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Cooking with Minimum Energy and Protection of Environments and Health

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Abstract

This paper describes the environmental and health impacts of toxic emissions from the energy usage for cooking along with application of simple physics with detailed experimental studies on procedures of reducing "on-stove time" and cooking with minimum Energy (Heat) using a new innovative energy efficient cooking techniques with a simple inexpensive insulation box. The total minimum amount of heat, Q_m, required to cook 1 kg of dry rice, 1 kg of dry beans, 1 kg of raw potato and 1 kg of goat meat using the new technique of cooking with a stove of power 626 + 10 W are found as: 562$\pm$ 3 kJ, 708 $\pm$ 4 kJ, 278 $\pm$ 2 kJ, 716 $\pm$ 4 kJ respectively. The energy savings with the new cooking method is unprecedented. The barest minimum (sensible) heat, h_s required to transform 1 kg of raw food into cooked food of these items are: 440 $\pm$ 3 kJ, 609 $\pm$ 4 kJ, 212 $\pm$ 2 kJ and 626 $\pm$ 4 kJ respectively. Our new cooking method have provided minimum energy for cooking, reduction of emissions of CO_2 and other toxic gases for protection of environment and health.

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Keywords: Sensible heat of transformation; energy efficient cooking; CDM potential, heat insulation box; environment ;health protection and toxic emissions

1. Introduction

Rice, meat, beans and potato are among the most common food items cooked and consumed globally. Rice is a staple food for over half of the world's population, accounting for over 20 percent of global calorie intake with the global rice consumption being expected to be around 500 million tons annually [1] by 2050. The total global consumption of dry beans and baked beans is roughly around $3.5\text{x}10^{10}$ kg annually [2-4]. The total consumption of meat stands at $2.5\text{x}10^{11}$ kg annually [5].

Meat and beans require on the average much more energy for cooking than rice and potato. The recent experiments (see discussion) show that approximately 3 MJ of energy is spent to cook 1 kg of dry rice on the average in controlled cooking (without firewood). Thus the energy used in cooking globally is enormous. Food related energy uses stood at 340 million BTU per person in 2002 [6]. With the current population of 7 billion, at that rate the current annual global energy uses for cooking can be estimated $2.380\text{x}10^{18}$ BTU = $2.519\text{x}10^{21}$ J. Except for the energy generation by solar, nuclear and hydropower, all processes of energy generation from wood and other biomasses, kerosene, coal, natural gas etc. give rise to emission of CO_2 and toxic gasses leading to environmental pollution and health effects. In many countries and villages these items are cooked with heat obtained from wood, coal and kerosene, wasting a lot of energy with emissions of toxic gasses resulting in environmental pollution. With ever increasing demand on available energy sources (petroleum products,

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firewood, coal, etc.), eventually these energy resources will be depleted in the near future. It will then result in scarcity of energy availability [7]. Excessive usages of energy sources have dual effects on our income and environment [8-10]. At most governmental levels energy issues are addressed at producing more energy and making more energy sources available [11], rather than making energy utilization processes more efficient. Wastage of energy more than necessary as per thermodynamic principles gives rise to environmental pollution due to excess greenhouse gas emissions. Such excessive wastages are mostly preventable by making the energy utilization processes energy efficient [12].

In African and part of Asian Countries with growing population, the increasing use of wood fuels (firewood and charcoals) mainly for cooking is giving rise to increased rate of deforestation [13] and environmental pollution due to the toxic emissions. This is mainly due to inefficient methods of cooking used and consequently the demand on firewood is ever increasing. In developing countries, specially, in rural areas 2.5 billion people rely on biomass, such as fuel wood, charcoal, agricultural wastes and animal dung to meet their energy needs for cooking. In many countries these resources account for 90% of household energy consumption OECDEMA [14]. Below we give a brief account of environmental pollution and health affects arising out of cooking.

1.1 Environmental pollution and health effects from cooking in third world (developing) countries

The emissions from different energy sources have been quantified [22]. The acute respiratory infection (ARI) is one of the leading causes of child mortality in the world, accounting for up to 20% of fatalities among children under five, almost all of them in developing countries which is caused by pollution from cooking [15]. This makes solid fuels the second most important environmental cause of disease after contaminated waterborne diseases and the fourth most important cause of overall excess mortality in developing countries after malnutrition, unsafe sex, and waterborne diseases [16]. The environmental insults at early ages can have long lasting influences on human health and productivity [17]. The higher concentrations of total suspended particulates (TSPs) are strongly associated with higher rates of infant mortality; it has been found that a 1% increase in ambient TSPs results in a 0.35% decrease in the fraction of infants surviving to 1 year of age [18].

1.1.1 Wood stove

India, biomass cooking fuels (wood or dung) have been strongly linked to tuberculosis (even after correcting for a range of socioeconomic factors) leading to conclusion that in subjects over 20 years of age 51% of the prevalence of active tuberculosis is attributable to cooking smoke [20-21].

1.1.2 Black, Elemental Carbon (EC)

Exposure to emissions from kerosene stoves within a confined space at elevated temperature may induce narcotic effects such as narcolepsy, cataplexy and confusion [23-24]. If the cooking methods can be made highly energy efficient, then demand on wood and other forms of biomass, coal, kerosene etc. energy sources can be reduced. Based on above discussion about the highly deleterious effects of the emissions arising out of the burning of these energy sources while cooking, minimization of energy uses for cooking can significantly add to the reduction of exposures to toxic emissions from cooking stoves and thus lead to increased protection of our environment and health. The aim of this study is to apply Physics to explore the possibility of finding out a new cooking technique to cook food with the lowest amount of energy so as to lead to considerable savings of energy (fuel) and on-stove-time over the conventional methods used in domestic cooking. With this aim, using an energy efficient cooking method, we find out the on-stove time, t_i, the actual amount of heat, Q_N, minimum heat, Q_m, and sensible heat (the barest minimum heat), h_s required to cook 1 kg of dry beans, 1kg of dry rice, 1 kg of raw meat and 1 kg of raw Irish potato using both the new technique and the conventional method of cooking by pressure cooker. The on-stove-time here is defined as the minimum time the cooking pot needs to be put on stove before being transferred to an insulating box detailed construction of which has been discussed in our earlier work. The data for beans and rice have been published earlier [25-26]. In this paper we published the experimental data on meat and potato quoting the earlier data [25,26] for comparison and discussion. In line with our main aim we also estimate the efficiencies of the cooking method based on the concept of the sensible heat, h_s [25], and possible Clean Development Mechanism (CDM). Potential of the new method of cooking each of the food item and when applied globally for cooking.

2. Materials and Methods

We have described the materials and methods at length in our earlier published works [25,26]. The cooking efficiencies for the items rice, beans, potato and goat meat have been calculated in this work. The cooked food items based on new method of cooking are shown in Figs.1-3. For ensuring same stove power, P_s each time of cooking, same level of kerosene and the wicks are maintained in the stove.

3. Data Analysis