How many sausages can you grill in the process of making 30g of biochar?

Demonstration of Carbon-negative cooking energy solutions at BayCEER Biochar Symposium 2010 (Bayreuth, Germany) by Christa Roth (FOODandFUEL consultant):

On the 8th July 2010 on the Biochar Symposium 2010 organised by BayCEER (Bayreuther Zentrum für Ökologie und Umweltforschung) at the University in Bayreuth (Germany) the answer was: at least 98 'Nürnberger' sausages in the time span of 40 minutes. That was when the supply of sausages came to an end, though the burner unit still ran for another 25 minutes before it had to be extinguished due to external time constraints.

How the experiment was done:

1 	**2** 
A common 425-ml tin-can served as fuel chamber, which was filled to a level of 70 mm with 200 g of standard 6-mm pinewood pellets. A 10-mm layer of pellets soaked in paraffin (kerosene, lamp-oil) was spread out evenly on top as lighting material and lit from the top with a match to initiate the pyrolysis process of the pellets in the fuel chamber.	After 1 Minute a 850-ml tin-can was slid over the firechamber. It features airholes and a concen-trator disk to thoroughly mix preheated secondary air with the woodgas created by pyrolysis in the firechamber. Thus a clean combustion can be achieved. The flame was strong enough for the grill.
3 	**4** 
In this demonstration the flame of the afterburner was established already well enough after 2 minutes, to accommodate the skillet, a modified pizza-tray, on top.	After one more minute the skillet was hot enough for the first sausages. The start-up phase is considerably shorter than if charcoal would be used as a fuel.

In the duration of 40 Minutes 98 'Nürnberger Rostbratwürstchen' were prepared and served to the participants. Due to lack of stock, the sausage grilling was stopped after 40 minutes and the griddle was removed from the fire to prevent overheating. The flame of the burner continued for another 25 minutes without emitting smoke. It had to be stopped prematurely as it was time to leave the university compound. So the fire was put out and the remaining fuel quenched by putting the tight-fitting can over the top of the can-lid screwed to the bottom of the bucket.

On the next morning the fuel container was emptied and it became apparent that a layer of 15 mm of pellets at the bottom was still in its raw stage and had not been carbonized. This entails, that about 65 mm of the original 80 mm of fuel stack in the fuel container had been carbonised over a period of 65 minutes. This means a downward progression of the flaming pyrolysis front of 1 mm per minute at atmospheric pressure without additional draft.
As the test was aborted prematurely, there was no point in weighing the char yielded in that experiment. In an earlier experiment with identical set-up on the 6th July 55 g of biochar were obtained from 200 g of wood pellets (see photo 6). The burner unit was emitting flames for 80 minutes, which corroborates the burn-rate of that particular fuel of 1 mm fuel-stack per minute.

5 

Results on 8.7.2010 in Bayreuth

6 

Results on 6.7.2010 in Eschborn

The burner-unit was built with own modifications upon inspiration by instructions for the EverythingniceStove by WorldStove. 'Do-it-yourself instructions' on left edge of page on http://worldstove.com/about-2/why-pyrolytic-stoves/, as well as further reading.

