SP5: Impact of fresh and processed African leafy vegetables on human health

Project partners:
Baldwyn Torto, African Insect Science for Food and Health (ICIPE)
Glaston Kenji, Julius Maina, Jomo Kenyatta University (JKU)
Joice Kinabo, Sokoine University of Agriculture (SUA)
Monika Schreiner, Susanne Baldermann, Leibniz-Institute of Vegetable and Ornamental Crops Großbeeren/Erfurt e.V. (IGZ)
Sabine Kulling, Biserka Becker, Markus Schmidt-Heydt, Karlis Briviba, Max Rubner-Institut (MRI)
Evelyn Lamy,University Medical Center Freiburg (UMCF)
Susanne Huyskens-Keil, Humboldt Universität zu Berlin (HUB)
Sascha Rohn, University of Hamburg (UH)

I. Objectives

Sub-Saharan Africa is the region of the world with the highest percentage of chronically malnourished people (OECD-FAO 2011). Malnutrition can either directly cause death or indirectly trigger secondary chronic diseases (Shiundu/Oniang'o 2007). The reasons for Africa's severely limited ability to nourish itself with sufficient quantity and quality of food are numerous (Shiundu/Oniang'o 2007) with emphasis on agronomic constraints and limitations due to locally appropriate processing and cooking techniques (Smith/Eyzaguirre 2007). Although traditional indigenous African leafy vegetables (ALV) are rich in nutrients and health-promoting compounds with suggested preventive effects against cancer, cardiovascular and infectious diseases (e.g. Habwe/Walingo/Onyango 2009; Schreiner et al. 2009; Mibei/Ojijo 2011), ALV also show a rapid nutritional degradation as large quantities of nutrients and health-promoting compounds are lost because of unfavourable cooking methods (Kimiywe et al. 2007). Regarding domestic cooking procedures, ALV are typically cooked prior to consumption for more than 40 minutes and then often additionally fried or deep-fried, resulting in significant nutritional loss (Kimiywe et al. 2007; Prabhu/Barrett 2009). Combined with unfavourable cooking methods is a specific problem - especially in Africa- the spoilage of ALV by fungi and the concomitant production of mycotoxins due to suboptimal household practices, giving rise to serious illness in the population (Wild and Montesano 2009). In addition, traditional vegetable drying results in contamination with microorganisms, formation of mycotoxins and infection with disease-causing microorganisms (Habwe/Walingo/Onyango 2008). Mycotoxins have been shown to be hepatotoxic, teratogenic, mutagenic, genotoxic and hepatocarcinogenic, depending on the duration and level of exposure and recurring acute aflatoxicosis in Africa.

Therefore, the overall aim and objective of the sub-project is to improve the current nutrition situation towards a more balanced human diet by increasing the consumption of fresh and optimally processed ALV that are rich in essential nutrients and potential health-promoting compounds, in order to reduce malnutrition itself as well as its implications on secondary chronic diseases. As such, the identification and quantification of relevant health-related nutrients present in fresh ALV, and present after typical and improved food cooking and processing conditions (which are being optimized in the postharvest/processing sub-project), will be determined as a prerequisite of recommendations for an improved human nutrition situation. These evaluation data of optimised cooking and processing conditions will be combined with *in vitro* studies and intervention trials for investigating the bioavailability in humans and possible protective effects of health-promoting compounds on human health. The knowledge generated will be made available to African households in rural, peri-urban and urban areas.

The relevance of the sub-project to the objective of the project (main output) is implied by the overall evaluation and exploitation of the biodiversity of ALV with emphasis on their nutritional and health benefits. A continuous, reliable and affordable supply to local and regional consumers will be promoted as well as consumer-oriented and affordable postharvest technologies throughout the value chain will be developed (Outputs 1-3, VCs of indigenous vegetables).

The research and/or technical goals of the sub-project will be the development of recommendations for nutritional and health beneficial cooking and processing procedures of ALV as suitable household technologies based on optimized cultivation management practices (e.g. water and nutrient supply).

II. State of knowledge

In Africa, a large number of plant species, either spontaneously grown or cultivated, are consumed as traditional food plants. These ALV are rich sources of nutrients (e.g. vitamins, minerals, and proteins) (Shiundu/Oniang'o 2007; Abukutsa-Onyango 2007) and potential health-promoting compounds (e.g. glucosinolates, polyphenols, carotenoids, alkaloids, and fibre) (Mibei/Ojijo 2011). Moreover, they are a significant precursor source of vitamin A, especially for the 6-9 month old children group in Kenya, for whom the vitamin A deficiency remains at a high level of 84.4% (WHO 2012). ALV contribute 65.7% of vitamin A obtained from plant sources and 32.7% of the household vitamin A intake in Kenya (Oiye/Shiundu/Oniang'o., 2009). Common to these vegetables is their neglect with respect to a targeted improvement in cultivation and subsequent cooking and preservation procedures on the household level. A specific problem with ALV is the rapid loss of nutrients due to domestic cooking procedures (Kimiywe et al. 2007; Prabhu/Barrett 2009) and due to spoilage by microorganism contamination and mycotoxin formation during storage (Habwe/Walingo/Onyango 2008; Wild/Montesano 2009).

