Stories from the Global Call on Agricultural Innovation

Climate Smart Farm – Integrated Chia and Oyster Mushroom for Sustainable Food Value Chain (CHIAM)

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Kenya

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ABSTRACT

The project develops and demonstrates a climate-smart farming system, which will be created by development of new agricultural technologies and a redesigned network of the existing African agri-food value chain to increase resilience, sustainability, and circularity. The deployment of the integrated chia-mushroom -pig biogas value chain contributes to the diversification and resilience of African food systems against the impacts of climate change.

The cascaded approach helps to create more added values from an area of land by multiplying and subsequent uses of the biomass flow in line with the circular bio economy concept “grow more with less”.

This will promote knowledge exchange and human capital capacity building, with specific emphasis on the development and enhancement of chia and oyster mushrooms value chain development and focus on addressing the fundamental social and economic challenges affecting resource poor farmers in Africa.

TAPipedia Tags

food security, sustainability, innovation, capacity building, climate smart agricultural technologies

Other keywords

Chia, oyster mushrooms, functional foods, food-nutrition security

Context

Chia, Salvia hispanica L., is a traditional food in Central and Southern America that is widely consumed for various health benefits especially in maintaining healthy serum lipid level, contributed by phenolic acid, omega 3 and omega 6 oils present in chia seeds. Oyster mushrooms (Pleurotus spp.) are generally rich in proteins with essential amino acids, physiologically important polysaccharides and essential fatty acids, dietary fibers, important minerals, and some vitamins. Both chia seeds and mushrooms are considered functional foods that provide health benefits beyond the provision of essential nutrients when consumed at efficacious levels as part of a varied diet on a regular basis. Chia seeds are known to be protein-rich with a good balance of essential amino acids making it suitable for malnutrition, particularly protein-energy malnutrition and micronutrient deficiencies, is widespread in rural Africa, exacerbated by reliance on staple foods like refined maize. As demand for functional foods with health benefits rises due to increased public health awareness, the potential of mushrooms—especially oyster mushrooms—as a sustainable, protein-rich food source remains underexplored. While wild mushroom consumption is common in various African communities, the cultivation of mushrooms, particularly oyster mushrooms, is still underdeveloped. Expanding mushroom production could improve the sustainability of small farms and contribute to rural development.

Mushroom production provides a number of opportunities for improving the sustainability of small farming systems and rural development.

Oyster mushroom production is a particularly effective form of bioconversion technology and can be based on a wide range of agricultural by-products. The capability of the oyster mushroom to decompose various agricultural by-products is due to the presence of its lignocellulosic enzymes which help to convert cellulose and lignin into useful carbohydrates such as glucose that can be used as an energy source for the mushroom.

Chia stalk can make such a valuable substrate for mushroom farming. Farmers, therefore, need to be sensitized on the benefits of establishing chia mushroom integrated farming system, and value addition into various functional products. To improve the circularity of the nutrients, especially the carbon, the Spent Mushroom Substrate (SMS) will be used as animal (in the first-place pig) feed. During the mycelia growth and mushroom development, all the cell wall elements of the agricultural residues, such as chia stalks, can be enzymatically degraded to improve in vivo dry matter digestibility, generating polysaccharides, vitamins, and trace elements that can be used to feed animals. Pig manure can be converted into biogas through anaerobic digestion, providing energy for farmers. The by-product of biogas production serves as a soil bio-fertilizer. This innovation increases the value of agricultural land by transforming agricultural by-products into protein-rich food, animal feed, and bioenergy, promoting a circular bioeconomy. It contributes to sustainable and resilient agriculture in Africa.

Oyster Mushroom growing DeKUT

Challenges addressed

- *Population and development dynamics, food and nutrition security, sustainable diets*
- *Climate change and disaster risks*
- *Food loss and waste*
- *Inclusion of the most vulnerable*

Key problem(s)

The overall novelty of the CHIAM project is the holistic approach of the research and innovation activities. The project demonstrates a complex climate-smart solution on small holders' farm-scale to provide evidence to the sustainable food systems embodying qualities that support the six dimensions of food security (productive and prosperous, equitable and inclusive, empowering and respectful, resilient, regenerative, and healthy, and nutritious).

Diversity is the norm in African farming systems. Even at the level of the individual farm unit, farmers typically cultivate 10 or more crops in diverse mixtures that vary across soil type, topographical position, and distance from the household compound (IAC). The further diversification of primary production alone is not enough to increase the stability and the prosperity of the African farming system. (continued below...)

