward knowledge' label to the 'poverty food' label. Parents have found it difficult to motivate their children to learn something about their traditional food crops and the effect of these labels are apparent in the youth; they hardly know the plants and prefer to eat the more fatty western foods. Studies done on foods harvested from the wild in South Africa from the 1930s to the 1980s culminated in a book where the authors raised their concern about the loss

of indigenous knowledge associated with these foods [1]. Addressing the problem of the poor image is the key to the survival of these crops in rural communities. This study looks at the problems encountered and how they were addressed to help improve the image of these crops.

Methodology

The work was done from 2000/1 to 2003/4 in three villages in South Africa that differ in terms of ethnicity, geography and climate. Diversity between the villages ensured as wide a range as possible in terms of uses and status of the traditional vegetables, thus being more representative of the diversity found within the country. The villages each represented a geographical area and an ethnic grouping. The villages were:

- Watershed, Ladysmith, KwaZulu-Natal: predominantly Zulu, close to the foothills of the Drakensberg with semi-arid conditions, summer rainfall, hot summers and bitterly cold winters (snows occasionally). Watershed's closest large town is about 45 minutes by taxi. There is no direct taxi service.
- Bushbuckridge, Limpopo Province: predominantly Shangaan, but five cultural groups are present. High summer rainfall, sub-tropical, mild winters, close to the Kruger National Park. Bushbuckridge is peri-urban, with a supermarket within the community.
- Mars and Glenroy, near Polokwane, Limpopo Province: two neighbouring villages with predominantly Pedi people, semi-arid with hot summers, cold winters, low summer rainfall, mainly savannah type landscape. Mars and Glenroy's closest large town about one hour away, no direct taxi service.

Information on the crops, their uses, importance and conservation status within communities were mainly done by using participatory approaches [2, 3]. Due to time constraints, much of the data collection was done in a rapid and extractive way, with participation increasing as the project progressed and the community trust grew.

The information from these studies showed the need to increase awareness of these plants due to the loss of status within South Africa [4]. Techniques used to increase the status of these plants within communities included interviews, group discussions, local resource collection, garden competitions, cooking competitions, training sessions, awareness days and participatory selection.

Local resource collection was used to identify the plants and lead to the discussion about the preparation, preservation methods, seed systems, cultivation, popularity, recipes and status of these crops.

The cooking competition was left in the hands of the community and was held on the awareness day hosted by the community. The judging was based on two criteria: taste of the individual dishes and variety of different recipes for the traditional leafy vegetables. The only imposed rule was that the tasting panel had to consist of school children and adults from both gender groups. This was added to ensure that feedback from young and old, male and female was available to the women during the evaluation.

Seed systems were discussed and evaluated in a focus group. Women were encouraged to show their storage systems, discuss problems and give a general overview of seed systems in the community and at home.

The training of a researcher from ARC-Roodeplaat at AVRDC led to the compilation of a small manual that was handed out during training to community members and extension. Included were cultivation practices, seed harvesting tips and some alternative methods for pest control. The booklet was well received and improved upon as suggestions from the users were incorporated.

ARC-Roodeplaat trained community members and extension personnel in the gardens with some theoretical work followed by the practical planting and maintenance of the crops. The gardens were finally evaluated during the community garden competition. School children were trained, both in theory and practically, in one school garden, from which they then had to plant their own garden. Continual visits to the gardens were done to evaluate, give suggestions and answer questions. This helped us to identify problems and evaluate the effectiveness of the training and the booklet.

Garden competitions were held for community gardens and school gardens. The steps of a biodiversity fair, as described by Rijal, Rana, Subedi and Sthapit [5], were used as guidelines. School gardens were only included in Arthurstone, due to the strong extension support in the area. During the first year four schools took part, with three other schools in two communities joining these schools in the second year. Evaluation criteria for community and school gardens included the diversity of leafy vegetables grown, effectiveness of harvesting, spacing, general appearance of the garden, correct use of production guidelines and knowledge about the plants.

An evaluation panel consisting of teachers, extension personnel and a researcher was established, and one day was used to evaluate and determine the winners. Not only the garden, but also knowledge of the plants and its uses were included in the evaluation. Inclusion of the knowledge testing ensured that children were exposed to the holistic nature of the crop, and not just its cultivation.

During a participatory selection process [6] local and AVRDC lines were planted to ensure that farmers could compare the lines effectively. The crops were planted in single rows, and community members were asked to evaluate the lines of each crop according to their own criteria. Feedback about the lines was given at each visit.

Results

Preparation

Local resource collection helped the researchers to identify the plants, and know their local names as well as their importance to the women in the community. As the women went out collecting plants, enthusiasm grew leading to others joining the activities. The levels of excitement grew as they realized that researchers were serious about learning about these crops, thus stimulating them to share even more. The women confided later that the interest shown by researchers (and later extension) in these crops helped them to start thinking again about the vegetables as a resource they needed to look after. The older women realized how little the younger generation knew, and also realized that some of the crops were actually becoming scarce. They were worried about the tendency of the children to ignore the importance of the crops, and their unwillingness to consume them. The women tended to mostly use one method of preparation, with some women telling us that they would cook the same way for weeks, as long as there was fresh material available.

Recipes and cooking competition

Fifteen different recipes were collected from all the communities we worked in. Most of the foods are cooked for a short time on very high heat, but currently the influence of this on the nutritional value is not known. This preparation method makes the best use of the local fuel wood resources, thus is difficult to change. Feedback from the results of the cooking competition, as well as the open tasting sessions afterwards led to the most popular recipes being exchanged on the awareness day.

Existing seed systems

Discussions were held with the women about the conservation status of these crops in their community. The role of seed custodian, usually assigned to an old woman of high status, has been lost due to various social and economic reasons. Generally, seed systems were informal, unorganized and seed exchange between family and neighbours happened regularly. Most of the seeds were stored in plastic or glass containers, with some adding ash and some not. Damage to seed led to the informal exchange of seed within the community.

Many women had not consciously realized that some of the crops were becoming scarce. One species Cucumis melo or 'phara' has been brought close to near local extinction by livestock browsing. In one community they realized in shock that only one person had seeds left from a specific climber that they enjoyed. The plants from these seeds were destroyed during the following season, leading to the loss of this plant within these communities. Efforts to re-introduce the species into the community resulted in a decision by the women to collect all the seeds they could in the coming season, and distribute them to a few women, to ensure the spread of risks. The community women immediately appointed two women in each community to look after 'phara' and ensure its survival in the community [7]. How close these two accessions were will now never be known.

The National Plant Genetic Resource Center in South Africa did a seed collection trip together with the ARC-Roodeplaat within the communities at a time specified by the women as the best time to collect seed. These crops were never incorporated into their collections, but the trip helped them to realize the importance of these plants in the communities. Women were very willing to share their seed when they understood the concept of gene banks.

