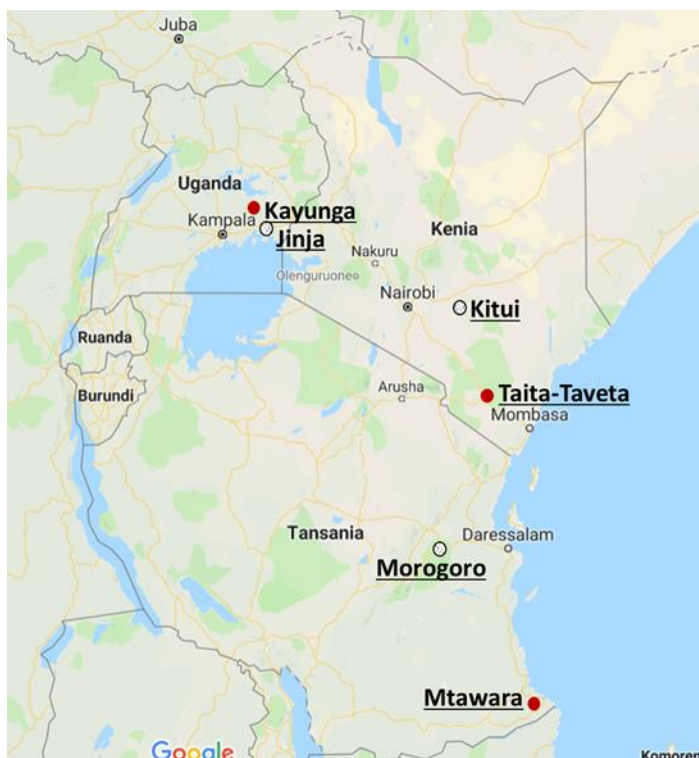


Project update

Project title (Acronym):	Fruits and Vegetables for all Seasons FruVaSe
Geographical focus:	Kenya: Kitui and Taita-Taveta Tanzania: Morogoro and Mtwara Uganda: Jinja, Kasese and Kayunga
Call reference:	Innovative approaches to process local food in Sub-Saharan Africa and Southeast Asia, which contribute to improved nutrition, as well as qualitative and quantitative reduction of losses
Cooperating partners:	University of Göttingen; Erfurt University of Applied Sciences; University of Nairobi and University of Eldoret, Kenya; Nelson Mandela Institution of Science and Technology, Tanzania; Makerere University, Uganda
Duration:	1st September 2018 – 30th September 2022
Budget:	1,051,913.89 €



- Vegetable region
- Fruit region



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Aim of the project:

The FruVaSe project aims to contribute to the fight against vitamin and mineral deficiencies in human nutrition in East Africa and to address the challenge of using fruit and vegetables as well as their waste, especially seasonal waste, in the value chain. Sub-goals are i) to select the most promising varieties of guava (*Psidium guajava*), cashew apple (*Anacardium occidentale*) and jackfruit (*Artocarpus heterophyllus*) as well as the green leafy vegetables cowpea leaves (*Vigna unguiculata*), African nightshade (*Solanum* spp.) and cassava leaves (*Manihot esculenta*) and ii) to evaluate traditional processing and shelf life extension technologies as well as to develop and evaluate new technologies, with a focus on juices, dried products such as fruit bars; sauces, relishes and pickles as well as instant soups and dried leaves; iii) the new products should be tested for consumer acceptance and possibly commercialized in pilot projects.

The FruVaSe project pursues an integrated system approach (water-energy-food-waste nexus) in order to iv) develop a model for energy-independent, resource-efficient processing methods embedded in a business model for empowering women in rural areas. In a life cycle concept, most of the plant parts of the selected fruits and vegetables are to be used: both for human consumption and as animal feed (guava in Kenya as chicken feed) or for biogas production (jackfruit in Uganda); v) in addition, a recycling concept for water and the analysis and purification of drinking water for juice production is being developed (Tanzania).

Results:

Fruit and vegetable processing (WP1, WP2)

Guava, Kenya

- Guava nectars processed and packaged in opaque packaging materials were found to have a shelf life of at least three months with minimal quality loss compared to nectars in transparent packaging materials.
- The guava nectar with *Moringa oleifera* extract showed significantly ($p < 0.05$) higher levels of proteins, zinc, iron, vitamin C, β -carotene, flavonoids and antioxidant activity compared to nectars without extract.
- Stem cuttings of pink guava treated with honey showed the highest percentage of survival and number of buds sprouted, while the highest root length was recorded when treated with apple cider vinegar for white-fleshed and red-fleshed guavas, respectively.
- In seed multiplication, the highest percentage of sprouting was recorded for white-, pink- and red-fleshed guavas treated with sucrose and citric acid.
- Guava fruits from Mwatate region (with pink, red and white flesh) had the highest zinc and calcium content compared to fruits from Wundanyi and Taveta regions (with and without irrigation).

Jackfruit, Uganda

- The study of different drying methods on physico-chemical properties of jackfruit showed that refractance window drying (RWD) was comparable to freeze drying and better than solar drying and oven drying.
- In addition, RWD is a faster drying method than the other three methods and is therefore potentially an alternative technique for producing high quality dried jackfruit.

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Cowpea leaves, Kenya

- The shelf life of the developed cowpea leaf soup mixes was at least 7 months when packed in aluminum bags but less than 6 months when packed in paper and plastic.
- Regardless of processing techniques, the developed soup blends had micronutrient compositions of 2mg/100g, 4mg/100g and 500ug/100g of zinc, iron and beta-carotene, respectively, sufficient for the recommended fortification levels.
- Solar drying was the most cost-effective technique for processing cowpea leaf soup blends.