Developed by Miklós Gyalai-Korpos, PhD, Pilze Nagy

Climate Smart Farm – Integrated Chia and Oyster Mushroom for Sustainable Food Value Chain (CHIAM)

Picture taken at DeKUT Chia Demo Farm, Kenya

The CHIAM project innovatively uses chia production by-products to cultivate oyster mushrooms, adding value to agricultural residues. It also introduces a small-scale pasteurization chamber to improve substrate preparation, overcoming current inefficiencies in Africa. The spent mushroom substrate (SMS), typically discarded, is repurposed as protein-rich pig feed, reducing external feed dependency.

The project integrates SMS into a circular farming system for the first time. Additionally, pig manure is turned into biogas through anaerobic digestion, producing renewable energy and reducing methane emissions. This process supports waste management, mitigates climate change, and improves living conditions for 900 million people in Sub-Saharan Africa lacking clean cooking and heating.

The CHIAM project introduces a novel approach by using chia production by-products to cultivate oyster mushrooms, adding value to agricultural residues. While oyster mushrooms typically grow on low-value lignocellulosic agricultural side streams, chia residues had not been explored for this purpose. The project also develops a small-scale pasteurization chamber to improve substrate preparation conditions, addressing the inefficiencies in current low-tech methods used in Africa. After harvesting mushrooms, the spent mushroom substrate (SMS), typically discarded, can be repurposed as a protein-rich complementary feed for pigs, reducing reliance on external feed sources. The CHIAM project is the first to incorporate SMS into a circular farming system.

Additionally, pig manure is processed into biogas through anaerobic digestion, with the digestate used as soil fertilizer. This process not only addresses waste management but also produces renewable energy, reducing reliance on firewood and capturing methane emissions, which helps mitigate climate change. The project's biogas production could improve the lives of 900 million people in Sub-Saharan Africa who lack access to clean cooking and heating, thus enhancing both environmental and public health outcomes.

INNOVATIVE SOLUTIONS

Researchers at Hohenheim University, German. Fortification of Ugali (Kenyan Staple Food) with chia seeds and oyster mushrooms

The CHIAM project will be implemented by an international and intersectoral consortium consisting of four Research Performing Organizations (RPOs) from Africa, two RPOs from Europe, one SME from Africa and one SME from Europe. Partners complement each other and their knowledge ensures their ability to reach the project objectives. Key to achieving the objectives is the promotion of novel ideas and policies for improving the livelihood of resource poor farmers that could improve access to nutritious foods while also creating opportunities for socio-economic empowerment in the home where this has an immediate impact on gender equality thus linking to the achievement of the SDGs.

In order to increase the income of vulnerable groups, there is a need to ensure participation through value chain development. Promotion of chia seeds and oyster mushrooms consumption will improve the health and nutritional status of the communities. The project will target the creation of jobs, increased household income levels, alternative sources of nutrients leading to a shift in market and economical use of land.

Gender equality and women empowerment will be enhanced through women associations improving community nutrition and sustainable land use and return on investment through value addition that in return will promote equity. A project website will be developed and used to link and communicate with each of the participating members. Online blogs, experiences and opinions will be encouraged through open platforms and phone apps used for the purpose of mining more knowledge which will be captured by postgraduate researchers and partners in the consortium.

Analysis will be used to guide decision making in the project. Video conferencing, social media and meetings will help to monitor progress, and, in turn may produce novel and innovative outputs. The partnership will promote knowledge exchange and human capital capacity building, with specific emphasis on the development and enhancement of chia and oyster mushrooms value chain development and focus on addressing the fundamental social and economic challenges affecting resource poor farmers in Kenya.

KEY OUTCOMES AND MEASURABLE IMPACTS

The ultimate beneficiaries of this proposed project are resource-poor farmers, who will benefit from chia and oyster mushrooms value chain development technology and increased capacity to improve their income generating activities. Partner collaborators will benefit through knowledge sharing and established North-South linkages.

Development outcomes that arise from this project will include the increased fortified foods in the market and access to affordable nutritious products for all persons in the communities directly or indirectly involved in the project, and production of renewable energy as a solution to the fight against climate change.

The value chain actors will build sustainable structures for supporting business support services including market development services, access to finance and entrepreneurial skills. By the end of the project, there will be an established mechanism for disseminating best practices through farmer-to-farmer mentoring, and field schools and exhibitions that can be replicated in other sectors and supply chain opportunities.

Ugali fortified with oyster mushroom powder

PLANNED OUTPUTS

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1) Building capacities within communities by forming sustainable management and governance structures that support the training of chia and oyster mushrooms value chain development through proper post-harvest handling and product development and assessment of performance.