Cultivation

Cultivation of traditional leafy vegetables characteristically entails broadcasting of some seeds between the maize. In some areas cowpeas (edible leaves and pods) and/or cassava (edible leaves and roots) are cultivated, as they have been for generations.

The women of the community were asked if they would be interested in cultivating some of the crops, and if they were interested in possible new crops that might be of interest to them. The interest was tentative, but they decided to try it and see what the impact might be. Later, evaluation of these plants brought mixed results, as some of the new plants (Amaranth from AVRDC) were popular while the introduction of Jute mallow (*Corchorus* spp.) led to non-adoption in areas where it was not known, as the mucilaginous consistency was not popular. Discussions with the women helped to guide choices in terms of which plants to introduce.

Production training

Cultivation of leafy vegetables had varying results in the different areas. Where the larger leafed Amaranth was introduced, it is still being cultivated or broadcast, due to its high leaf yield and good taste. The cowpeas and pumpkins are also being cultivated. More broadcasting of Jute mallow and Spider plant (*Cleome gynandra*) is taking place than before.

The enthusiasm of the school children was high during training, but the effectiveness of the training and the school gardens was determined by the enthusiasm of the teachers involved. The competition was well received by community and schools, and led to much community enthusiasm.

Participatory selection

During the participatory selection trials the women were asked to evaluate the crops according to their own criterion. In the first year the women identified taste as their only criteria, but as the season progressed this changed. Characteristics that became important included yield, space needed, taste and how much labour was needed. Where space was limited, bushy types were preferred to spreading types, larger leaves were generally preferred to smaller leaves (if the taste was acceptable), and minimal labour needs were preferred. Feedback about the crops was given at each visit.

Awareness days

The season in the communities ended with awareness days. The rules and programme were determined by the community, thus ensuring their buy-in. The awareness competition events, held at school and community gardens, culminated with the awarding of prizes. Likewise, the cooking competition took place on this awareness day, with children and adults taking part in the evaluation of the dishes. Schools were asked to provide entertainment with a message about African leafy vegetables (ALVs) where possible. One school performed a play where the message of health and leafy vegetables was transmitted in a hilarious way. In Watershed, a local radio station interviewed the women and further disseminated the message about the value of traditional leafy vegetables to a large area in the province.

General awareness activities

To help spread the message of the importance of ALVs, a logo with a slogan was designed that was incorporated into all the activities and publications where possible. T-shirts were printed that were worn regularly during community work. The T-shirts were handed to children participating in the school gardens, to influential people in the community, women involved with the project and extension personnel involved in the project. The T-shirts were worn with pride and became a uniform on special days of the project.

Discussion

The tendency of the women to use mainly one method of preparation, as well as preparing the dish daily for weeks on end, led to the suspicion that the 'poverty food' label might be boosted by the monotonous way in which the food was prepared. To help address this, the women should benefit from training in different traditional vegetable recipes without fear of being criticized. The cooking competition was incorporated into the awareness day to help with this process. The 15 recipes prepared at these awareness days will, with the kind permission of the community members, be used in a recipe book that will continue to expand as more recipes are collected and distributed to communities. This should help increase the variety in cooking methods and the willingness to eat the crops.

Nutritional value studies are now being done at various institutions, based on these preparation methods. Preparation of cowpea leaves (some are boiled for up to three hours) are a cause for some concern, but the toughness of the leaves seems to be a problem. Use of varieties with less tough leaves might be a possibility.

Revival of the role of seed custodians for crops that are not part of the private seed sector, are vital for the conservation and preservation of the genetic diversity of these crops. Observations of the seed systems of all the traditional vegetable crops indicate that one bad season could have severe implications on germplasm availability for the next season.

The seed collection trip of the National Plant Genetic Resource Center in South Africa had a big impact on the awareness of the women about the vulnerability and importance of the biodiversity in their communities. They started to understand better how important biodiversity was, and the influence they had on their own diversity. Many women decided to keep some seed each year, especially with the unpredictable weather and the scarcity of some of the crops. Effective seed harvesting was incorporated into the production training and during informal occasions when seeds were seen on the plants.

The production training at the schools had varying degrees of success. Where teachers were very involved the gardens became part of the classroom. Biology and mathematics were taught using the garden as an example. Some schools sold their produce to help support the school fund, while others used the leaves to help supplement the feeding schemes at the primary schools. Teachers mentioned several pupils taking their knowledge home and teaching their parents how to plant these crops. Generally the children's knowledge about the plants increased, and the involvement of research in these actions increased the status of the plants.

The awareness days at which these competitions culminated were well attended by schools, community members and the political structure within the community. The potential of these crops was realized at all levels of the community, with local politicians looking at the opportunities that these crops have in the development of their communities. Feedback from the women, schools and governing bodies was positive, with many women being asked for seeds and recipes of the different crops. This sharing of seeds, production information and recipes ensured the success of the awareness days.

The exposure of the women to the different crops and cultivation practices during the participatory selection stage increased the women's awareness of the leafy crops and helped to diversify their food basket in terms of taste.

The development of the T-shirt with the "Leafy Power" logo helped to sensitize the other people in the community and increased the pride of the women in their knowledge and their ALVs.

The main concern of most of the women was the loss of knowledge about the ALVs. By documenting all aspects of the use, conservation and importance of these plants, some of their fears have been alleviated. The collecting of recipes has the additional bonus of making the recipes available to non-traditional users of ALVs, thus creating an opportunity to broaden the market for these crops in the urban areas. Some of the plants are being sold on a small scale in a large supermarket chain, but the lack of instructions on their preparation has kept many from buying them. This aspect will need to be looked at carefully, especially with the Intellectual Property laws as they currently stand in South Africa. Increasing the awareness of the youth has led to an elevation of status of the women who know about the crops, and has made some of the youth more interested in these crops.

By creating awareness outside the community about the importance of the ALVs, the status and awareness of these crops increased. Stimulating discussions in the research community about the importance of these plants for food security of communities, as well as the lack of knowledge about these crops, has led to many collaborative activities between teaching institutions and other research councils. Research on traditional crops, the indigenous knowledge associated with them and the possible interaction with scientific knowledge was carried out in collaboration with the Human Sciences Research Council and the Department of Science and Technology. Several universities are now collaborating on work on food safety aspects and nutritional value of these plants. ARC-Roodeplaat is currently also involved with an Africa and EU network on urban and peri-urban agriculture and traditional crops.

Conclusion

Creating awareness is a time consuming and expensive process, but once the mechanisms have been worked out, it does have an effect within the community. Just targeting the community is not enough, as the image of a crop is not just determined by community members, but also by all the people they come in contact with. The recent worldwide interest in these crops has had a positive effect, as more scientists are now willing to spend time on them. The cooperation between different groups of scientists is on the increase, but awareness creation at community level must be part of the whole process. Without appropriate awareness creation at all levels, the efforts of groups currently deeply involved with these crops could come to nothing.