The consumption of traditional ALV presently gains increasing popularity in Africa. This behavioural change has been stimulated by the realization of their high nutritional value and proclaimed positive health benefits such as the prevention of cancer (Russo 2007). However, so far, scientific knowledge on the efficacy of their potential health benefits is unacceptably low. Even for the little information available, the active principle responsible for protective properties and the underlying responsible physiological and molecular mechanisms are still unclear. The ALV studied will predominantly include amaranth, African nightshades, spiderplant, cow pea leaves and African kale (Abukutsa-Onyango 2007). It is known that these vegetables are a valuable source of mineral and vitamin intake as well as of protein (Abukutsa-Onyango 2007). ALV are also increasingly recognised for their high content of possible contributors of health-promoting compounds including ß-carotene (Smith/Eyzaguirre 2007), glucosinolates (Schreiner et al. 2009) or flavonoids and other phenolic compounds (Mibei/Ojijo 2011). These groups of bioactive agents have considerably contributed to the concept of cancer prevention and control in the western world (Mehta et al. 2010) and could account for a health-promoting effect also of the ALV. Optimizing the concentrations of nutrients and health-promoting compounds could be done by development of appropriate cultivation and processing/cooking procedures (e.g. Schreiner et al. 2009, Prabhu/Barrett 2009, Verkerk et al. 2009).

The biosynthesis and degradation of nutrients and health-promoting compounds is known to be mainly regulated both genetically and environmentally (Brown et al. 2003). Exploitation of these regulatory factors during cultivation and processing/cooking of traditional ALV could have pronounced effects on nutrient and health-promoting compound concentrations, and this in turn has strong implications for the production of nutritional and health-promoting ALV foods for human nutrition (e.g. Verkerk et al. 2009). Moreover, the bioavailability and bioactivity of health-promoting compounds in humans is influenced by a variety of factors, starting from plant processing to microenvironment conditions within the human body but also the amount and pattern of precursors in the plant impacts availability at an organ target site as well as the compounds´ efficacy against diseases. This has been demonstrated for a variety of plant species and should be done also for ALVs.

III. Utilization of results

- After having identified the optimized cooking/processing procedure for maintaining nutrients and health-promoting compounds which also prevent the formation of mycotoxins in ALV, we will give recommendations for the appropriate processing/cooking procedures combined with training courses for African households in rural, peri-urban and urban areas (VC indigenous and urban/peri-urban vegetable). This will increase the promotion of a balanced human diet and hence reduce malnutrition itself and its implications on secondary chronic diseases.
- These processing/cooking recommendations will be described in an easy to handle, step-bystep protocol for the appropriate processing/cooking procedures which will support extension and advisory services providers to give realizable information to African consumers about diet and appropriate cooking/processing procedures.
- On an advanced level, these processing/cooking recommendations could be the starting point for a general campaign to improve African human diet and thus human health by appropriate processing/cooking procedures of the entire group of plant-based food. Therefore, collaboration with policy and decision makers and scientists to support further development in the African health sector by developing recommendations for nutritional and health beneficial cooking/ processing procedures of plant-based food will be initiated.

IV. Internal division of labour and cooperation with other subprojects/ third parties

- Cooperation within the partners of this sub-project will be done by exchange and completion of analytical methods, joint supervision of the PhD students and continuous information and discussion of the research results.
- Cooperation with partners of the sub-project “Quality assurance and preservation of African vegetables during postharvest for reducing food losses and improving nutritional value, storability and food safety”. Interaction will determine effect of postharvest treatments on concentrations and bioavailability of nutrients and health-promoting compounds in ALV.
- Cooperation with partners of the sub-project “Increasing water use efficiency in indigenous vegetable production systems”. Interaction will determine how cultivation conditions, especially water supply, will affect nutrients and health-promoting compounds in ALV.
- Cooperation with partners of the sub-project “Sustainable soil fertility and nutrient management in horticultural production systems“. Interaction will determine how cultivation conditions, especially nutrient supply, will affect nutrients and health-promoting compounds in ALV.
- Cooperation with partners of the sub-project “Knowledge creation for value chain promotion for prioritised Value Chains”. Interaction will provide knowledge of how added value from fresh and optimally -processed ALV, rich in nutritional and health-promoting compounds and mycotoxinfree, will open new marketing possibilities.
- Cooperation with partners of the project “Value chain effects on livelihoods and food security of vegetable producers and consumers”. Interaction will provide knowledge to inform and to teach African households about appropriate cooking/processing procedures of ALV in order to introduce a balanced human diet with the consumption of fresh and well-processed ALV rich in nutritional and health-promoting compounds and free of mycotoxins.