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Development of a plant oil pressure stove

Kratzeisen, Martin[a], Elmar Stumpf[b] and Joachim Müller[a]

[a] Institute of Agricultural Engineering 440e, University of Hohenheim, Garbenstrasse 9, 70593 Stuttgart, Germany, Email: martin.kratzeisen@uni-hohenheim.de.
[b] Bosch Siemens Home Appliances BSH GmbH, 81739 München, Germany

Introduction

In rural areas of tropical and subtropical countries wood is still the main energy source. Steadily increasing wood consumption for cooking purposes results in deforestation of large areas. This leads to severe ecological, economical and sociological problems. Today, more than 1 billion people face wood shortages. For those persons the energy for meal preparation is often more expensive than the food itself. Due to this lack of fuel, poor families have to either reduce their expenses for food in order to save money for the fuel or reduce the number of cooked meals per day. These problems lead to an increasing malnutrition.
Cooking on open fires with firewood is often done in poorly ventilated or even closed rooms, which leads to serious health risks for the users. Noxious gases cause eye and lung maladies. In Nigeria for example, more than 95 % of the users of exposed fires complain of eye irritations and more than 50 % suffer from respiratory diseases.
This current situation urgently requires introduction of alternative ways of cooking. Fuel-efficient wood stoves can significantly reduce the firewood consumption but the decrease in consumption will soon be compensated by the fast growing population. Plant oils are a promising alternative energy source offering a variety of economical and ecological advantages. Their utilization as cooking fuel will assure a sustainable energy supply for numerous communities in developing countries and will secure an adequate food preparation.
Therefore at the Institute of Agricultural Engineering of Hohenheim University in cooperation with Bosch-Siemens-Home Appliances GmbH a plant oil pressure stove has been developed. The plant oil pressure stove can be operated with various plant oils.

Plant oil as burning fuel

Replacing traditional biomass by cooking stoves using fossil fuels like gas or kerosene as energy source can economically and ecologically hardly be recommended in developing countries. Moreover, most tropical and subtropical countries are depending on fossil fuel imports. This often burdens the foreign currency reserves to a great extent. Because of the required infrastructure for distribution fossil fuels are expensive especially in remote areas. In addition, fossil fuels are becoming more depleted and prices will rise (Fig. 1). Utilization of plant oils as cooking fuel presents a promising alternative and secures a sustainable and local available cooking energy supply.

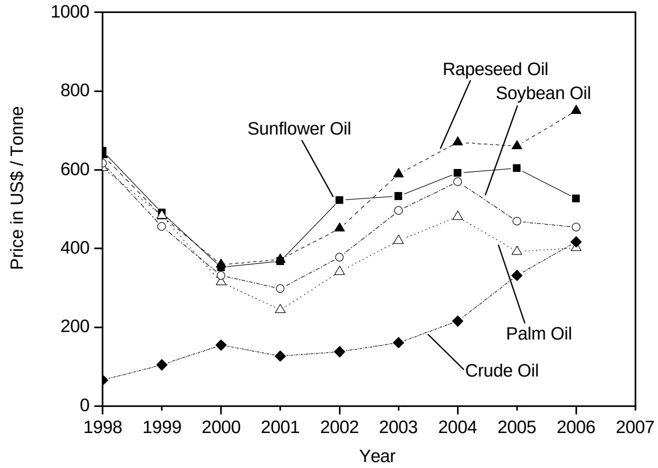

Fig. 1: Price of mineral and plant oil in US$ per ton (Tecson GmbH, 2006, Ista- Mielke GmbH, 2006).

An exceeding variety of oil plants originate in tropical and subtropical climates and a big share of the world plant oil production are coming from countries like Malaysia, Indonesia, China, India and Brazil (Fig. 2). A couple of oil-bearing plants grow on marginal locations, which are unsuitable for food crops while their oils are often toxic. Those plants are often cultivated on waste lands in order to prevent further erosion and inhibit desertification. Energetic utilization of their oils will not compete with food production (Rehm & Espig, 1996). Prominent examples of those oil plants are Jatropha Curcas L. or Ricinus communis L. (Heller, 1996; Peterlowitz, 1995).