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Marketing African leafy vegetables: challenges and opportunities in the Kenyan context

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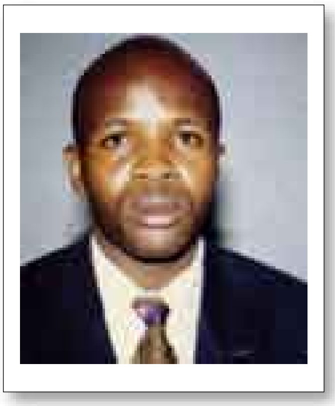

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Abstract

Activities to scale up production and consumption of African leafy vegetables (ALVs) have increased greatly in the recent past. What are the emerging issues in relationship to commercialization of these vegetables, given their previous unexploited state? The market share of ALVs vis-à-vis other vegetable species, particularly kales, cabbages and spinach, has been on the upward trend in the urban markets and there has been increased consumption in rural areas too. How has this influenced the various players in the ALVs sector, for example, farmers, traders and consumers? Issues of quality control, reliability and pricing remain critical to the future success of ALVs farming. The fact that ALVs are fast becoming the vegetable of choice, especially in the hitherto, non-consuming segments of the society including the upper and middle class households, and generally among the elite in Kenya, is a situation that requires serious assessment and action plan. The paradigm shift in the consumption patterns of ALVs has implications on the continued availability of the vegetables to the lower-end of the market consumers – the poor. Therefore, the reality that their income and nutritional resources could be exploited to their disadvantage is very much a possibility. What should the policy and research considerations be in the unfolding scenario? Women have been closely associated with cultivation and selling of ALVs; however, studies have shown that whenever a crop begins to appreciate in the market and starts fetching higher income, men tend to push their way into the trade. Similarly, higher income prospects in any trade create competition and sooner or later non-competitive segments of the market fall by the way side in due course, and in our case these would be small-scale farmers and traders. These issues are fundamental and need focusing as ALVs enter a new phase of production and consumption regimes. More efforts are needed to cushion the vulnerable groups, who have previously dominated the ALVs market, against the emerging big and medium commercial players. Otherwise, exploitation and loss of livelihoods among the vulnerable groups will be inevitable.

Key words: African leafy vegetables, women, commercialization

Introduction

Humanity derives most of its food, many medicines and industrial products from both wild and domesticated components of plant genetic resources. However, the reduction of this biodiversity has been an inevitable consequence of human development as species-rich forests and wetlands are converted to relatively species-poor farmlands and plantations [1].

The diversity of plant species

It has been estimated that there are between 3,000,000 and 5,000,000 species of higher plants, of which approximately 240,000 have been identified or described [2]. About 30, 000 are edible and about 7,000 have been cultivated or collected by human beings for food at one time or another [3]. Thus, several thousand species may be considered to contribute to food security. It is, however, known that only 120 are important on a national scale, as 30 of these crops 'feed the world' and provide 95% of the dietary energy (calories) or proteins [4, 5].

Status of plant genetic resources in Africa

Plant genetic resources are the biological basis for food security and directly or indirectly support the livelihoods of the rural majority in Africa as they are used as food, medicines, feed for domestic animals and other amenities [6]. Plant genetic resources are the raw materials used in the production of new cultivars, either through traditional plant breeding or biotechnology. Whether used directly by farmers as raw materials or plant breeders, these resources are a reservoir of genetic adaptability that acts as a buffer against potentially harmful environmental and economic changes [7].

Genetic erosion and the causes

The genetic base of Africa's plant diversity is being seriously eroded, largely as a result of a multiplicity of environmental, political and socio-economic factors. The main cause of genetic erosion in crops, as reported by almost all countries that are signatories to the Global Plan of Action (GPA) on plant genetic resources for food and agriculture is the replacement of local varieties by 'improved' or exotic varieties and species [8]. There are many other causes of this erosion, which has been accelerating throughout the 20th century in parallel with the demands of an ever increasing population and greater competition for natural resources [9, 10].

Conservation status

The impetus for conservation has been inspired by several recent global initiatives such as the Convention on Biological Diversity (CBD), the UNCED and more recently, the GPA. Traditionally the conservation of genetic resources has primarily been through ex situ conservation [11-13]. However, there is increased realization that this method is not adequate for conservation of the various gene pools due to increased and diversified user demands and requirements. The CBD and the GPA have specifically called for both in situ and ex situ conservation measures for biodiversity and genetic resources conservation [14, 15].

The decision on the choice of conservation methods is not only a matter of available technology and resources, but it is also influenced by biological, economical, management, socio-economic, cultural and political considerations [16, 17]. The objective of ex situ conservation of genetic resources is the collection, maintenance and regeneration of the genetic variation of a gene pool, ensuring its existence and availability in the long term. The concept demands that collection methods initially capture maximum variation, and subsequently conservation and regeneration techniques minimize losses through time [18].

For *in situ* conservation, the objective of conservation is to maintain viable breeding populations in their natural habitats, and for crops, in land use systems and cultural heritages in which they have continually evolved and are adapted to [7, 6].

Lately, *in situ* conservation has included the continued cultivation and maintenance of land races by farmers 'on farm' such as in the areas where they have continued to evolve and have developed their distinctive properties [19, 20]. This offers the possibility of providing incentives to local farmers to act as custodians of traditional varieties and selections nurtured in their fields and backyards [21]. In this case the cultural integrity of the local peoples and the conservation of the genetic resources are closely linked [22].

African leafy vegetables in sub-Saharan Africa

It is estimated that there are more than 45,000 species of plants in sub-Saharan Africa (SSA) of which about 1,000 can be eaten as green leafy vegetables. This group of vegetables, which researchers fondly refer to as "African spinach" , a kind of short-hand for hundreds of green leafy vegetables, happen to be the mainstay of traditional African diets. Eaten largely in rural areas, African spinach provides millions of African consumers with the vitamins and minerals needed to maintain health and fight off infections.

Included are crops with names such as Garden Rocket, Cat's Whiskers and Garden Huckleberry [23].

Today, access to food around the world is not secure [24]. Eight hundred million people are undernourished while 200 million children under five years of age are underweight. In the next 30 years, the world's population is expected to grow by over 2,500 million to reach 8, 500 billion. Reliable and sustainable improvements in yield will be needed to meet the demands of this growing population. The conservation and sustainable utilization of plant genetic resources are key to improving agricultural productivity and sustainability, thereby contributing to national development, food security and the alleviation of poverty.

Per capita consumption of fruits and vegetables in SSA lags behind that of the other regions, showing an overall decline between 1986 and 1995. While per capita apparent consumption of vegetables in developing countries went from 68.7 kg per capita in 1986 to 75.3 kg in 1995 on average (a 0.92% increase), SSA showed a 0.19% decline and remained as low as 29 kg of vegetables per capita consumption on average [25].

