

# In-situ energy and security evaluations of wood stoves in the High Andean region of Ecuador

## Evaluaciones in situ de energía y seguridad de estufas de leña en la región Alto Andina de Ecuador

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#### ABSTRACT:

A plancha stove has been compared to a traditional "grill" stove, additionally the change of room temperature in both kitchens was measured. Only the thermal efficiency of the plancha stove was higher than the one of the grill ( $p < 0.10$ ). The total cooking time was 41% longer for the plancha stove; however, the total mass of meals cooked was 17% greater for the plancha ( $p < 0.10$ ). The safety assessment ranked the plancha and grill stoves into tier 2 and 0 respectively.

**Keywords:** cookstove, biomass, Andean, grill stoves.

#### RESUMEN:

Se ha comparado una estufa a plancha con una estufa tradicional de "parrilla". Solo la eficiencia térmica de la plancha fue superior a la de la parrilla ( $p < 0,10$ ). El tiempo de cocción total fue 41% más largo para la estufa a la plancha; sin embargo, la masa total de comidas cocinadas fue un 17% mayor para la plancha ( $p < 0,10$ ) respectivamente. La evaluación de seguridad clasificó las estufas de plancha y parrilla en el nivel 2 y 0 respectivamente.

**Palabras clave:** Estufa, biomasa, Andino, estufa de parrilla.

## 1. Introduction

About half of the world's population, still rely heavily in the use of biomass for satisfying their energy needs; mainly for cooking and heating (Vaccari, Vitali, & Mazzù, 2012) (Obi, Ezeoha, & Okorie, 2016) (Arora, Jain, & Sachdeva, 2014). Several stove assessments have been conducted for characterizing wood-burning cookstoves using mainly laboratory surveys; however, there have been few studies in-situ on the performance of woodstoves, almost all of these reports conclude that in-field assessments are necessary for observing the real performance of cookstoves (N. MacCarty, Still, & Ogle, 2010) (Lask et al., 2015) (Smith et al., 2007). Additionally, most of fire-related deaths occur within low and middle

income countries(Gallagher, Beard, Clifford, & Watson, 2016). The plancha stove is among the initiatives of improved cooking and quality of life for families in developing countries; it has recently been promoted in Ecuador; however, according to the literature, there is no statistical difference between the efficiency of plancha stoves and open fires(McCracken & Smith, 1998). For the reasons stated before, four standard tests were performed on a plancha stove and on a traditional stove; all the tests were performed in-situ; it should be recognized that performance in the field under varied climatic conditions may be different than performance in the laboratory or predicted by any model; they will be real functioning data(N. A. MacCarty & Bryden, 2015).

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## 2. Methodology

In this research paper, a plancha stove has been compared to a traditional "grill" stove using four tests. The protocols followed corresponded to the four tests carried out, namely the water boiling test (WBT 4.2.3), the biomass stove safety protocol (BSSP 1.0), the controlled cooking test (CCT 2.0) and the kitchen performance test (KPT 2.0) for studying the behavior of both the stoves. All tests were performed in Pucará, an Ecuadorean indigenous community located at 3106 m.a.s.l. Local available eucalyptus fuelwood was used. The thermal measurement was done using three thermohigrometers and an infrared thermometer. Figures 1 and 2, show the tested woodstoves.

