Martin Kratzeisen and Joachim Müller, Hohenheim, Elmar Stumpf, Bretten, as well as Susanne Trojer, Munich

Plant Oil as Fuel for Household Cooking Stoves

In developing countries and countries in transition more than 500 kg firewood per person is used for meal preparation on open cooking stoves annually. Firewood utilization results in uncontrolled deforestation and the problems resulting from it. Increasing prices for mineral oil products like kerosene and gas worsen the situation further. A possible solution is plant oil as an energy source for daily meal preparation. Different qualities of plant oils were tested for their suitability as fuel in a newly developed plant oil stove.

Dipl.-Ing. (FH), M. Eng. Martin Kratzeisen is member of the scientific staff at University of Hohenheim, Institute of Agricultural Engineering, Department Agricultural Engineering in the Tropics and Subtropics (Head: Prof. Dr. J. Müller), Garbenstraße 9, 70599 Stuttgart; e-mail: *martin.kratzeisen@uni-hohenheim.de.*
Dr. Elmar Stumpf is Head of the product management of exhaust hoods of the company Bosch and Siemens Home Appliances GmbH, D-75015 Bretten.
Susanne Trojer is Head of the product management and development of plant oil stoves of the company Bosch and Siemens Home Appliances GmbH, D-81739 München.

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In the majority of developing countries and countries in transition wood is the main energy source for traditional cooking on open fireplaces. The high consumption of fire wood between 500 and 700 kg wood per person and year is also caused by the comparatively low efficiency of those cooking places of 8 to 10 % [1, 2]. This high consumption of wood in combination with the growth of population results in an increasing deforestation, combined with severe ecological consequences as erosion, desertification and flooding. Cooking on open fires often takes place in poor ventilated or even closed rooms. Incomplete combustion of firewood leads to emissions with high concentration of carcinogen substances and causes severe health problems by eye- and lung diseases especially to women and children [3, 4].

Plant oils as fuel

In the tropics and subtropics, there is a variety of oil plants domiciled [5]. In many regions, traditional methods for the extraction of oils exist [6]. At present, plant oils are especially used as edible or technical oils. The production process of plant oils even takes place locally in isolated regions. In doing so especially small to medium-sized, manual and motor driven oil presses were deployed. The rural population is able to create income through the plant oil production. The press cake, accruing in the oil production, can be used as feeding stuff or organic fertilizer. Production and handling of plant oils are harmless because of the biological decomposability. Currently, plant oils are increasingly used in most diverse technical applications in industrial and developing countries. Particularly in rural and suburban areas of tropical and subtropical countries plant oils are also used as fuel for cooking stoves.

The usage of plant oils as cooking fuel is connected with a multiplicity variety of ecological, economical and sanitary advantages for the users, who usually burn wood, plant residues or manure on the open fireplace. Today in developing countries the most frequent used liquid fuel is kerosene.

Compared to kerosene, plant oil has different physical and chemical characteristics, e.g. a higher viscosity, a higher vaporisation- and flashpoint as well as a considerably larger amount of conradson carbon residue. The conradson carbon residue content relates to the formation of residues in plant oil stoves. Table 1 shows the characteristics of various fuels.

Plant oils mainly consist of triglycerides of fatty acids. Fatty acids are aliphatic mono carboxylic acids. Their molecular chains contain between 4 and 24 carbon atoms. Plant oils are being characterized through their constitution of fatty acids. The formation of residues deposited in the vaporizer refers to the chemical decomposition reactions of the plant oils during heating. The precise reaction mechanism of the chemical reaction during heating of plant oil is unknown so far.

Table 1: Properties of different fuels for household cooking stoves

	Calorific value **MJ/l**	Viscosity **mm²/s**	Flashpoint **°C**	**Conradson Carbon Residue %**
Kerosene	35.0	1.3	84	< 0.01
Coconut oil	32.3	61	188	0.27
Jatropha oil	34.3	48	224	0.32
Rapeseed oil	32.1	75	288	0.30

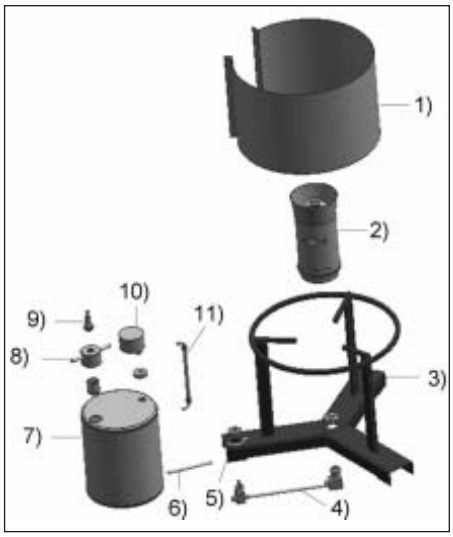

Fig. 1: Plant oil stove "Protos" Bosch und Siemens Haugeräte GmbH; 1) windshield, 2) flame holder with vaporizer inside, 3) frame, 4) oil lining with valve, 5) regulation knob, 6) connecting hose between tank and frame, 7) pressure tank, 8) filter neck, 9) air valve, 10) manometer, 11) oil level indicator

