Background information

Coconut Oil as Cooking Fuel

Model project
Plant Oil Cooking Stove for developing Countries

presented during the

Workshop „Sustainable Development, natural Fibres for modern Technology, Subsistence and Biodiversity Improvement Projects in the Philippines“

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Background information

PROBLEM

- Traditional cooking

Two of the most important development issues facing the Philippines in the 21st century are the food security and the sustainable and affordable energy supply particularly at the household level.

In 1998, 30 % of the total primary energy used in the Philippines was covered by biomass of which fuelwood and charcoal supplied 56 % and 6 %, respectively. Agricultural wastes like coconut husks, rice husks or maize cobs were accounted for the rest. Only 25 % of the total biomass energy used is donated to the industrial sector whereas the remainder is employed in the residential sector, especially utilized for cooking and water heating.

More than half of the 13 million families in the Philippines live with less than 5000 pesos per month. Among those families in the urban and especially in the rural areas the vast majority fulfills their daily cooking requirements with the traditional cook stoves applying open woodfires.

Those open fires have very low efficiencies of less than 10 %.This results in a consumption of more than 2 tons of firewood for an average family in one year which sums up to a total of more than 38 million cubic meters of fuelwood in the whole country. Due to population growth the number of households utilizing firewood in the Philippines is increasing. However, due to the deforestation the total amount of firewood used is decreasing. According to the lack of wood available the population faces wood shortages in many regions of the country. Hence, collection of firewood becomes increasingly difficult and time-consuming and the families have to pay steadily rising prices for the fuelwood, respectively.

The deforestation has serious ecological consequences like an increased soil erosion. Especially in the Philippines soil erosion is a tremendous problem, since intense tropical rainfalls result in devastating amounts of soil losses and silting-up of coastal regions. In addition, soil fertility is diminished and the natural water cycle is disturbed.

The lack energy due to firewood deficiencies is partly covered by an increased utilization of agricultural wastes. Those crop residues are normally left on the field in order to protect the soil from erosion and remain in the nutrient cycle, respectively.

Next to those ecological problems, cooking on open fires comprises serious health risks for the users. The emissions of those fires include numerous products of incomplete combustion like carbon monoxide, nitrogen oxide, divers hydrocarbons, and suspended particulate matters. The concentration of those components very often exceed the values of health standards by far. For example, during one day an average rural woman is exposed to the quantity of benzo-alpha-pyrene (BAP) which equals to smoking of 450 non-filter cigarettes. The noxious gases cause respiratory diseases like chronic bronchitis and lung or throat cancer. A study for Indonesia revealed that 29% of the deaths of children aged 1 to 4 years were caused by respiratory illnesses due to open fire emissions. This is the second highest death reason following diarrhea which accounts for 37 % of the deaths. Other health effects of open fire emissions include severe eye diseases like blindness.

Workshop „Sustainable Development, natural Fibres for modern Technology, Subsistence and Biodiversity Improvement Projects in the Philippines“

Background information

Existing alternative cooking energies

The currently predominant open fire cooking is desperately in need of improvement or even
-efficient stoves may alleviate the current situation since their
– 40 %. Nevertheless, the fundamental problem of firewood
emand due to population growth remains.

firewood the production of charcoal is very contaminating for the environment and implies a very low efficiency. Therefore, t
one for the open fires.

connected to the national grid. Even though electricity becomes more widespread many

Due to the lack of firewood Liquefied Petroleum Gas (LPG) and kerosene are utilized more

year. In 1995 490 million kg of LPG and 750 million liters of kerosene were used by

national foreign currency reserves. Prices are expected to rise even further in the future s
with a more intensive utilization of fossil fuels, distribution of those fuels is difficult and very expensive especially in remote areas.

