Czech-UNDP Challenge Fund
Milestone Reporting

CZECH REPUBLIC
DEVELOPMENT COOPERATION

UNDP

Project Title: The Use of Mango Stones as a Source of Valuable Fats and Renewable Energy

Milestone number		**4**
Innovator		**Mendel University in Brno**
Local Partner		**Royal University of Agriculture, Kirirom Food Processing**
Project Locations		**Phnom Penh, Takhmao city**
Start date – End Date		**11/2022 – 10/2023**
Funding (total USD)	**UNDP Award**	**Co-Funding**
57 160	**40 000**	**17 160**

SUMMARY

After the first project stage which was mainly about the administration work and communication with Cambodian partner, second, practical part has started.

In March and April 2023 a work travel of Czech experts was realised. The project topics were discussed with representatives of Czech Embassy in Phnom Penh. After that, the project works were done together with both partners, Royal University of Agriculture (RUA) and Kirirom Foof Production l.t.d. (KFP). The mango waste production was quantified, the material samples were collected. The market research was done for identification of machinery available on Cambodian market. Available machines and devices were checked on RUA.

Collected samples of mango waste materials were brought to Czech Republic. The production of briquettes and fuel pellets from the mango pits shells was started. The analysis of mango pit shells and kernels were started in the laboratories of Mendel University in Brno and Czech University of Life Sciences.

Pilot fabrication of products was successful and products were further analysed.

Second work travel was realised during October 2023. Together with partners, the most successful product, mango pit briquettes, was examined and presented to all stakeholders. The final roundtable meeting was realized.

The project team has not faced any problems during this period and the recommendation is to follow the project activities as planned.

BACKGROUND

Cambodia is one of the world's important mango producers. The processing of mango creates processing waste - the mango stone which is woody and of big size. Currently stones are only treated as a waste and in case of bigger fruit processers it performs a problem for local environment. Big dumping sites occupy arable land and pollute the underground water.

The project intents to bring a new renewable source of energy- mango stone pellets. Another product is mango butter with use in food and cosmetic industry. Mango processing industry will be able to increase a profit from its production as it decreases cost of energy sources. It will also positively affect the environment as the usage of fuelwood will decrease. Increase of knowledge and mindset change on waste utilization and circular economy will be intentional side-effect of the project.

The implementer has been active in Cambodia in development and educational projects for over 7 years. It has great and long-term partnership with both project partners – with RUA on projects supported by MFA to improve higher education, with KFP - joint projects and cooperation in mango processing in last 5 years.

MAIN ACTIVITIES AND KEY RESULTS

The following paragraphs describe the activities carried out by the expert team during the project implementation time.

Phase I.:

Activity 1 – Survey on the current mango waste management in Cambodia
The survey was done by search of information online and by communication with two main partner. The results has proved the expectations that the production of mango waste is huge and the processing of it is almost missing.
The activity 1 brought the basic data for further continuation of following activities. The activity continued by its practical part also during following project stages. The results are attached to the report.

Activity 2 – Coordination with local partner, gathering data and desk research
The activity 2 has started by online meeting with two main partners and followed by collecting data online by the Czech side and by collecting data in Cambodia by partners. Both partners performed enthusiasm in their involvement into the project. The cooperation has been intensified during next months, when the implementer did the terrain work in Cambodia.
As it is cross-sectional activity, it continued also during next project stages.

Research and planning phase II.:

Activity 3: Survey on the current mango waste management in Cambodia. Coordination with local partner, gathering data and desk research.

Expert team field survey in Cambodia:

21.3.2023 – Monday, Phnom Phen: presentation of the project to the embassy representatives Ms. Barbora Žáčková.

Meeting and working together with representatives of the partner Royal University of Agriculture in Phnom Penh.

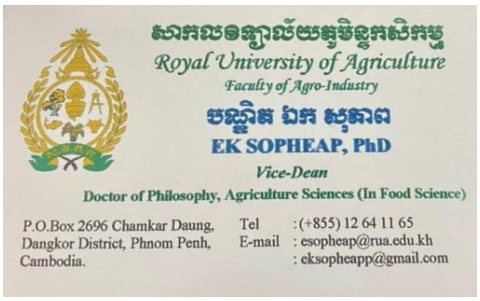

Figure 1 - A tour of university facilities to identify appropriate technologies for collaboration.

Figure 2 - Checking the laboratory equipment

27.3.2023 – Visiting Expo 2023: International Science, Technology and Innovation Exhibition EXPO 2023 in Cambodia:

During the fair, three experts visited relevant partners and discussed the topic of mango processing waste.

An effort Furthermore, technologies for pellet production and pellet incineration were also sought. None of these technologies available in Europe were found at the fair.