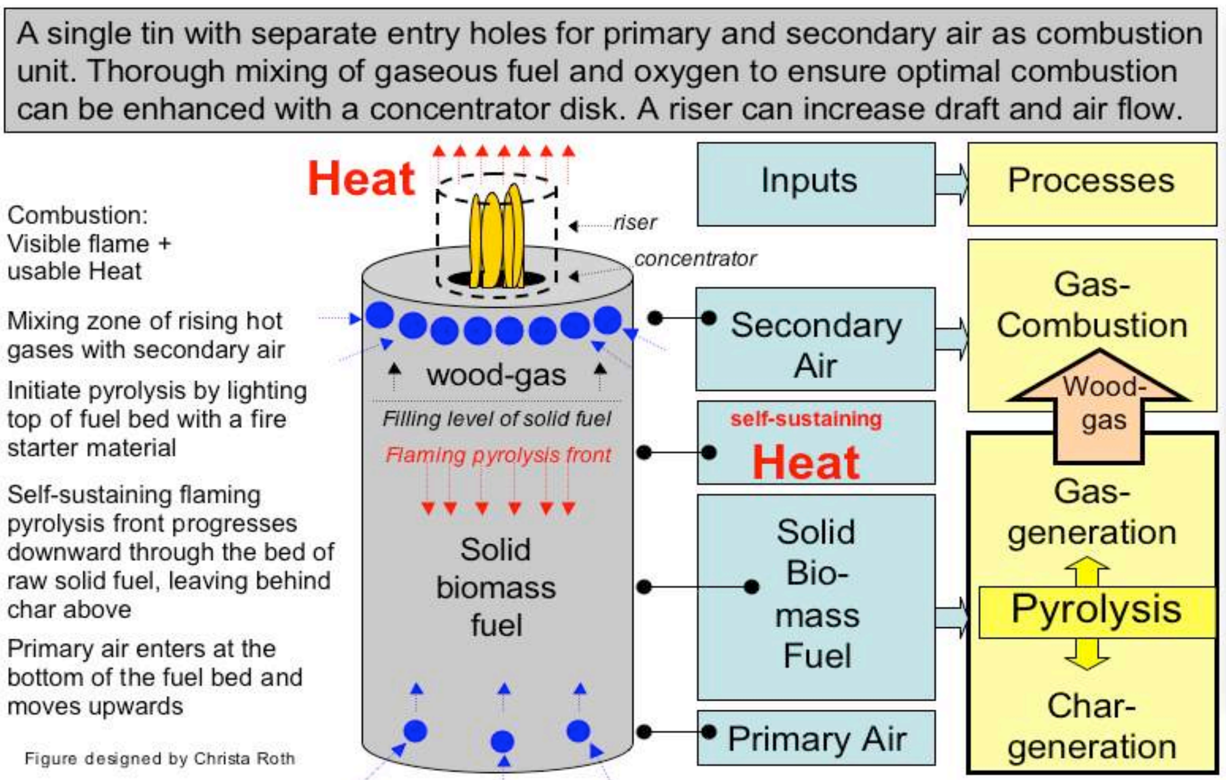
Conclusion: Biochar can be produced with very simple devices as a by-product of a routine cooking-process: over 2 billion people cook their daily food on solid biomass fuels, using mostly inefficient open fire or simple devices with poor combustion and high smoke emissions. Pyrolytic gasifier cook-stoves are currently the cleanest burning devices available to burn biomass under atmospheric conditions. With appropriate air-control the biochar yield can be 20-30 % in weight and 50% in volume of the original raw biomass.

When combusted, the wood-gases obtained in the pyrolytic processes deliver thermal energy, that can be used e.g. for cooking purposes.

Pyrolytic micro-gasifiers can decentrally produce small amounts of biochar, as long as the raw biomass is dry and in suitably sized chunks of ca. 5 to 50 mm. This allows the thermal use of small-size biomass residues from agriculture, forestry or agro-industry, which could otherwise not be used as cooking fuels in conventional cook-stoves. As it makes only limited sense to chop down timber-sized wood to fit into a micro-gasifier fuel container, for so-called 'stick-wood' other efficient cook-stove technologies like rocket stoves are recommended.

Technology: Top-lit up-draft (TLUD) micro-gasifiers are specifically suitable for cooking-purposes, as the combustion of the generated wood-gas happens close-coupled above the gas-generation zone. Thus sequestration or cleaning of the wood-gas can be avoided.
The principle of TLUD micro-gasifiers was first developed by Dr. Tom Reed (USA) and Paal Wendelbo (Norway) in the 1980ies and has since been refined (see figure next page).

Basic design principle of a pyrolytic TLUD gasifier burner



The primary air supply is consumed by the self-sustaining flaming pyrolysis front, preventing the complete conversion of the raw biomass to ash. The oxidation process is limited to the pyrolytic conversion of raw biomass to char and wood-gas. The char remains due to the lack of oxygen for its combustion. The hot wood-gas, containing combustible pyrolytic vapours and gases, rises through the char and can be cleanly combusted if well mixed with an excess of secondary air above the stack of solid fuel.

The flaming pyrolysis front sustains the heat needed for the pyrolysis by partial combustion of the created gases, restricted by the limited amount of available oxygen in the primary air. The front progresses downward through the solid fuel stack, in the case of 6 mm diameter woodpellets about 1 mm per minute. Temperatures reached are between 450 and 800° Celsius. The quality of the biochar highly depends on the temperature and the speed of the conversion process, which is controlled by the available primary air. This can be influenced e.g. by the amount and flow rate of air which is a function of the created draft, either with a chimney or riser for natural draft or a fan/blower for forced convection. When no raw fuel is left to convert, quenching the hot char by cutting off all air supply to avoid the conversion to ash should result ideally in a deep-black biochar. If this biochar is incorporated into the soil and not burnt for energetic purposes, the cooking-process can become carbon-negative.

Outlook: A manual on micro-gasifier cook-stoves is currently being compiled by the German sector programm 'Poverty oriented basic energy services' commissioned to the German Technical Co-operation (GTZ) by the German Ministry for Economic Co-operation and Development. Publication is planned for later in 2010.

Summary: Small-scale biochar production as a by-product of daily cooking with biomass: Pyrolytic micro-gasifier burner units can turn cook-stoves into clean-burning, efficient and carbon-negative thermal energy applications, while alleviating many other problems originating from conventional use of solid biomass cooking fuels like indoor air pollution, black carbon emissions, forest degradation and other environmental issues.

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