Solar cookers were developed as alternatives to the open fires. Some of the low cost solar

Nevertheless, both cooker types can not store energy and can only be operated during periods of hig
operate those solar cookers in the sun during the day, the dissemination of the solar cookers is very much limited in the Philippines in general, since the country counts with extended

CHALLENGE

In order to assure a sustainable cooking energy supply for the Philippine population, the current situation urgently requires exploration of new alternative cooking energies. Utilization
ing fuel presents a very promising alternative im
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economic as well as ecological benefits. Plant oils as cooking fuel secure an independent

At the Ins
University, Stuttgart, Germany, a plant oil cooking stove was developed. This is the first stove existing which can be fueled with pure plant oils. Within the cooperation betwe
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preliminary test of the cooking stove is carried out with coconut oil as fuel.

Background information

Coconut oil is used since it abundantly available in the Philippines. Within the project, a first long-term testing of the stoves within a developing country takes place as well as the suitability of coconut oil as cooking fuel is investigated.

- Plant oil cooking stove

In terms of handling and functioning the new plant oil cooking stoves equals the well-known kerosene pressure stoves. In those stoves pressure is induced in a tank through application of a pump. The liquid evaporates in a vaporizer and emits through a nozzle into a combustion area. The jet rebounds at a rebounding plate, mixes with ambient air and burns in a blue flame. The combustion area is surrounded by a flame holder. The power output is adjusted with a valve regulating the fuel flow. For ignition, a small amount of ethanol is incinerated in a pre-heating dish beneath the vaporizer.

However, kerosene and coconut oil have very distinct physical, chemical, and combustion properties, therefore a completely new development of the cooking stove was necessary. Those property differences are according to the distinct chemical structure of these two liquids. Kerosene consists of hydrocarbon molecules with chain lengths of C_{10} whereas coconut oil comprises of tri-glyceros with predominantly saturated fatty acids. For example, the viscosity of the coconut oil is 20 higher than the value for kerosene. Nevertheless, since the gross calorific value per volume of coconut oil is 33.2 MJ/l and therefore only 4 percent lower than the value for kerosene, the oil can be regarded as suitable substitute. Since the temperature of the coastal areas in the Philippines remains always above 22 °C which is the melting point of coconut oil, the coconut oil can be used as cooking fuel during the entire day.

In preliminary investigations on utilizing plant oils as cooking fuel the stoves by other research groups needed an admixture of at least 50 % of kerosene to the plant oil in order to perform satisfactorily. However, residues of the fuel mixture clogged the vaporizer and left the cookers unusable after short operation time.

The new cooking stove from Hohenheim University, however, allows continuous operation with pure plant oils. The main focus of the investigation were the new design of the burner, especially the vaporizer. Plants oils in general have very elevated flash points, the flash point of coconut oil in particular is at 188 °C, whereas the value for kerosene is at 88 °C only. Therefore, the retention time of the fuel within the vaporizer of the Hohenheim plant oil stove is increased considerably. Moreover, at temperatures around 250 °C, the molecules start to dissociate leaving cracking products at the vaporizer walls which may lead to clogging. The amount of those cracking products formed is considerably higher for the plant oils than for kerosene which is represented by an elevated value for the carbon residue. Therefore, in the Hohenheim design the vaporizer can be released from the cooker frame. Thus, the vaporizer can be cleaned manually with a wire rope.

Like the kerosene stoves, the cooker is started with a small amount of ethanol being incinerated in the pre-heating dish. This flame heats up the vaporizer until operation temperature is reached. Regarding power output and efficiency the plant oil stove is comparable to kerosene stoves. Utilization of coconut oil as fuel, however, prevents users from severe operating risks related to the easy inflammation of kerosene. In addition, the emissions of the plant oil stove are very much lower than the ones for open fires and are within the same range of the kerosene stove emissions. For example, the hydrocarbon emissions of the plant oil stove are 370 times lower than the emissions of an open fire with comparable power output. Likewise, the carbon monoxide and the nitrogen oxides emissions

Biodiversity Improvement Projects in the Philippines“

Background information

of the open fire are 120 times and 15 times higher than t
respectively.

Even though the new plant oil burner can be adapted for existing kerosene stove tanks, a new cooking stove prototype was designed according to the local conditions in the ies of existing stove designs. This stove can be manufactured locally with simple means and available materials at a very competitive price. esign is very robust and assures a stable placement of the woks or the pots ooking process.