It is therefore, no wonder that micronutrient deficiency (mainly vitamins and minerals, particularly iron, selenium, folate, copper, zinc, iodine and vitamin A) is a serious problem in SSA – affecting about a third of the population and with far reaching effects. It is the major cause of anemia, impaired intellectual development in thousands of children and affects the immune system, provoking birth defects and debilitating economic prospects of countries [26].

It is ironic that as Africa grapples with malnutrition, the continent is endowed with a high diversity of underutilized fruits and vegetables that are rich in micronutrients [27]. It is in this regard that in 2001, Bioversity International (formerly IPGRI) – with support from the International Development Research Centre of Canada – has been spearheading a major public awareness campaign including training of farmers to grow leafy vegetables in hygienic conditions and has worked with a marketing expert in Kenya to attract new customers for ALVs. A local NGO, Family Concern, distributes the farmers' produce to Kenya's largest supermarket chain [27].

According to the results of a survey done in Cameroon, Yaoundé by scientists from the International Institute of Tropical Agriculture (IITA), it was interesting to find that often overlooked traditional leafy vegetables are essential for both nutrition and economic livelihood. The scientists reported that in and around Yaoundé, traditional vegetables were not only more important than Brassica spp. for household food consumption and income generation, but they were also among the most commonly found vegetables in home gardens of the poorest households [28].

African leafy vegetables and nutrient bioavailability

ALVs represent one of the richest sources of biodiversity in African food systems and a potential rich source of beta-carotene [29]. However, the poor bioavailability of provitamin A in a number of studies has called into question the importance of these accessible, acceptable foods in the diets of local African communities [30]. Nonetheless, many of the benefits of non-nutrients in ALVs may exceed those attributable to the beta-carotene or other nutrients.

For example, vegetable diets that make modest contributions to improving vitamin A status result in significant increases in serum levels of lutein, antioxidant xanthophylls which offer protective benefits in relation to ocular disease, as well as cardiovascular disease and cancer, are increasingly recognized as of importance to health [30, 31]. Such insights have potential significance in tropical countries where cataracts represent the major cause of blindness [32]. In one study it was shown that Nigerian patients with cataracts had lower intake of fruits and vegetables than control subjects [33]. Compilations of data on xanthophylls point to the richness of the ALVs in these non-nutrient carotenoids; extension of these analyses to indigenous plant foods is needed [34, 35]. In light of this important functional activity (and undoubtedly others), the single-minded attention on the limitation of ALVs and other plant foods as sources, for example, of a single nutrient such as provitamin A seems somewhat shortsighted [30].

Bioversity International African leafy vegetables project in Africa

Sub-Saharan Africa is the region with the highest percentage of undernourished people in the world's total population. It was estimated that about 34% of the population were undernourished in 1997-99. It is the only developing region in the world where agricultural output has been trailing population growth for most of the last three decades [36]. The reasons for Africa's inability to feed itself with sufficient quantity and quality food are numerous and varied and include conflicts, diseases such as malaria and HIV/AIDS, poor-performing economies, poor governance and policies, inadequate technology and technology transfer mechanisms, lack of access to foods that are nutritionally rich in vitamins and minerals, and inability to make full use of the easily accessible traditional foods.

Bioversity International (formerly IPGRI) has been involved in promotion of ALVs in SSA since 1995 [23].

Bioversity, with funding from the Dutch Government, has led a campaign to try and reverse the decline in use of ALVs.

They have managed to document the ALVs species and identified the key issues hindering their cultivation, conservation and marketing. About 210 species were recorded in Kenya alone. Yet only about 10 of these found their way to markets, usually back-street markets frequented by a small number of regular customers [23].

Subsequently, in the second phase of the campaign which began in 2001, the project supported a variety of activities and projects including collecting and analyzing samples of the most widely used leafy vegetables, such as Amaranth, African nightshades, and Cowpea.

Collaboration of Bioversity and local NGOs to promote ALVs

The outcomes of the African leafy vegetable project

The rapid acceptance of ALVs among the socially elite in Kenya means that the ALVs production is now becoming a potentially profitable venture and soon will no longer be a simple women's crop, meant only to supplement the family diet. Men could take up the trade in view of their increasing demand, as they have also become main consumers of ALVs. Evidence is emerging that ALVs are now a much sought-after item on menus of back-street eating venues, in the five-star hotels and are now served even in Parliament.

The project has managed to improve farmers' livelihoods in project areas by providing them with high quality seeds and market opportunities in the formal and informal markets. Sections of consumers now have better access to the vegetables and this is bound to affect their nutrition and health status positively.

Marketing is a major constraint in the use of ALVs and often the missing link. In Kenya, this has partially been solved by training farmers on quality seeds and linking them to the formal market. The appearance of ALVs in supermarkets for example, has given the vegetables status.

This success story needs to be scaled-up to other towns in Kenya and other countries. Consumers also need more nutritional information and recipes. The little information available has proved very useful in promotional campaigns and has been in high demand. Important as urban and peri-urban vegetable production may be, it still poses major challenges, particularly of hygiene and heavy metal contamination and therefore, the need for more thoughtful solutions.

The reported successes in terms of rising levels of demand for ALVs have a flip side to it. The fact that the vegetables are increasingly perceived as lucrative means that many well-heeled players are joining the fray, but the most worrying aspect of this trend is the continued marginalization of the small-scale players, both farmers and traders alike.

Women have played a key role in the past in conserving ALVs through cultivation and consumption in rural areas.

This might soon be a thing of the past, as the ALVs assume a more commercial outlook, and men increasingly get involved in their production and marketing. The possibility of both women and small-scale players losing out in what was once their traditional source of livelihood cannot be gainsaid. Almost inevitably, the propensity of ALVs playing a role in alleviation of poverty and malnutrition among the poor may significantly reduce.

This is aptly captured by what has happened in Uganda regarding traditional vegetables. In Uganda traditional vegetables have been commercialized, including species such as 'Malakwang' (*Hibiscus* spp.), 'Nakati' (*Solanum gilo*), 'Katunkanna' (*Solanum indicum* subsp. *Disticum*), 'Doodo' (*Amaranthus dubius*), and 'Bbugga' (*Amaranthus lividus*) particularly around the city of Kampala and in other urban areas. It is instructive to note that now it is mainly the men who cultivate them. Middlemen purchase these vegetables from the farmers (men) and transport them to the markets and in the market women buy them and retail to the general public [37]. Indeed here, women have ceased to be farmers and now they can only be contented with the retail trade component of the traditional vegetables.