Figure 3 - Visiting Czech embassy stand and project partners

27.3.2023 – 30.3.2023 – KIRIROM COMPANY – project partner visit:

Cooperation with a representative of Kirirom: Mr. Holy Meas, Deputy Managing Director

Figure 4 - Meetings in Kirirom company

Kirirom processes: during the field investigation, Kirirom processes were mapped in order to optimize designs for waste recovery and conversion into products which are documented in the pictures below:

Figure 5 - Pits for burning mango seeds

Figure 6 - Drying the mango peel on the sun

Figure 7 - Mango peel grinder

Figure 8 - Grinded chips of mango peel

Figure 9 - Mango peel chips are packed in the plastic bags and transported to the customers

Figure 10 - Seed mango formed by two parts

<u>Implementation phase:</u>

Activity 4: Mango fat extraction and production of briquettes in laboratory conditions

Dried kernels were cut in fragments of 1 cm size in mechanical crusher. Further, the material was pressed in the Czech-made screw press Farmet UNO. The oil were pressed under low temperature.

Figure 112 Pieces of cut mango kernel and oil extraction machine Farmet Uno

The samples of mango pits – the fibrous part- has been brought to Czech Republic The fabrication of fuel briquets and fuel pellets has been started. The details about the fabrication and analysis of products are stated in the attachment.

Mango oil solvent extraction

Kernels from the stone of mango were separated from outer leather by decortications and dried to evaluate the oil content. Mango kernels were crushed into small segments (1-2 mm) by mechanical crusher. The material was used for oil extraction in laboratory conditions using laboratory extracting chamber. The experiment was done twice. First, using hexane and second using ethanol. Both ways performed notable differences. Using hexane, 8,6 % of oil was extracted. Using ethanol, only 3,5 % of oil was extracted.

These results confirm the findings from literature, where hexane is considered as a best solution for the oil extraction.

Briquetting

The mango endocarps were first crushed through **8 mm** screen using a 5.5 kW motor hammer mill (model 9FQ-40C, Pest Control Corporation, s.r.o., Vlčnov, Czech Republic). Briquette production was carried out using a hydraulic piston press BrikStar CS 25 (Briklis, Malšice, Czech Republic). The performance of press 40 – 60kg/h. The diameter of the briquettes was approximately 65 mm.

Dimensions of Briquettes

The dimensions (length and diameter) of 20 representative samples of briquettes were measured using an electronic digital calliper POWERFIX model Z22855F.

Activity 6: Implementation and Analysis: Research results, including proposed design of machinery and procedures for using pressing and pellet machines

Mechanical Durability

The mechanical durability of briquettes produced from the mango endocarps was determined by the use of a Briquette durability drum BT 105. Approximately 2kg of the briquettes were placed into a rotation drum and subjected to crumbling for 5 minutes. The mass of the briquettes was measured before the test and after the test. The durability was then calculated using equation (7).

$$DU = \frac{m_2}{m_1} \times 100 \qquad (6)$$

where:

DU – mechanical durability, (%)

m_1 – mass of briquettes before the test, (g)

m_2 – mass of briquettes after the test, (g)

Combustion Test

The combustion test was carried out using a manual fuel supply combustion device with a fixed combustion grate, like those used in heating houses. The device has a rated thermal output of 8 kW, with an average thermal efficiency of 80% and a standard fuel consumption of 2.5 kg/h based on the manufacturer's specification. The mass flow of the briquette during the tests was approximately 2 kg/h.

Emission concentrations were measured using a Madur GA-60 flue gas analyser (Madur Polska Sp. z o.o., Zgierz, Poland). During the measurement, flue gas temperature was monitored and the concentrations of O_2, CO, NO, and NO_2 in the flue gas were measured by inserting probe to the chimney. The results were automatically recorded after every minute of the combustion process.

Figure 12 Pilot fabrication of mango pit fuel briquettes

More details of the pilot products fabrication contains the feasibility study.

Activity 5: Analysis of mango fat and mango stone pellets to confirm its suitability for use in cosmetic industry

Analysis of mango kernel, mango fat laboratory extraction and mango fat has been started on Faculty of Agronomy on Mendel University in Brno.

The analysis were conducted in accordance with ISO standards in laboratory of the Department of Food Technologies on the Faculty of Agrisciences of Mendel University in Brno headed by Associate Professor Tomáš Gregor, Ph.D. Details are stated in the feasibility study.

Melting pont 41,1 °C

Derivation of fatty acids

Stearic acid: 38,4 %, Palmitic acid: 6,7%, Linoleic acid 5,7 %, Oleic acid: 40,2 %, Arachidic acid: 1,9 %

Saponification value 190,1

Iodine value 49,2

The complex analysis of mango pits (fibrous part) have been done in Laboratories of Biofuels on the Czech University of Life Sciences. The details are stated in the attachment.

Figure 13 Mango pits briquettes and its combustion test

More details of the pilot products fabrication contain the Annex II and the feasibility study.

Activity 7: Finalization of the feasibility study
The feaseibilty study was finalized and presented to stakeholders in October 2023.