2) Postdoctoral and postgraduate research on chia seeds and oyster mushrooms value addition through fortification of local products, product development and waste management.

3) Develop a set of quality control and analytical tests to determine the quality of chia and oyster mushrooms novel products that can be used by households, communities, and organisations to improve nutrition and health.

4) A value chain map for the outputs of the chia and oyster mushrooms production system that can be used to determine potential market opportunities, as well as retained value for smallholders, opportunities for biomass and energy production and mechanisms for soil health improvement.

5) Develop, test and promote new chia and oyster mushrooms fortified products in the market for consumer acceptance.

6) A nutrition survey will be used to evaluate household consumption of chia and oyster mushrooms to determine the nutritional improvement that has taken place in terms of diet compared to the baseline.

7) Dissemination through academic publications; conference papers and peer-reviewed journal articles, flyers, posters, and training materials.

8) Dissemination of the project and best practice in public events including farmers' field days, agricultural shows and also via a short policy document.

9) Dissemination through research informed teaching and learning activities at both universities and development of inter-institutional linkages.

10) Throughout the process, a key outcome will also be improved population nutrition and health and also efficient utilization of agricultural waste for animal feeding, biogas production and soil amendment. Finally, this project will build capacity, knowledge generation and dissemination from the participating universities and identify further food and nutrition security and intervention opportunities for sustainable agriculture.

11) Development of an atlas or GIS map of the main chia and oyster mushrooms growing zones in Kenya.

Factors for Success

DeKUT the project Coordinator has an established chia demo farm that supports research activities and farmers' capacity building. The counterpart Kenyan partner, Keyrio Farm, are growing mushrooms that will be used in this project. The delay in fund release in Kenya has some negative effect on the implementation of planned activities.

Regarding the Hungarian partners, PILZE carried out an assessment of the cultivation and market possibilities of oyster mushroom in Kenya. PILZE designed an automatic substrate production system that can be placed in a standard container and provides high production security based on agricultural by-products of Kenyan small farms. The first version of the research methodology was prepared by BZN who conducted laboratory tests with biomass by-products available in Africa and produced during the cultivation of chia seeds. The results of the tests will be used during the evaluation process of substrate raw materials suitable for oyster mushroom cultivation.

Universität Hohenheim, in Germany started working on the fortification of the most common foods in Kenya with Chia and mushroom. They have characterized the raw materials for bread and ugali fortification establishing measuring methods for the process optimization considering the effects on the structure forming processes.

Algerian Partner, CRSTRA focuses on chia cultivation and chemical characterization. They are gathering useful information on chia seeds cultivation and optimal conditions of production. Six different sites have been s elected from the East (Touggourt, El Outaya, M'Sila) to West (Bechar, Naama, Sidi Belabbas) with different climate conditions which is beneficial to study and determine the effect of these climates on yield, nutritional value, chemical composition and in biological properties of chia seeds. A smart irrigation system has been installed and a doctorate researcher has been engaged to do phytochemical characterization of chia extracts and oils.

CRITICAL CAPACITIES

The dissemination and exploitation of the project's results is one of the key enablers of the success. Though our circular and sustainable food system approach will be presented in two demo locations, our main aim is to increase the resilience of small farms in Kenya and other parts of Africa by spreading the knowledge developed during the project.

All the activities below are formulated based on the characterization of our main target group, the Sub-Saharan Africa smallholder farmer.

Kenyans favor personal communication and interaction, but 90 percent of the population is available in the online space. Based on this, the education, awareness raising and training events will be held in person and the outreach and information via online platforms.

As digital farming is an upcoming trend in Sub-Saharan, we will use the platforms related to this to communicate the project and disseminate findings online, too, where other African partners, Egypt, Morocco, and Algeria will benchmark from. Other target groups of the project are farmers' organizations, feed producer associations and agricultural extension officers. The project is also of interest to research organizations, consumer organizations and the public.

CRITICAL CAPACITIES

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Dissemination and Exploitation

Dissemination and exploitation of the project's results are key to help the transition of the African agriculture to a more resilient and sustainable path. The main elements of dissemination are tools that facilitate direct interactions and knowledge sharing with farmers.

This includes workshops and short courses (training manuals) for universities in Africa and more importantly site visits. At the local level and in an informal way, DeKUT and Keyrio farm will work with communities and accept them at the demo site as capacity building and knowledge exchange.