Environmental view

Investigation within the current project focuses on coconut oil as fuel, since 300 million coconut trees are planted all over the Philippines. In the last ten year, the Philippines ut oil per year. This production, however, may be reduced in the future since many senile coconut palms are cut down due to a reduced oconut oil. Those plants are not replanted which has serious economical nsequences like a
fuel, however, would give new incentives for replanting and utilizing those coconut trees. Moreover, utiliz tion of coconut oil as cooking fuel will reduce the amount of firewood as well as agricul
the crop residues in the nutrient cycle, respec

The coconut oil is bio degradable and the burning is carbon dioxide neutral since the CO_2 was originally acquired by the plants from the atmosphere through pho
important particularly for the Philippines, since a substantial part of the greenhouse gas emissions are discharge from the biomass stoves at hous hold level.

Sustainability aspects

The coconut oil is produced either by the dry or the wet process. In the dry process, the

refined. In the wet process, the coconut milk is extracted from the grated coconut meat with a

residues. The oil is separated from the residue by filtering. Especially the wet process is utilized even in remote areas at household level, because of its
equipment require
utilizing the plant oil stove.

refined oil is still somewhat higher than the 12.80 pesos for one liter of kerosene. However,

fueled not only with low quality plant oil but also with crude oil which has a much lower price

needed to produce 1 liter of the coconut oil. Regarding the dry process, an average of around 0.65 liters of coconut oil can be extracted from 1 kg of
about 8.50 pesos. Therefore, the total fuel costs per year for coconut oil as cooking fuel are expected to be in the range of kerosene and below the LPG which has a price of 25 pesos nal open fires are higher, especially being used with charcoal.

Background information

The local oil production strengthens the decentralized structures providing employment and income opportunities. Utilization of the plant oil stove assures a sustainable cooking energy supply and will directly increase the living standard for rural population.

Utilization of coconut oil as cooking fuel encloses many other socio-economic benefits for the user which are, among others:

- time and effort associated with firewood collection will be reduced considerably
- utilization of plant oils as fuel secures a long-term and independent heat energy supply for meal preparation and boiling water
- handling of the coconut oil is both simple and free of danger
- plant oils substitute imported fossil fuels like kerosene

The stove itself can be produced locally and can be easily maintained within even rural settings. This provides income opportunities for the local population. The low production costs enable a sale at competitive prices.

- Transferability aspects

Open woodfires are the predominant household cooking stoves in many tropical and subtropical countries cooking. In general, the problems outlined in the first section of the paper are prevalent for numerous regions of the Tropics and Subtropics.

In general, all plant oils liquid at ambient temperatures can be utilized as cooking fuel. The Hohenheim plant oil stove was already tested successfully with Jatropha oil, sunflower oil, rapeseed oil, and palm oil, among others. Moreover, it can be fueled with divers plant oil esters and even with kerosene or diesel fuel if necessary.

Since operation and handling of the plant oil cooking stove is similar to the wide-spread kerosene pressure stoves, it can be easily introduced not only in the other areas of the Philippines, but also in other developing countries. The design of the stove allows easy modification in order to meet local conditions. Even though the prototype is developed as a one-flame cooker it can be easily adopted to a cooking stove with multiple flames. Depending on the required cooking task, the burner can be built in different sizes with distinct power outputs.

CHANCES AND PERSPECTIVES

Utilization of coconut oil as cooking fuel implies numerous ecological, economical as well as sociological advantages. Among others, it will significantly reduce the amount of firewood and kerosene used, respectively. Moreover, it will increase the demand for coconut oil again giving new incentives to intensify the plantings of coconut trees which will prevent further erosion.

The plant oil stove technology will ensure a sustainable cooking energy supply for the local population not only in the urban but also in the rural areas. In the Philippines, the long-term behavior of the plant oil stove utilizing coconut oil as well as further economical evaluation

Background information

according to the test results. The successful completion of this test will allow a broad dissemination of the plant oil st lippines.

The plant oil cooking stove technology is not at all limited to the Philippines but can also be introduced in most tropical or subtropical countries, since the cooking stove can be fueled lant oil mixtures which are liquid at ambient tem

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