Mobilization of women farmers by Rural Outreach Program

Rural Outreach Program (ROP) is a non-profit organization based in Kenya. Since 1997, ROP has been working with farmers of Butere Division in rural western Kenya to grow ALVs and to produce seed for marketing, with an overall intention of alleviating poverty and improving nutrition among the resource-poor farmers of this predominantly sugarcane growing area. ROP works mostly with women groups.

There are over 200 women groups, with a total membership of about 5,000 people. ROP recognized the marginal position women occupy in this community, and therefore, primarily initiated the ALVs project as a way of addressing food and nutrition security, income generation and women's empowerment, factors whose negative effects on overall well-being of the community are pronounced.

ALVs are probably the only crop today in the western part of Kenya, which provides a practical opportunity for women to earn income. Why? Because in this predominantly sugarcane growing zone, the main cash crop – sugarcane – is dominated by men. The deterioration in the socio-economic status of most households in this area has been attributed to this marginalization of women when it comes to planning and use of sugarcane proceeds.

Studies have found that introduction of cash crop farming is not necessarily beneficial to food and nutrition security in some communities. Kennedy and Cogill found that a shift from maize (food crop) to sugar cane (cash crop farming) resulted in higher incomes but the nutritional status of preschoolers did not change [38].

ROP started with a modest coverage, serving one sub-location of Butere Division in western Kenya. The area of focus has since expanded to cover much of Butere-Mumias District. About 5,000 farmers affiliated to ROP now supply vegetables and seeds to other farmers in the rest of the district, which has a population of about 540,000 people. The farmers also supply seeds and vegetables to major cities like Kisumu and Nairobi. This is now a major source of income for the farmers.

Selected trained farmers grow vegetables for seeds. Seeds are sold to a local 'seed bank' managed by ROP. On average, the bank receives about 40 kg of seed per month from the farmers. In 2001, ROP opened a distribution point in Nairobi, the capital city where farmers from all over the country (small scale as well as commercial) could access the seeds.

Since 2002, ROP farmers have been supplying ALVs seeds to farmers in peri-urban Nairobi and surrounding rural areas. Today, the bulk of the vegetables that are supplied by farmers to the formal sector in Nairobi is supported by seed material from Butere farmers working with ROP. The linkage with Nairobi markets has succeeded because of the facilitation done by Family Concern Inc., a local NGO.

Women in Butere-Mumias District, particularly in Butere and Khwisero divisions are among the pioneer ALVs traders in Kenyan urban centres. The cultivation and marketing of the vegetables thrived mainly as a result of cheap rail transport that links Butere to major urban areas of Kisumu, Nairobi and Mombasa. With time and as the business became lucrative, men joined, often as middlemen. Middlemen buy the vegetables in bulk from women farmers at very low prices, and then transport them in passenger trains to Nairobi and other parts of the country.

In the mid 1990s, the rail services to Butere from Kisumu, the nearest city, were suspended for economic reasons. This almost ruined the once-thriving ALVs business in the area, which by the time of suspension stood at over 2 tonnes of trainload per day. The main destination was urban markets of Kisumu and Nairobi. In the absence of rail transport, most traders resorted to local markets and others opted for buses. But this option proved quite expensive and so the majority of traders went out of business.

Almost a decade later in 2004, the railway services resumed and quickly the ALVs business was back on track but on a smaller footing because the service was only available two to three times a week. In early 2005, the railways managing agency, Kenya Railways Corporation banned the use of passenger cabins from transporting any agricultural produce including ALVs on its Butere-Nairobi train-passenger services. Instead, passengers were supposed to use the luggage cabins. Traders using the luggage cabins suffered heavy losses due to poor aeration in the cabins leading to rapid deterioration of the vegetable. It is now difficult to use the train and farmers and traders have again turned to the more expensive means – the buses. The traders have now formed some form of cooperatives that transport the vegetables in bulk and also negotiate lower transport costs with local bus companies.

Challenges emanating from increased utilization of ALVs in addressing nutrition and income generation of resource-poor farmers

Seasonal production

Like the rest of agricultural activities in Kenya, ALVs farming relies mostly on rain-fed agriculture. Consequently, this leads to fluctuating supply of ALVs on the markets. The outcome of this is pronounced in the remote parts of the country where production takes place. Because most small-scale farmers lack means to transport their produce to distant and lucrative markets in the urban centres, they are open to exploitation by middlemen. This can be addressed through value adding processes, particularly solar drying and proper packaging.

Research

Researches focusing on improving the productivity of ALVs are few and far apart, not converging to a meaningful consensus of issues. But this has improved tremendously in the past four years or so. It is also worth noting that in the absence of clear policy on these vegetables, there is a lot of duplication of activities by organizations.

All these contribute to continual low production and negligible improvement in the income of resource-poor farmers whose dependence on this activity is particularly critical.

Physical infrastructure

The poor state of infrastructure, particularly roads, that is found in most of the rural areas where ALVs are cultivated worsens during the rainy season. There is much wastage because of unavailability or limited means of transport to reach the markets at such times. Even those vegetables that manage to get to the markets are poor in quality owing to delay and subsequent biological deterioration during transportation and distribution processes.

Diversity in production and cross consumption

The nature of ALVs is that each community tends to have a number of species, which they have been exploiting over many years or even centuries. Hence, some species are only consumed in particular parts of the country. This to an extent limits the marketability of some species across the communities, regions, across generations and even gender.

Possible opportunities emanating from increased utilization of ALVs in addressing nutrition and income generation of resource-poor farmers

Irrigation

Reliance on rain-fed agriculture in production of ALVs has been one of the major obstacles in expanding their production. There is always overproduction of the vegetables in the rainy season and this obviously depresses their prices, in-turn occasioning great loses to farmers and traders. Use of irrigation to produce ALVs during the dry season is extremely useful in optimizing farmers' returns when the supply is low in the market. Similarly, irrigation production ensures continued supply, which ensures stability in the prices of vegetables in the market thus enabling even the low-income groups to access them.

Co-operative structures

In areas where ALVs farming is a major economic activity like in Kisii region and Western Province, there have been efforts to mobilize farmers to form groups. The level of organization is still basic. The farmers need to work together in order to have a strong voice and a united position as they negotiate for favorable prices for their produce.

It is even much easier to transport ALVs in bulk if farmers agree on the logistics, hence avoiding falling victims to the middlemen. This approach may also reduce the transactional cost for farm inputs and aggregate demand for services such as training and advisory services.

Export market

Possibilities exist for exporting the vegetables. Kenyans in the Diaspora would relish identifying themselves with the vegetables. The Asian vegetables are a major component of Kenya's horticultural industry, because of the people of Asian origin who reside in the United Kingdom and other parts of Europe. The possibility of exporting ALVs to Africans, East Africans or Kenyans living abroad, is worth investigating for possible action.