The findings of the project will be shared with the public, policymakers, and the scientific community through policy papers, popular science articles, peer-reviewed journals, and presentations at local and international conferences. To scale up and replicate the outcomes, a knowledge inventory will be created to capture and analyze the project's results and lessons. This inventory will also ensure that outcomes are properly assigned to target groups, communication channels are established, and intellectual property ownership is clarified.

Communication

The activities aim to raise the project's visibility and facilitate interactions with relevant stakeholders including the engagement of multipliers and future adopters.

Thus, key messages will include how the project and its outcomes impact the everyday activities of the main target group, for example, by diversification of the product portfolio, increasing resilience, improving nutrition, and supplying energy in the form of biogas.

The partners have years of experience with working with the target groups which secures the proper language and networks when formulating messages.

The main communication channels will be the project website, social media platforms (including digital farmers' groups), blogs and newsletters, workshops, and press releases by all partners. Based on the partners' network, direct communication via email will also take place while respecting the data management guidelines of the project.

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Challenges encountered

The Kenyan Partners started the project late due to delayed release of support by the funding body, National Research Fund (NRF). However, the funds were later released, and the project flowed smoothly.

The Investigating Partner from the University of Sultan Moulay Slimane (USMS), Morocco withdrew from the project, but was replaced by another faculty member in the same organization.


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Lessons learned

By promoting sustainable agribusiness models for chia and oyster mushroom products, we can achieve change through value addition linking farmers to markets and food systems. Chia and Oyster mushrooms are regarded as super foods due to the rich profile of macronutrients, micronutrients and functional properties leading to their potential application in a wide spectrum of food products.

The delay in funding for the Coordinating organization, DeKUT, did not affect the project implementation since the lead investigator, Dr. Monica, operates a chia demo farm that became the basis for this project. The CHIAM project was a continuation of a previous chia project, thus it was easy to integrate mushroom farming to the same facility. Dr. Monica, a renowned Scientist continued with farmers' education and project development even without funding. She engaged graduate researchers who carried preliminary work on various aspects along the chia-mushroom value chain.

The Algeria and Morocco partners are benchmarking with Kenya in establishing an integrated chia-oyster mushroom production, with their main activities coming in the second year of the project. Thus, the transition of the Moroccan partner did not affect project implementation. In the South, it was found that by increasing various stakeholders in value chain development, the synergy created enhances income of vulnerable groups.

Promotion of chia seeds and oyster mushrooms consumption improves the health and nutritional status of the African communities. Processing chia agro-waste to organic substrate for mushroom production ensures less environmental impact and also provides a cheap source of animal feeds and soil amendments for crop yield improvement.
This project could positively impact both economic development and social welfare and provide a case study for future projects of this nature in Kenya.

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Links to additional materials

CHIA PROJECT

SCHOLAR

Acknowledgements

Dedan Kimathi University of Technology (DeKUT), Kenya – Expertise Food science and technology, GIS agronomic aspects of chia, pigs rearing, and capacity building of farmers.

Keyrio Farm, Kenya - Expertise in Agricultural Economics and Globalization. Hands on experience in rearing and marketing beef cattle, pigs, poultry, mushrooms, fruits and vegetables. Production and utilization of biogas for small scale farmers.

Universität Hohenheim (UH), Germany – Expertise: Food Science and technology, cereal science, optimization of processes, modelling

Pilze-Nagy Ltd (Pilze), Hungary - Expertise: Applied research of biomass valorization technologies, agricultural waste management, mushroom cultivation, and biogas production

Bay Zoltan Nonprofit Ltd for Applied Research (BZN), Hungary – Expertise: Laboratory analyses, microbial and molecular biological monitoring, feeding experiments, LCA, LCC, S-LCA,

Agricultural Research Center (ARC), Egypt – Expertise: Plant breeding, Molecular biology, Agricultural mobile application

University of Sultan Moulay Slimane (USMS), Morocco – Expertise: Environmental engineering, Microbiology

Centre de Recherche Scientifique et Technique sur les Régions Arides (CRSTRA), Algeria – Expertise: Plant physiology and bioactive molecules, agronomic aspects, GIS and modeling, water management and smart irrigation

THE TROPICAL AGRICULTURE PLATFORM

The Tropical Agriculture Platform (TAP) is a G-20 initiative launched in 2012 to promote agricultural innovation in the tropics. TAP has formed a coalition of more than 50 partners, led by the Food and Agriculture Organization of the United Nations (FAO) and generously supported by the European Union (EU). The main goal of TAP is to strengthen agricultural innovation systems (AIS) in developing countries through coordinated multi-stakeholder interventions.

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Global Call for Agrifood System Innovations and Stories of Capacity Development for Innovation

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