Activity 8: Roundtable presentation of the FS to stakeholders and experts
The roundtable presentation and final meeting was realized on October, 20th in Phnom Penh. Results of the project activities and the feasibility study were provided to all stakeholders in Cambodia as UNDP Cambodia Office, Embassy of the Czech Republic, academic institutions, development agencies, fruit processing plants, NGO's etc. Both project partner, Royal University of Agriculture and KFP actively took part of the presentations and discussions. RUA expressed it's will to support creation of centre of excellence, where model technologies will be set up and will serve for transferring know how.

Another partner, Kirirom Food Processing stated it's decision to start the production of mango pit briquettes from it's waste to obtain the source of solid fuel for heating the fruit dehydrators.

Activity 9: Project Closure and Final Report

The project was successfully closed and final report presented

PARTNERSHIP AND SUSTAINABILITY

Main partnerships were established already before the start of the project. Communication and common work with both main partners, Kirirom Food Production ltd. and Royal University of Agriculture, was strengthened during the implementation period.

Both partners showed their full involvement in the project and quite a lot of enthusiasm in their active participation. RUA Has participated in the research part. It expects to benefit with new knowledge to continue research on mango waste. It has a plan to establish a center of excellence which will present also the technologies of mango waste processing. Secondly, KFP will benefit with functional mango stone briquette making process knowledge which will improve its situation with current mango stones dump sites as well as with current usage of unaffordable source of energy. Regarding the calculations, it can reduce the fuelwood consumption by 41,42 % when fabricates mango pits briquettes as a fuel.

During this period one new partnership was established with Czech University of Life Sciences. Due to their grand experience, they were involved in different analysis and fabrication of mango pits pellets and briquets.

KEY CHALLENGES LESSONS LEARNED AND RECOMENDATIONS

Within this reported period, no unexpected challenges occurred.

MEDIA COVERAGE AND PUBLIC OUTREACH

Project results were published by Mendel University in Czech:

https://mendelu.cz/diky-ceskym-vedcum-vznika-v-kambodzi-z-mangovych-pecek-energie/

www.tropicalforestry.cz/undp-kambodza-2023

and in English:

https://mendelu.cz/en/czech-scientists-create-energy-from-mango-pellets-in-cambodia/

Then it was published on Facebook and X of Faculty of Forestry and Wood Technology on Mendel University:

https://www.facebook.com/ldf.mendelu

https://twitter.com/ldf_mendelu?lang=en

And on Facebook of partner Holistic Solutions

https://www.facebook.com/holisticsolution

It has quite wide outreach as many of web news portals took over information published bz MENDELU.

Examples:

https://www.novinky.cz/clanek/veda-skoly-kambodza-muze-nove-topit-mangovymi-peckami-diky-ceske-vede-40450879

https://brnodaily.com/2023/11/15/science/czech-scientists-help-generate-energy-from-mango-pits-in-cambodia/

https://ct24.ceskatelevize.cz/veda/3628586-brikety-muzete-vyrabet-z-mangovych-pecek-radi-brnensti-odbornici-v-kambodzi

https://www.idnes.cz/ekonomika/domaci/brikety-mango-kambodza-mendelova-univerzita-brno.A231114_095336_ekonomika_hyk

https://www.ceskenoviny.cz/zpravy/2440353

https://ekolist.cz/cz/zpravodajstvi/zpravy/z-mangovych-pecek-lze-vyrabet-brikety-radi-brnensti-odbornici-v-kambodzi

https://www.enviweb.cz/rss/331067

https://zemedelec.cz/mangove-pecky-lze-vyuzivat-na-vyrobu-palivovych-briket/

http://www.biospotrebitel.sk/eko-spravy/cl/z-mangovych-pecek-lze-vyrabet-brikety-radi-brnensti-odbornici-v-kambodzi-57214

https://openiazoch.zoznam.sk/priemysel/z-mangovych-kostok-mozno-vyrabat-brikety-radia-brnenski-odbornici-v-kambodzi/

https://www.youtube.com/watch?v=i_Wtp6KX798

PROJECT'S FINANCIAL PERFORMANCE

Please attach original budget sheet and add report current utilization of budget to the email.

Attached

DELIVERABLES AND ANNEXES

Please include (attach to the email or share via online storage) deliverables listed in the Contract.

Please include any additional information such as articles, leaflets, publications, reports and drafts of studies developed during the project implementation.

Please include up to 3 photos relevant to the project implementation relevant for the current milestone.

Annex I: Survey on the current mango waste management

Annex II: Mango seed test

Annex III: Feasibility study

CHECKLIST

☒ *Deliverables described in the Contract included/attached*

☒ *Photos attached*

☒ *Budget sheet attached*

☒ *Invoice attached*

PREPARED BY:

Date: 20.11.2023

Name of the responsible person: Petr Němec

Signature: