Federal Ministry
of Food
and Agriculture

PROCESSING

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

ProciNut: Production and Processing of Edible Insects for Improved Nutrition

country/countries	Madagascar, Myanmar (and Thailand)
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project management	Federal Office for Agriculture and Food – BLE
project coordinator	ZEF, Center for Development Research, University of Bonn
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key words	Nutrition, Entomophagy, food security, insect rearing, trainings, small scale farming, sustainability, south-south-cooperation, gender equality, value chain, knowledge transfer, capacity building

background	Across the world the diet is dominated by livestock and crop species, but many nutritious and promising food sources are neglected. There are around 2,000 edible insects, of which many have a high profile of nutrients (proteins, vitamins, minerals, amino acids), a high feed conversion rate and low greenhouse gas emissions (van Huis 2013). In about 113 countries (Rumpold and Schlüter 2012), entomophagy (i.e. human use of insects for food) is culturally accepted and finds around two billion consumers (Halloran et al. 2014), most of them living in the tropics. The FAO (2013) has recognized the colossal role that the diversity of insects can play, if properly managed and utilized, in fighting malnutrition. Edible insects, so far still a niche topic, bear a large potential in contributing to protein enriched diets for the predicted world population of nine billion by 2050. Especially in Sub-Saharan Africa (SSA), South and parts of South East (SE) Asia insect consumption is common yet many countries in these regions struggle to meet the SDG target 2 on achieving food security. It calls for innovative approaches in exploring alternative food sources, their production, processing and prevention of nutrient or food losses along the value chain, yet research is limited. The high nutritional value of edible insects is widely recognized (van Huis 2016, Rumpold and Schlüter 2015, Bukkens 2005). They often play an important role for diet diversity, a fundamental aspect of good nutrition (Keding et al., 2013; Tontisirin et al., 2002) and in filling overall animal protein gaps in diets as they have the same amount of protein content as ruminant meat. They also address seasonal gaps of micronutrients (van Huis 2016). Often consumption increases, when staple food stocks come to an end, before harvests and during seasons, when less meat is available (FAO 2013). Among consumers the nutritional value of edible insects is often unknown and they are generally neglected by extension services and policy makers. Most edible insects are seasonal and their consumption is limited to killing and eating or cooking (frying, fritters, curries, soups, etc.) when available, and their potential of preservation, processing and storage remains highly underexplored (Johnson 2008, Dossey et al. 2016).
objective	The ProciNut project aims to use the nutritional and economic potentials of edible insects by ▪ establishing and improving small-scale farming ▪ production of safe and nutritious end products with increased shelf life using different processing techniques ▪ reducing the (often seasonal) nutritional insecurity of households ▪ improving the economic situation of rural women and close gender gaps ▪ facilitating capacity building and knowledge exchange for development agents and farmers ▪ promoting South-South-Cooperation between Madagascar, Myanmar and Thailand
results	▪ The seasonal supply of edible insects does not satisfy the population's demand. Insects are mostly collected by villagers for their own

use. Nevertheless, edible insects appear to be an important food item for urban consumers and an important source of income for farmers, at least seasonally.

- A supportive policy environment helps interested producers to start, grow or stay in business with insects. Potential insect producers need access to knowledge and capital, as well as initial insect material (preferably from a species that is already known and consumed locally) and feed to start production.
- Insect value chains are evolving in Shan State and are already contributing to food security in Eastern Shan State, but still at low levels.
- Bamboo worm harvesters take the highest share at around 39% of the retail price, followed by retailers at 38%, while local buyers get 15% and wholesalers get 8%. Bamboo worms therefore not only generate protein-rich food, but also employment opportunities and income in poor regions of Myanmar.
- The most popular edible insect is the giant cricket. The majority of customers are female and spend between USD 10 and USD 65 per year. The first purchase is influenced by photos of edible insect preparations and feedback from other customers, while price seems to be less important. The main factors to become a regular customer are good taste, timely delivery, quality, freshness and processing the insects by removing inedible body parts. Customers prefer online shopping to traditional markets.
- A political analysis of the insect sector in Myanmar concluded with five policy recommendations to be implemented as soon as the political environment is conducive to further develop the insect sector:
  - Establishment of an interdepartmental working group on edible insects.
  - Definition and recognition of edible insects as farm animals.
  - Consideration of edible insects in future national strategic food safety policies, plans and documentation
  - Establishment of a Good Agricultural Practices (GAP) standard for the production of insects for Myanmar
  - Support for the creation of a stakeholder-led association of edible insect breeders.
- In Madagascar, surveys have shown that a wide range of people are positive about insects and willing to establish a formal edible insect sector to supply markets with insect products. However, this would require regulation of the sector to ensure the quality and safety of insect-based food and feed.
- Gryllus madagascariensis larvae develop better on leaves of their natural food source of U. bojeri, but can also be reared on guava leaves (P. guajava), which are more widespread in Madagascar and thus more readily available.
- The isolated nurseries built by small farmers have a good temperature for the production of *Hermetia illucens*, even on colder nights in the cool season. The survival rate of the larvae in the smallholder

rearing rooms was close to the rate under laboratory conditions.

- The low production of larvae by the rather small production unit in the University of Antananarivo's nursery and the high cost of pupae used as strains to start breeding activities result in high production costs. In fact, the production of 1 kg of fresh larvae costs between 13,900 and 25,500 Ariary (approx. 2.84-5.22 Euros/kg).
- According to the developed business plan, the production and marketing of larvae as a breeding strain is considered a profitable activity. In fact, a largely positive Net Present Value (NPV) was observed, a high Internal Rate of Return (IRR) of 114% and a Recovery Time of Invested Capital (DRCI) of 2 years, which means that the invested capital after only two years of activity is restored.
- The development of the cricket farming business plan identified three areas, namely the sale of whole crickets, the sale of cricket powder and the incorporation of cricket powder into agro-food products. The latter remains the best option for creating a sustainable cricket farming business plan, as the consumption of cricket powder and by-products is more appreciated by local consumers.
- Our results show that the red locust (*Nomadacris septemfasciata*) is one of the most protein-rich in Africa (77%). The protein contains all essential amino acids with levels exceeding the FAO/WHO recommendation, with the exception of methionine. In addition, *N. septemfasciata* powder (NSP) contains high amounts of omega-3 fatty acids at 10.8 g/100 g. The iron and zinc content are also high at 9.99 mg/100 g and 21.16 g/100 g, respectively. NSP is also rich in vitamin E, folic acid and vitamin B12.
- *Borocera cajani* and *Bombyx mori* silkworm pupae are also high in protein, with levels of 63.98% and 54.37%, respectively. Both of these types of silkworms are exceptionally rich in omega-3 fatty acids. Linolenic acid (C18:3n-3), an essential fatty acid, accounts for 23.43% and 24.4% of the total lipids of the two species, respectively. In addition, the high iron content of *B. cajani* and *B. mori* of 20.6 and 28.5 mg/g, respectively, makes them ideal candidates for combating anemia, which affects the majority of women and children in Madagascar.
- Our results also demonstrated the feasibility of incorporating insect repellants into two commercial products made from wheat flour: “caca-pigeon” (pigeon droppings), a popular snack, and baguette bread, a common breakfast item. The addition of 10% cricket powder to the traditional recipe of these two foods increases their crude protein and mineral content. The sensory analysis of the enriched products showed that the products with 10% locust powder are highly appreciated. This enrichment also improves the flavor and aroma of these foods, according to the sensory assessment participants.
- Unfortunately, the trials confirmed that the domestication and rearing of giant crickets (*Brachytrupes portentosus*), which are very popular with consumers in Myanmar and are wild-caught, takes too long

	and is therefore not economically worthwhile. ▪ The results show that sun drying of silkworm pupae was microbiologically unsafe, but the process could be improved by adding salt. The sun-dried product with 1% salt was tasty and can be eaten as a snack, whereas the sample with 3% salt tasted too salty but had a good shelf life. ▪ Roasting the silkworm pupae at 200°C for 30 to 35 minutes can be used for preservation, but the high temperature roasting caused a strong smoky flavor that was reduced during storage. ▪ According to the traditional production of shrimp or krill paste (Thai Kapi or Myanmar Ngapi), crickets were fermented and processed into a paste. The ground salted cricket (grille to salt ratio of 10:1, w/w) was sun dried and fermented with inoculum (5% Kapi) for 4 weeks. The fermentation not only preserves the insects, but also creates a unique flavor due to the activity of lactic acid bacteria and halophilic bacteria. In summary, sun drying and fermentation can be used as household-level preservation and processing methods for silkworm pupae and crickets. ▪ Varying the substitution rate of fishmeal with BSF (*Hermetia illucens*) meal had significant effects on the chemical composition and energy value of the experimental feeds for broilers, weight gain, feed intake, feed efficiency and carcass yield of the experimental batches. The results showed a significant increase in slaughter live weight and carcass weight in animals fed a diet enriched with *H. illucens* larvae meal. ▪ Through the activities of the IZNE, manuals on the production and processing of insects as food and feed have been produced. Fact sheets have also been developed and video recordings made. In cooperation with the international partners and experts, both on-site and digital trainings were conducted.
recommendations	▪ The development of trade and the promotion of consumption of edible insects require broad support, awareness raising and involvement of various intersectoral actors. Collaboration is needed to create regulatory frameworks, including eliminating the use of pesticides for locust control and disseminating locally appropriate technologies for locust mass collection, proper processing, marketing, and improved preparation and consumption techniques by those who benefit most. ▪ Despite the steps still to be taken, the production of edible insects such as the black soldier fly shows a promising future for Madagascar. The exploratory study on the BSF business model has shown that the market for black soldier flies is very large and still underdeveloped and that the larvae resulting from production can be used to generate sustainable income. Therefore, given the recommendations, a more in-depth analysis on integrating soldier fly production into a circular economy is needed. ▪ Developing a sustainable and profitable cricket farming business plan in a farm setting still requires improvement plans by optimizing pro-

duction techniques to reduce costs and be able to carry out multiple productions in a year.

- The feeding trial showed that *H. illucens* larvae meal could replace fishmeal or soybean meal in the diet of broilers and layers without any negative impact on performance.
- The enormous potential of edible insects is becoming better known worldwide. Accordingly, research and knowledge exchange are becoming more important. At the same time, it is essential that communication and public relations work reduce inhibitions such as disgust and instead arouse curiosity. This is possible through educational work. Corresponding topics should be considered in further projects. In addition, the principle of learning-by-doing and trying out unconventional ways of working is helpful and purposeful, which is often neglected in research.

photos

Figure 1: Insect rearing house in Sandrandahy (Madagascar). Photo: RAKOTONANTOANDRO Lalaina

Figure 2: Training in rearing of different cricket species in Keng Tung, Myanmar (2019). Photo: Isabelle Hirsch

*Figure 3: Training in rearing Black Soldier Fly (*Hermetia illucens*) in Sandrandahy, Madagascar (2019). Photo: Isabelle Hirsch*

Figure 4: FGD with insect cards, Kengtung (Photo Ingo Wagler)

Figure 5: Palm weevil larvae, one profitable insect in the market (Photo: S. Nischalke)

Figure 6: Small-scale cricket farmer, Thailand (Photo: S. Nischalke)