**Figure 1**  
Plancha stove



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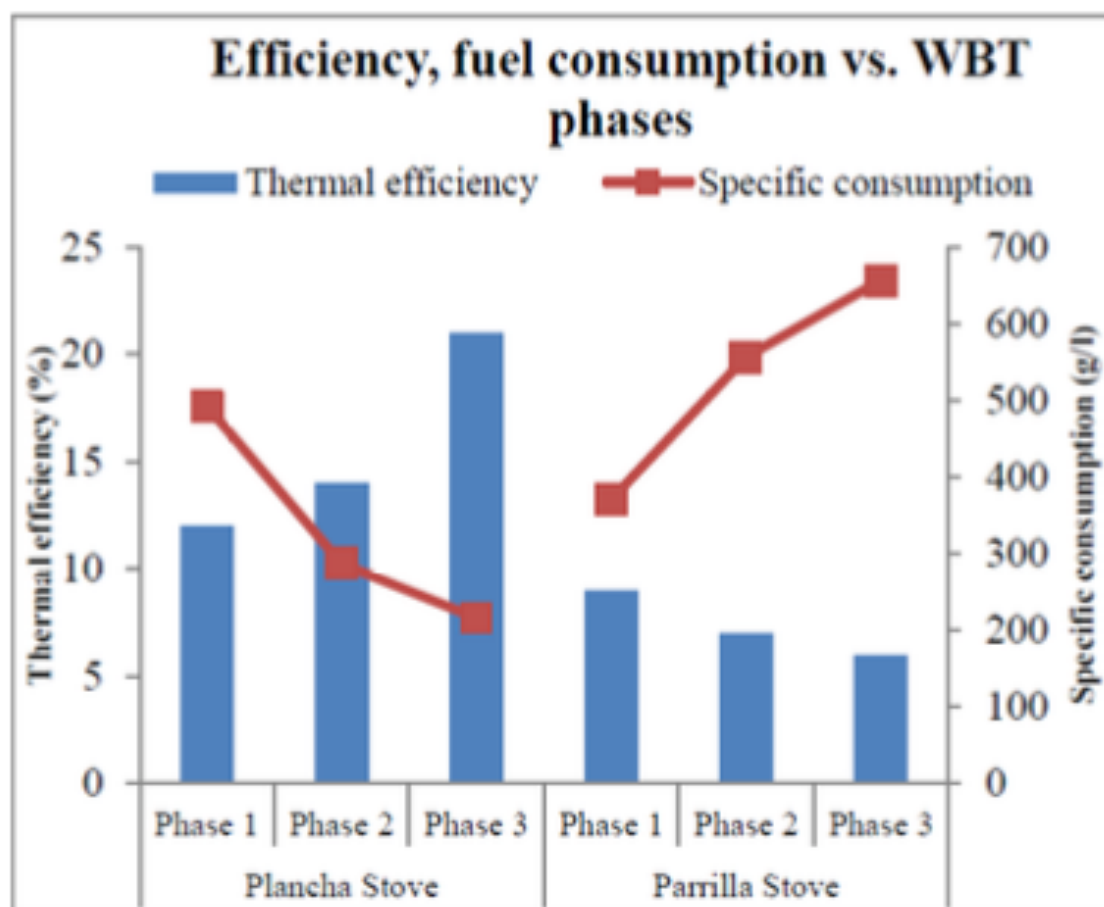
**Figure 2**  
Traditional "grill" stove



### 3. Results

Another research work, where plancha stoves were studied under the same standards, it was concluded that efficiencies of the open fire are higher than the ones of the plancha stove in all the tests's phases(McCracken & Smith, 1998). In this research project, we encourage a redesign of the plancha stove to improve performance metrics, however, the thermal efficiency was higher for the plancha stove in all the test's phases. The effect of altitude on combustion also plays a major role in these results, showed in figure 3.

**Figure 3**  
WBT Results



The recipe used for the controlled cooking test was a local common meal that required several cooking tasks. The results showed no significant difference between the two woodstoves, however, the weight of meals from the plancha stove was significantly higher than from the grill ( $p < 0.10$ ) as shown in figures 4 and 5. The total cooking time was 41% longer for the plancha stove; however, the total mass of meals cooked was 17% greater for the plancha ( $p < 0.10$ ).

A kitchen performance test was performed over three days between two households with similar economic status and number of inhabitants. The results from Table 1 show no significant difference between the woodstoves ( $p < 0.10$ ); however, plancha stove users reported few or no smoke into the kitchen.