Capacity building in marketing and business skills

Public education and promotion of ALVs needs to support the marketing component. Farmers need to be taken through marketing and business skills to enable them maximize output as well as income from their farms. This can be done through workshops and seminars. Farmers can also have exchange-visit programmes to familiarize themselves with marketing concepts, especially those that work.

Use by public institutions

Many public institutions are yet to incorporate the indigenous vegetables – in the wider context, traditional foods – in their dietary systems. Boarding schools and colleges, prisons and hospitals have an opportunity to vary and improve their dietary contents with the highly nutritious indigenous vegetables. Few institutions use these vegetables, and where they do, it is very occasional.

Research and extension

It is generally agreed that the future of ALVs depends on increased research on nutrition and crop genetics, and on improved seed storage facilities, processing and marketing [39]. It is not enough to encourage local farmers to grow their traditional crops. Successful marketing is important in the effort of creating sustainable livelihoods.

The issue of toxicity is very important hence the need to develop and apply standard scientific methods to evaluate the nutritional and toxic properties of the ALVs. Further, it is critical to educate the public on the nutritive values of ALVs and possible associated toxicity. This will promote user confidence and increase vegetable consumption [40].

Conclusion

There are many odds against the accelerated growth of ALVs trade, yet at the same time the wave of goodwill going around the world through poverty reduction strategies focusing on biodiversity and underutilized species, gives indigenous vegetables a unique opportunity to make a lasting impact in the area of food and nutrition security, especially for the millions of vulnerable and resource-poor households in Africa.

Getting neglected crops back on the menu is important, but it is also important to ensure that the poor get a fair share of any commercial benefits that arise from exploiting these genetic resources.

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Promotion of African leafy vegetables within the Agricultural Research Council - Vegetable and Ornamental Plant Institute: The impact of the project

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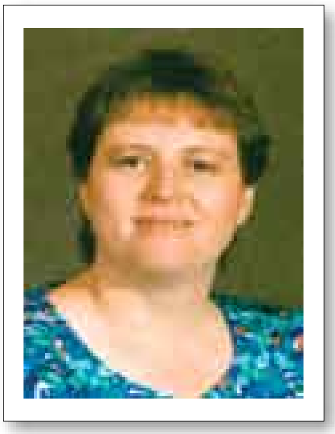

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Abstract

The importance of indigenous knowledge and traditional crops in the survival strategies of rural people have only recently been recognized by researchers in South Africa. The purpose of this paper is to illustrate the effect of the 'Promotion of African leafy vegetables (ALVs) for food security and nutrition' project on African vegetable research and its impact in the Agricultural Research Council (ARC) of South Africa.

Indigenous crops research has been a research focus area for ARC-Roodeplaat since 1994. The impact of the 'Promotion of African leafy vegetables for food security and nutrition' project, however, was noteworthy, since it strengthened existing research projects. The reason for this is that the baseline information gathered as part of this project provided a better understanding of the role these crops play in the survival strategies and food security of the rural communities in South Africa. The production training and awareness actions spilled over into larger extension groups and resulted in more communities targeted, with both gender and age differences addressed.

New research has been initiated to help address some of the problems (production systems) and lack of information (baseline, consumption patterns, nutritional analysis, market value) identified. The food-based approach, addressing low vitamin A status with the use of orange-fleshed sweet potatoes and dark green leafy vegetables, is now starting to incorporate the information gathered during the study in the different communities, thus ensuring a more holistic approach. The potential commercial value of these crops was highlighted and the role it could play in establishing emerging farmers enhanced. Awareness creation within the scientific community was done through publications, papers, posters, workshop and conference attendance, with some conference organizers specifically inviting these contributions. The exposure has led to more national and international institutions making use of the capacity built during the project duration. Universities are partners on nutritional and consumption studies, thus helping to strengthen the capacity in the scientific community on traditional vegetables. All these actions help to uplift the image of ALVs from a poor man's crop to a high value niche market crop.

Key words: African leafy vegetables, food security

Introduction

The importance of indigenous knowledge and traditional crops in the survival strategies of rural people has only recently been recognized by researchers in South Africa. The use of traditional leafy vegetables in communities has been mentioned in various studies from 1963 to 1982 [1]. In South Africa the awareness of indigenous/traditional vegetables is not very high and it is mainly perceived as "poverty food" by many [2]. The World Health Organization (WHO) HIV/AIDS statistics in 2005 show increasingly more people affected by this disease and the effect it has on the productivity of vulnerable groups. [3]. These statistics emphasize the potential role that indigenous leafy vegetables could play to improve the quality of life of many people suffering from the disease or as a result of the disease.

The use of leafy vegetables during winter helps to address food shortages at this time. Revival of the use of indigenous leafy vegetables within communities will also ensure a focus on the conservation of these crops while ensuring the availability of diverse genetic material for future needs [4]. These studies indicate the value and important role that indigenous vegetables could play in the survival of populations at risk. ARC-VOPI initiated a research programme on indigenous vegetables in 1994 and has been a partner in the aforementioned project. The purpose of this paper is to illustrate the effect of the 'Promotion of African leafy vegetables for food security and nutrition' project on African vegetable research in the Agricultural Research Council (ARC) of South Africa. The results obtained from this project contributed to improved decision-making processes and priority setting of projects within the ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

Materials and methods

To enable us to determine the effect that the project had on research in this field in the ARC, it is important to reflect on the research done prior to the implementation of the aforementioned project. The research done by the Institute prior to the project was prioritized based on a regional meeting facilitated by the International Centre for Underutilized Crops (ICUC) in 1995. This workshop was attended by researchers from various African countries.

Twenty major African vegetable crops were identified and the Institute embarked on a research programme for the development of production practices for five indigenous vegetable crops, including Amaranthus spp., Cleome gynandra, Vigna unguiculata (Cowpea), Vigna subterrannea (Bambara groundnut) and Okra. The Institute also hosted an African Crops Workshop in March 1995 which was also attended by various researchers from Africa. The Institute was invited to participate in the project funded by Bioversity International (former IPGRI).

At that time the Institute was among the few research organizations in South Africa that did research on indigenous/ African vegetable crops. Our focus was mainly on the development of production methods, and pest and disease identification and mitigation. During the period 1998 to 2004, researchers from the Institute were members of an initiative from the South Africa Government driven by the parliamentary portfolio committee (Department of Science and Technology) to promote and protect the use of indigenous knowledge systems.

The Science Councils and universities in South Africa participated in this initiative. The development of indigenous crops became one of the strategic focii of the Institute as well as other institutes within the Horticulture and Grain, and Industrial Crops divisions of the ARC.

During the initial phases of the project it was confirmed that African leafy vegetables (ALVs) still play a major role in the food security and nutrition and survival strategies of many rural communities in South Africa [2]. During the time that we were involved with the development of indigenous African vegetables another major research focus area was the development of food-based models for the alleviation of malnutrition, with specific emphasis on alleviation of the major vitamin A deficiency problem in the country.