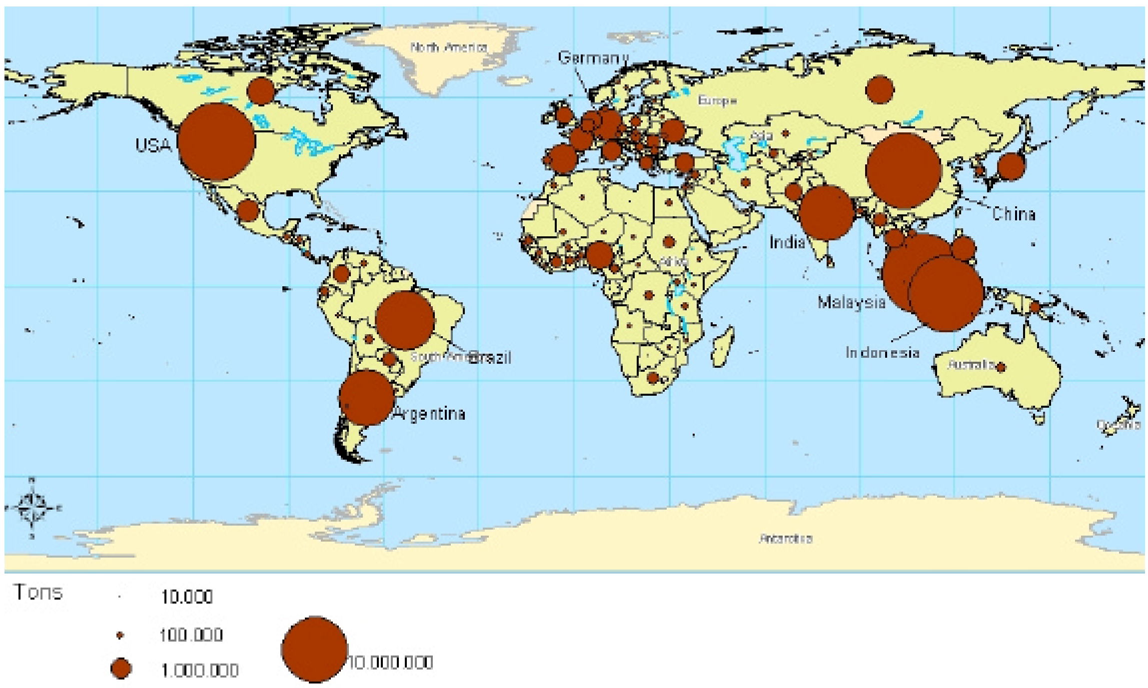

Fig. 2: Plant oil production in tons, 2004 (Weis, 2007).

In contrast to kerosene that consists of hydrocarbon molecules with chain lengths of C10, plant oils consist of tri-glycerol's of fatty acids whose chain lengths range mostly from C12 to C18. Based on those structural differences, the liquids show distinct physical and chemical properties (Tab. 1).

Table 1: Heating value, viscosity and flash point of kerosene, coconut oil, jatropha oil and rapeseed oil.

	Calorific value MJ/l	Viscosity mm^2/s	Flashpoint °C
Kerosene	35.0	1,3	84
Coconut oil	32.3	61	188
Jatropha oil	34.3	48	224
Rapeseed oil	32.1	75	288

Plant oil stove

At the University of Hohenheim a plant oil pressure stove has been developed in cooperation with Bosch-Siemens-Home Appliances GmbH (Stumpf, 2005). Pressure is induced in a tank through application of a pump. The liquid evaporates in a vaporizer made of a stainless steel tube 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 is adjusted with a valve regulating the fuel flow. To start-up, a small amount of ethanol is incinerated in a pre-heating dish beneath the vaporizer (Fig. 3).

Fig. 3: Plant oil stove developed at University of Hohenheim in cooperation with Bosch-Siemens-Home Appliances GmbH, Munich. (© Bosch-Siemens-Home Appliances GmbH, Munich)

Since the operation of the plant oil cooking stove is similar to the kerosene pressure stoves, it can be easily introduced even in rural areas of developing countries. Regarding power output, efficiency, and emissions the plant oil stove is comparable to kerosene stoves. Utilization of plant oils as fuel, however, prevents users from severe operating risks related to the easy inflammation of kerosene.

Comparison of stove types

Different local types of stoves have been compared with the new developed plant oil pressure stove in terms of carbon monoxide emission, cooking performance, fuel cost and investment. In Tab. 2, the stove types are arranged in order of their complexity in terms of technology and fuel supply. Standard assumption was a family with six members preparing three hot meals per day. Economic data were based on prices valid in December 2005 in Baybay (Leyte, Philippines).

Table 2: Carbon monoxide emissions, cooking performance, fuel cost and investment of different types of stoves based on prices in December 2005 in Baybay (Leyte, Philippines).

Type of stove	CO emission ppm	Cooking time h	Fuel cost €/d	Investment €
Wood fire	> 1000	3	0.20	1-3
Kerosene wick stove	> 500	3.5	0.29	5-8
Kerosene pressure stove	210	3	0.24	8-20
Plant oil pressure stove	20	2	0.24	30
Gas stove	160	2	0.25	30-40

Due to incomplete combustion, a wood fire shows the highest carbon monoxide emissions, followed by the kerosene wick stove, where the combustion is also inefficient. Lowest emissions are recorded for the plant oil pressure stove, due complete combustion at a high flame temperature. Cooking time was lowest for the plant oil pressure stove and gas stove, both requiring 2 hours for cooking 3 hot meals per day. For the kerosene wick stove cooking time was longest with 3.5 hours. As fuel wood has to be purchased on the market in Baybay, also fuel cost could be recorded for wood fires that accounted for 0.20 €/d. Fuel cost for the kerosene wick stove (0.29 €/d) was higher than for the kerosene pressure stove (0.24 €/d) because cooking time was shorter due to the higher efficiency. The fuel cost of the plant oil pressure stove was calculated for locally produced coconut oil and was equal to the fuel cost of the kerosene pressure stove, whereas fuel costs of the gas stove (0.25 €/d) was slightly higher. Investment required for the different stove types increased with technological complexity, starting with 1 € for the pan support of a wood fire and ending at 40 € for the plant oil pressure stove or a high quality gas stove.

Conclusions

A pressure cooking stove was developed which can be fuelled by pure plant oils. Only a small amount of ethanol is needed for start-up. The cooker can be operated with various plant oils like rapeseed oil, sunflower oil, coconut oil or the oil of Jatropha curcas. In addition to the novel burner a new and very robust stove prototype was designed which can be build at competitive prices. Utilization of the plant oil cooking stove can produce numerous ecological, economical, and sociological benefits in developing countries. Plant oils are a sustainable energy source ensuring sufficient cooking energy for adequate meal preparation. Introduction of the new plant oil cooking stove can be readily acceptable to people in tropical and sub-tropical countries since its operation is similar to the well-known kerosene stoves.

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