**Figure 4**

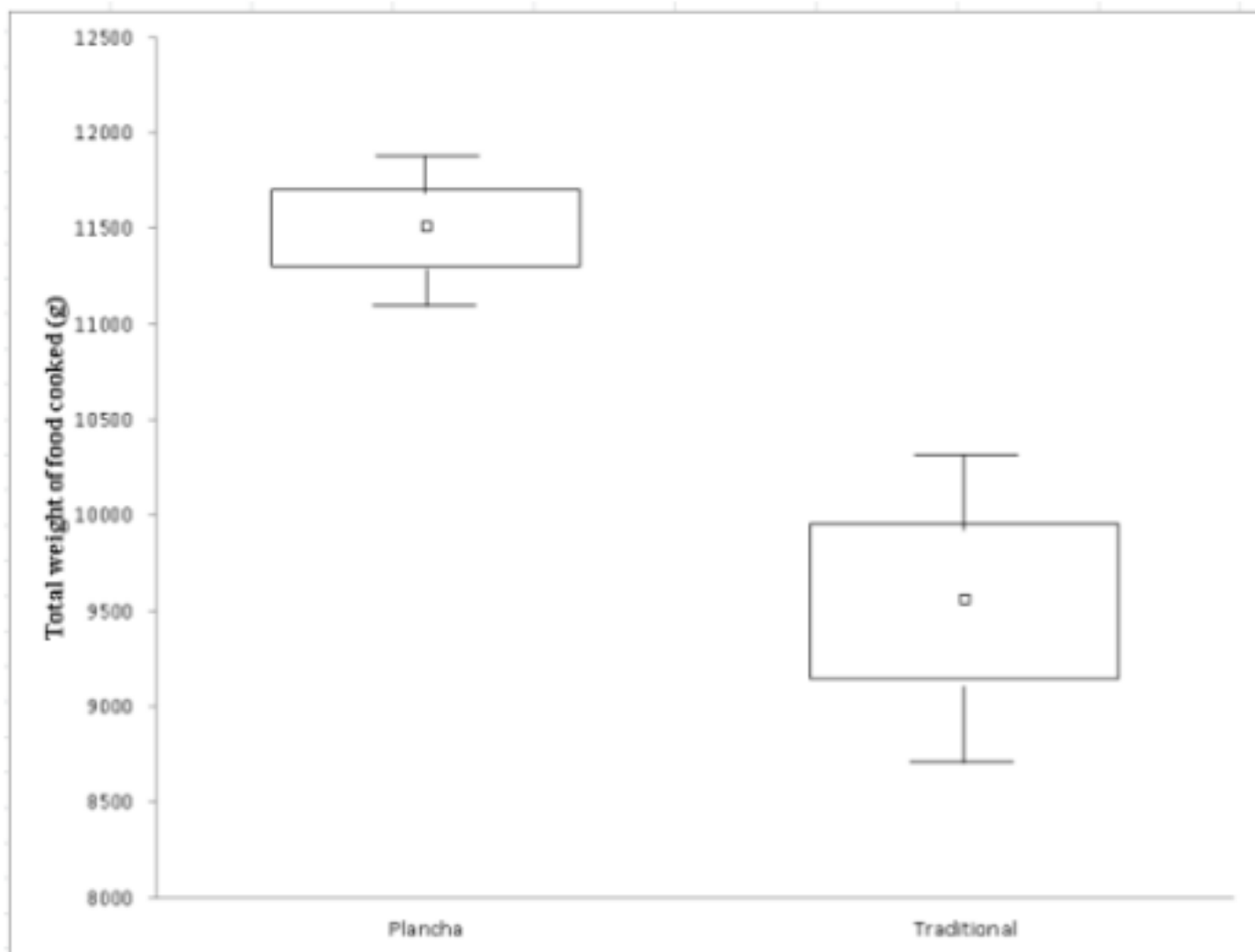
Energy consumption during the cooking tasks



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**Figure 5**

Total weight of cooked meals



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**Table 1**

Results comparison between the plancha and grill households

Results comparison	%difference	Significant 90% of confidence
No. Of adult equivalents	-46%	NO
Wet wood per cap	-27%	NO
Energy per cap. (MJ/cap)	-27%	NO

Even when the average room temperatures are in a comfortable range, plancha's surface temperature was over 250 °C which diminishes its safety. The safety assessment ranked the plancha and grill stoves into tier 2 and 0 respectively.

## 4. Conclusions

Thermal efficiency for the plancha stove was higher than that of the grill, in contrast with the results of other research works. The data obtained in this report are actual operating data obtained through in-situ tests, dealing with ambient and combustion issues. There are significant differences in cooking time (longer for plancha stove) and in the mass of cooked food (larger for plancha stove).

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