This programme was driven by the Medical Research Council of South Africa (MRC) and the ARC and in the end led to SA becoming a partner in the Vitamin A for Africa initiative originally driven by the International Potato Center (CIP). Although this initiative mainly focused on the promotion and development of orange-fleshed sweet potatoes (OFSP) to alleviate vitamin A deficiency, results obtained from this and other studies indicated that the diversification of the food basket available to people in rural communities was crucial if food security was to be addressed in its broadest sense.

The result was the development of a strategy to increase the consumption of micro nutrient-rich foods through the production and promotion of indigenous foods. Researchers from ARC attended an international workshop organized by FAO and the World Vegetable Center (AVRDC) in March 2002.

It is therefore clear that various new initiatives and developments, including the above-mentioned project influenced the research agenda of ARC-Roodeplaat, Vegetable and Ornamental Plant Institute. Although a formal impact study was not conducted, the specific influence and value of this project on the research agenda of ARC-VOPI became apparent. Information that was gathered as a result of the project assisted in identifying critical research needs and the Institute developed a research programme based on criteria developed from this information.

Results

The results of the project influenced the research agenda in the following ways:

Changes in food production per household

The utilization of indigenous vegetables in South Africa is mainly through harvesting them in the wild. Through the project and others that were initiated as a result of this project, various communities in KwaZulu Natal, Limpopo, Mpumalanga, Northwest, Eastern Cape and Gauteng are now cultivating these crops as part of their home gardens. This resulted in an increase in food supply, a wider variety of food available containing the necessary mix of protein and carbohydrates, together with vitamins and minerals for a healthy diet, as well as an improvement in the quality, quantity and diversity throughout the year. A clear result is that the genetic diversity supports food security in these areas and also provides security against pests, diseases and other environmental conditions.

This was also found by Almekinders and de Boef [4] and they further highlight the important basis that this genetic diversity provides for future agricultural development in the world [4]. It was realized in this study that the preparation, processing and marketing of the indigenous/traditional vegetables is an important part of the strategy to have nutritious food available all year round. Researchers from the Institute have been invited to present results obtained through this project as well as other results from our previously established research programme at various conferences in South Africa, including international conferences and workshops on nutrition.

Improved diets and health of various communities in South Africa

This project and others proved that improved food supply throughout the year has a fundamental impact on health, which in turn allows adults to be more productive and children to attend school and be able to concentrate on learning. These projects have improved the year round supply of vegetables and in many instances children were the main beneficiaries. The results obtained from these studies made it clear that in the decision-making process of priority setting, factors that are not necessarily related to agricultural production should be taken into consideration and those are now included in the criteria for prioritization of projects of the Institute. Clearly, these can address food insecurity and balanced nutrition problems that lead to the fact that many families will not be able to carry out all of the existing or increased number of tasks as described by Hunter and Twine [5]. It will also increase their ability to become increasingly productive and will result in improved health of many malnourished populations at risk. The results of the study also indicated the value of these crops which can be harvested with minimal inputs in terms of labour and finances, a fact also reported by Warren [6].

Conservation of genetic diversity and seed supply systems

A direct result of this project was the increased number of accessions of indigenous/African crops in our genebank. The ARC-Roodeplaat genebank maintains various accessions of traditional and indigenous root and leafy vegetables as well as medicinal plants as seed or as *in vitro* or *in vivo* plants. The seeds are stored in cold storage and *in vivo* plants are kept in field collections, which are planted annually, or in screen houses. *Manihot esculenta* (Cassava) and *Plectranthus esculentus* (Livingston potato) are maintained *in vitro*.

Seed of a wide variety of local and foreign *Amaranthus* species are stored. Eight of the local accessions were regenerated for screening for drought tolerance. Accessions of *Abelmoschus esculentus* (Okra), *Cleome gynandra* (Cat's whiskers), *Taraxacum officionale* (Dandelion), *Symphytum officionale* (Comfrey) and *Gomphrena globosa* (Globe amaranth) are maintained as seed accessions. A total of 429 accessions of 19 species of *Amaranthus* are held at the National Botanical Institute at Pretoria. Nineteen leafy vegetable accessions are held in the genebank of the ARC-Range and Forage Institute.

A direct result of the project was the realization of the importance of access to planting material and the development of sustainable seed supply mechanisms in rural areas.

Nutritional value and expansion of research activities as a result of the project

The nutrient potential of South Africa natural fauna and flora is not known and it is therefore a challenging new area of research. Currently only 20% of South African foods has ever been analyzed for nutrient content. This is despite the fact that results of food that has been analyzed so far in South Africa show that the food composition of local foods differs substantially from those of other countries. However, food composition data is essential in nutritional research, for planning and assessing nutrition intervention studies, planning national food and nutrition policies, and prescribing therapeutic and institutional diets, as diets of individuals are usually analyzed by utilizing this information.

In a study done by the Department of Food Science at the University of Pretoria, the nutrient content of five traditional dark green leafy vegetables was determined. The nutrient analysis revealed that they are a good source of protein, and minerals such as iron, calcium, phosphorus, magnesium, and beta-carotene. The values of this experiment differed from previously reported values owing to a range of variables. Variables which could have had an influence on the nutrient content are the difference in raw material (the maturity of the leaves), part of the plant utilized, fertilizer used and post-harvest handling. Cooking also had an effect on the nutrient content of the dark green leafy vegetables. The moisture content increased insignificantly in the cooking process while there was a significant decrease in mineral as well as proximate composition. Research studies have shown that the beta-carotene in dark green leafy vegetables is more bioavailable than in cooked leaves. *Curcubita maxima, Cleome gynandra* and *Amaranthus cruentus* had a higher index of nutritional quality than *Corchorus olitorius* and *Vigna unguiculata*.

The consumption of *Curcubita maxima, Cleome gynandra* and *Amaranthus cruentus* should therefore be encouraged. Owing to the high nutrient content of these five dark green leafy vegetables, it should be recommended in South Africa and other developing countries that the vegetables are used to alleviate micronutrient as well as protein energy malnutrition. These leafy vegetables are available in a diversity of regions in South Africa. This knowledge of the nutrient content of these leafy vegetables can therefore play an active role in reducing food insecurity in South Africa.

As a result of results obtained from this project, the Institute will now participate in a project funded by the European Union with the aim of identifying the role and value of indigenous vegetables in urban agriculture in various participating African countries. It will involve a baseline study (questionnaires) in two urban areas as well as various seminars/workshops in different African countries where participants will share knowledge and expertise. Another broad objective is to ensure the identification of market chains and consumer consumption trends as well as indigenous vegetables and livelihoods along the rural-urban continuum. The principal partner is the Centre for Arid Zone Studies (CAZS) of the University of Wales. Other partners are from Europe (4) and Africa (10). The project will also focus on the linking of communities, extension services, researchers and policy makers for indigenous vegetable production.