Plant oil stove

The plant oil is stored in a tank and pressurized by a pump. The plant oil runs through a pipe into the vaporizer where transferred into gas phase by the combustion heat. After the gas leaves the nozzle, it mixes with the ambient air to a combustible gas mixture. This mixture comes up against a rebounding plate and there it burns in the flame zone, which is surrounded by a flame holder. To start the plant oil stove (*Fig. 1*), ethanol is burned, which preheats the vaporizer up to operating temperature. The power of the plant oil stove is regulated by a valve.

Table 2: Technical data of the plant oil stove

Fuel:	various plant oils, plant oil esters
Consumption:	in a 4-5 people household, about 2 l oil per week
Performance:	1,6 to 3,8 kW
Efficiency:	30 to 40 %, performance-related
CO_2-balance:	neutral

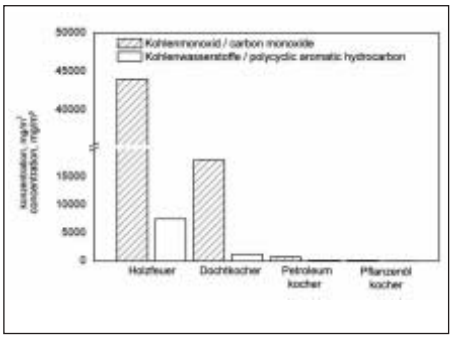

Fig. 2: Comparing emissions of different cooking stoves

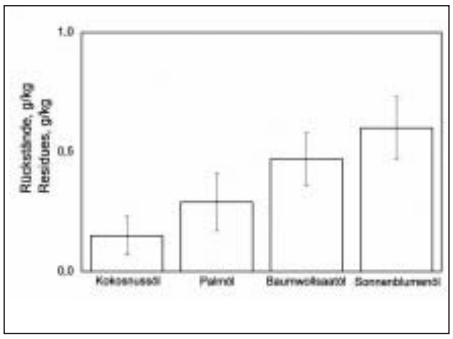

Fig. 3: Deposition of residues in dependence of the plant oil

Cooking with plant oil

Cooking with plant oil is CO_2-neutral since the amount of emitted CO_2 was assimilated by the plant while growing. By substitution of fossil fuels such as kerosene and gas with plant oils, up to one ton of CO_2 per stove and per year can be reduced.

Table 2 shows the technical data of the plant oil stove „Protos" from the company Bosch and Siemens Home Appliances GmbH.

The plant oil stove can be operated with various plant oils and plant oils of different quality. That allows discharging plant oil out of the refining process according to the required quality. This can save production costs of the plant oil fuel.

Figure 2 shows the emissions of various domestic stoves. The high emission values of open fires and wick stoves which partly resulting from incomplete combustion, whereas plant oil stoves showed the least emissions.

The residues emerging during the combustion of plant oils have to be removed periodically. The frequency of cleaning of the vaporizer depends on the used fuel and happens with a hand-held unit. Plant oils which have been filtered rather tend to an increased deposition of residues than refined plant oils. Here the formations of residues refer to the plant oil contents that have been eliminated during the refining process. *Table 2* shows the effect of the refining degree on various parameters of plant oil.

Furthermore differences in deposition of residues are known between the various plant oils such as coconut oil, palm oil, sunflower oil and cotton seed oil. *Figure 3* shows an overview of the investigated oils.

Cotton seed oil (Tansania)	Water-content [mg/kg]	Phosphorus content [mg/kg]	Acid value [mg KOH/g]	Total contamination [mg/kg]	Calcium/ Magnesium [mg/kg]
Unrefined	2210	244.0	12.82	6868	73
Simply refined	145	4.0	0.29	18	6.1
Doubly refined	289	0.5	0.24	74	0.5

Table 3: Plant oil ingredients in dependence of the refining degree using the example of cotton seed oil

Conclusions

The plant oil stove is a simple cooker concerning construction and function. Thereby the danger of a non–acceptance because of technical barriers can be avoided. This is shown by experiences of a two-year-old field test on the Philippines. Diverse plant oils can be burned. This allows plant oil which locally is the cheapest and according to quality it can be used.

The plant oil parameters which also contribute to the formation of residues have to be investigated separately.

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