African nightshade leaves, Tanzania

- Increased β -carotene content in fermented African nightshade products (pickles & relish) was found, yet, at the same time also a reduction in vitamin C content, mineral content (Fe, Zn, Ca, Mg, K, P, Cu & Ca), total phenol content, chlorophyll content and also reduction of undesirable substances tannin and oxalate.
- Fermentation increases the shelf life of fresh African nightshade and the majority of consumers liked the fermented relish of African nightshade leaves.

Cassava leaves, Uganda

- The optimal conditions for producing nutrient-rich dry cassava leaves were drying at 60°C for 3 hours. The optimised dried cassava leaf powder is safe for consumption within 12 weeks of production, as it meets food safety standards for mould and total plate count.

Fruit and vegetable products in the diet (WP3)

- The cost of a standard diet for children aged 6-23 months in Tanzania was US\$0.38 to US\$3.00 during peak harvest season and US\$0.29 to US\$1.92 when the selected fruits and vegetables were not in season. For 6-13 year old children, they were US\$ 5.64 and US\$ 5.04 respectively. The cost of feeding women (non-breastfeeding/non-pregnant women) was US\$3.53-13.22 in the peak season and US\$3.84-10.70 in the off-season.
- The limiting nutrients in the standard diet of women and children in all seasons included calcium, iron, zinc, vitamin B2, vitamin A, vitamin C and vitamin B6.
- Intake of processed fruits and vegetables reduced the cost of diets for women and children aged 12-23 months by up to 64% and 53%, respectively. The cost of feeding children between 6 and 11 months increased by up to 150%. For children between 6 and 13 years, costs decreased by 48% in the high season, while they increased by 6% in the low season.
- The addition of processed fruits and vegetables offset all limiting nutrients in the diets of women and children aged 12-23 months and 6-13 years. For children aged 6-11 months, all limiting nutrients were balanced with the exception of iron, vitamin B6 and B2.

Energy and water demand in fruit and vegetable processing (WP4)

Energy

- Waste from jackfruit, banana peels and pineapple peels are potentially suitable for biogas production. Joint fermentation with cow dung increases the potential of agricultural waste for biogas production.
- Furthermore, after detailed preliminary tests and optimisations, briquettes were produced from the organic waste with local equipment, which can be used for cooking in

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rural households. As part of the cyclical approach (recycling), the residues from biogas production were characterised and tested for their use as fertiliser. Here, the adsorption of N, P and K by jackfruit waste (for activation of plant carbon as fertiliser) was optimised. A life cycle analysis of the whole process was carried out, for resources and greenhouse gas production.

Water

- The electrocoagulation process has shown positive results in treating water with high fluoride concentration up to the limit set by WHO and TBS (1.5 mg/L).
- 60 minutes are needed to treat the water to reach the standard fluoride limits in Tanzania. The electrocoagulation process additionally disinfects the water at appropriate current levels.
- Overall, the results are still considered to be in need of improvement. The provision of clean water for processing operations, especially juice production, will be incorporated into the project's recommendations.

Marketing of fruit and vegetable products (WP5)

- A reasonable number of consumers (> 40%) are already willing to pay the optimal market price for guava nectar, cowpea leaf soup, dried cashew apples and jackfruit juice.
- Consumers who are not willing to pay the optimal market price place more importance on knowing the processor of the food they buy, are better educated and are mostly from urban areas.
- A relatively large group of consumers, almost 50% of the participants, appreciates cereal porridges enriched with cowpea leaves as much as normal cereal porridges.
- Sensory attributes of jackfruit nut bars are positively rated on average, and price preferences are similar to established snacks; willingness to pay increases with sweetness, age and frequency of snack consumption.

Training

- In training courses with farmer and women groups, the new techniques for fruit and vegetable processing were passed on, as well as the new results on the use of organic waste for biogas and briquette production.
- Various information materials such as manuals, leaflets and posters were produced, some of them in local languages (including Kiswahili). In addition to the training of trainers and group training, in Uganda the new information was also passed on via radio.

Key statements and policy advice:

- Limited knowledge on value addition technologies coupled with lack of equipment remain major limitations on processing, preservation and improved consumption of green leafy leaves and local fruits. → An important recommendation is therefore that processing methods are (for the short-term) adapted to the equipment available in rural areas. In addition, other local fruits and vegetable or even other local foods should be considered for processing, so that processing units can be used to capacity throughout the year.
- Dehydrated products from cowpea leaves as well as from other leafy vegetables contain adequate amounts of limiting minerals and hence provide possible food vehicles

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for dietary diversification of the populations vulnerable to micronutrient deficiencies.
 → An important policy recommendation is that people now need to be sensitised for the importance of processed leafy vegetables and fruits – for the off-season when no fresh products are available/affordable – as many eat only the fresh vegetables and without more information and campaigns might not adopt the processed products.

- When processed fruits and vegetables were included in the standard diet, diet costs could be brought down for an adequate and healthy diet for women and school aged children, however, not for children 6-11 months. Also, nutrient gaps could be closed for women and children by including some of the processed fruits and vegetables, yet, again not for children 6-11 months.
- Waste from jackfruit, banana peels and pineapple peels are potentially suitable for biogas production. Co-digestion with cow dung increases the potential of agricultural waste for biogas production. Briquettes were produced from organic waste using local equipment, which can be used for cooking in rural households.
- More than 40% of consumers are already willing to pay the optimal market price for guava nectar, cowpea leaf soup, dried cashew apples and jackfruit juice.



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Practical demonstration session on African nightshade drying in Morogoro DC.

All pictures above © Edna Makule, NM-AIST, Arusha, Tanzania



MUG, Uganda, dissemination activities



- A: Removal of seeds from arils
- B: Pasteurizing of the juice
- C: Bottling of the juice

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