Another initiative is a project funded by the Water Research Commission (WRC): Nutritional value and water use of indigenous crops for improved livelihoods. The research partners are UP, ARC-Roodeplaat, Tshwane University of Technology and the MRC. The aim of this project is improved livelihoods through increased food security and well-being among groups that are vulnerable to malnutrition through increased water productivity in indigenous crop cultivation in selected areas of South Africa. This project is also a result of research carried out on determination of the drought tolerance of some indigenous crops in South Africa, funded by the WRC and IAEA.

Plant protection

The aim of Amaranth (*Amaranthus hybridus*) research conducted by the New Crop Pathology Programme (NCPP) of the Department of Plant Pathology at the University of the Orange Free State is to serve new crop growers with information on sustainable methods to manage or control actual and potential disease problems. The primary research objective has been to develop an understanding of the biotic interactions that occur between Amaranth and endophytic/latent infecting fungi (particularly *Alternaria, Botryosphaeria* and *Fusarium* species) and, where relevant, insect pests that are associated with these interactions. The relevance of these interactions to the health and yield of Amaranth has been the main focus. In the past five years significant breakthroughs were made regarding interactions between *Amaranthus hybridus*, pathogenic fungi such as *Fusarium* spp. and quiescent pathogens such as *Alternaria tenuissima*. Vector relationships between fungal pathogens of the crop and various insect pests were also studied. This provided an excellent foundation for the development of sustainable integrated pest management (IPM) programmes for South Africa. A very large sample of endophytic *Alternaria* isolates (ca. 3000) was collected, which will serve as a very valuable asset to understanding this important genus of fungus.

Technology transfer

The potential commercial value of indigenous crops as well as their role in food security and survival strategies of communities was highlighted. The role indigenous crops could play in establishing emerging farmers was also determined. Awareness creation within the scientific community was done through publications, presentations, posters, workshop and conference attendance, with some conference organizers specifically inviting these contributions. The exposure has led to more national and international institutions making use of the capacity built during the project duration. Universities are partners on nutritional and consumption studies, thus helping to strengthen the capacity of the scientific community on traditional vegetables work. A direct result of this and other projects was the understanding of how farm productivity can be increased through the utilization of indigenous crops. The attendance of community feedback sessions, interaction with farmers and scientists now resulted in the principle that the farming system in its totality needs to be taken into account and research will be done to investigate multi and intercropping to enhance the intensification of a single component of the farming system. The addition of new productive elements to the farming system became crucial and future initiatives are to focus on interventions that will boost the total farm food production system and income.

Discussion

Lessons learnt from this project strengthened other projects and *vice versa*. Social learning was a vital part of this process in the adjustment to sustainable production systems. It was proven that the conventional model of understanding technology adoption as a simple matter of diffusion is no longer valid. The systems developed are about the building of capacity of farmers and rural communities to learn about the complex ecological and biophysical complexity in their fields and farms and then to act in different ways that are appropriate to the system. The process of learning provoked changes in behaviour and resulted in the fact that we now collectively understand and transform this information into workable sustainable seed supply systems. This led to greater innovation in the rural areas where this and other projects are based with the increased likelihood that the underlying social processes are more likely to persist. This also impacted on improved social and human capital. Communities and researchers now formed a stronger social organization where norms for collective natural resource management were established and the local capacity to experiment and solve own problems were increased.

By identifying culturally-accepted foods of a high nutrient quality, the general heath of the communities in South Africa can be improved by combating malnutrition and human diseases, as effective community nutritional education can be performed based on this knowledge.

If suitable innovative processing is applied to foods with a high nutrient content, that are, eaten by rural populations, new technologies and value adding could be introduced to the products. New markets can be developed not only benefiting South Africa, but also the Southern African region. Amaranthus grain has been developed as a high value niche market crop in the Gauteng Province of the country and products of this crop are being sold in a chain store supermarket. In this way farmers have been supported to participate in mainstream agriculture and become economically competitive. As a result of this programme, farmers have been enabled to make economically-viable decisions.

As our communities become more exposed to the value of their indigenous foods, food patterns and food habits are changing. By selecting foods from rural populations in SA and determining the nutrient and taste potential they can be utilized as a valuable source of raw materials and developed into useful new products (information), and in this way contribute to the basket of foods available for not only food security, but also commercial potential in terms of diversification.

By identifying the culturally accepted methods of preparation more information became known about the nutrient status. Once a new nutritious product has been established in the community, this food product could be identified, processed and distributed within the community thereby contributing to prosperity. As people become urbanized they very often yearn for the nutritious foods from their childhood. This is an area in the food chain that has not yet been exploited to the full in South Africa.

Conclusion

It is clear that the broader indigenous crops research programme both gained from and contributed to the successes achieved in this project. Information gathered strengthened other projects whereas other projects in their turn contributed to the outcomes of this project. Skills and capacity gained during this project will now be utilized in other projects. It is hoped that this project will also be continued with new research priorities identified as a result of this and other studies. All these actions and interventions helped to uplift the image of ALVs from a poor man's crop to a high value niche market crop, but still highlighted the importance of these crops in the survival of many rural communities in South Africa. Major contributors to success through these projects were: the introduction of appropriate technologies which were adapted and adopted by participants in the various projects; increased participation of communities and farmers in the experimental process to adapt appropriate technologies within their unique situation; social learning and participatory approaches were utilized and developed to optimally engage all role-players; and good linkages between various projects/initiatives and the researchers participating in those facilitated an enhanced learning process where outcomes of one project strengthened others and vice versa.

Recommendations

It is recommended that an in-depth impact study be done. This is important to identify potential gaps and research priorities for future research. From results obtained to date it was determined that further studies should be carried out to determine nutrient content of a wide range of indigenous crops. Sensory tests should be conducted. The role of these sensory tests is to provide valid and reliable information to research and development, production, and marketing in order to make sound business decisions about the perceived sensory properties of indigenous vegetables. Descriptive sensory evaluation addresses the complexity of food systems by taking into account as many of a food's attributes or notes as possible.

The appearance, flavour and texture of vegetables are the most important characteristics influencing the consumer's acceptance and eventually behaviour towards buying or not buying. Information obtained in this regard will supply meaningful recommendations to the product manufacturers as well as give insight into the positioning of the products relative to each other in the current market. Furthermore it is important to develop production packages and guidelines for these crops and continue to participate in international networks in this regard. It will be important to establish systems for participatory learning if we want to ensure that information on sustainable agriculture spreads to more communities and farmers. Attention should be given to developing an enabling environment and investing in infrastructure for markets, transport and communication. Efforts should be made to ensure that government agencies are supportive of the initiatives within the context of this and future projects.

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