Rice husk – an alternative fuel in Perú

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Introduction

This study investigates the usefulness of rice husk as an alternative fuel for household energy. The work included an analysis of the production of rice in Perú, visits to the productive zones, evaluation of rice husk, development and test of rice husk briquettes and the stoves that use them as fuel.

Rice husk in Perú

Currently, in Perú, the use of the agricultural wastes as fuel is limited and inefficient. In 1999 a study was implemented to identify those agricultural wastes with the most useful energy potential within Perú; rice husk, black coffee husk and cotton stalks were found to be best. This conclusion was reached through a study of the fraction of the wastes produced, and where they had been produced in the previous seven years. Other factors included the distance between the users and the point of waste generation, the economic and environmental advantages and disadvantages of its elimination, the use of the waste in non-power applications, and the registered worldwide experience of its use.

The species of rice that is cultivated in the Perú is *oryza sativa*. Between 1992 to 2001, production reached 1900 kilotonnes per year, as shown in Figure 1. Rice is processed in 471 mills, and 70% of them are located in the north of the country. The rice husk generated in the milling process represents about 20% of the rice casing. At present, only 5% of the rice husk is used as a fuel – in brick manufacture in Piura – the rest is burned or thrown into the river.

An analysis of the rice husk produced in northern Perú show that volatiles comprise nearly 60% of the total residue mass, with carbon accounting for over 30% (Table 1).

Maximum calorific values are similar to wood and other agricultural wastes. However, the low density of the husk makes it difficult to store and increases the cost of transportation.

Around 380 000 tonnes per year of rice husk are produced, which could provide 120 000 TOE (tonnes oil equivalent) per year of available energy. Of this, 60 % is very accessible because of its concentration and its proximity to local markets.

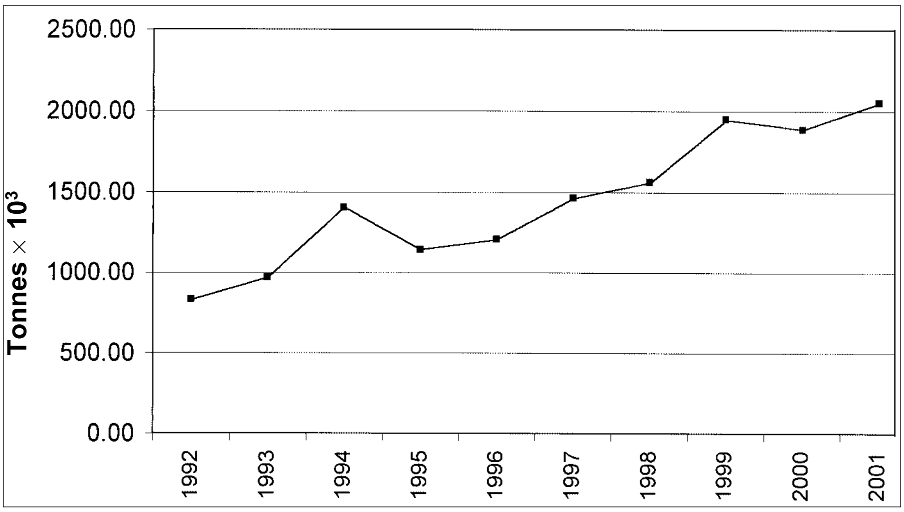

Figure 1 Rice production in Perú

Rice husk briquettes

Briquetting is a technology which uses either a dry or a wet process to compress rice husks into different shapes. The dry briquetting process requires high pressure and does not use a binder. This process is expensive and recommended only for high production levels. On the other hand, using a wet process allows lower pressure equipment, but a binder must be used.

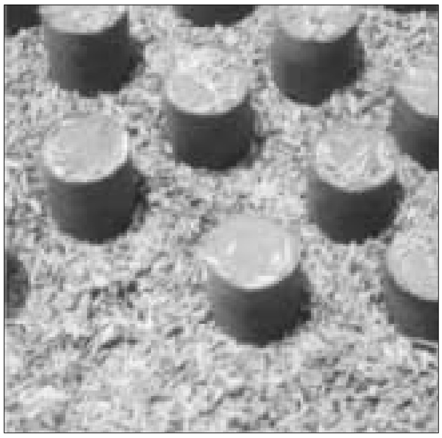

Figure 2 Rice husk briquettes

In this project, cylindrical briquettes were made using mechanical compression and including a binder in the mix (Figure 2). The mixture comprised well-rotted husk with a binder of clay, bentonite or yucca starch. The use of a binder allowed lower pressures to be used. The briquettes could be made in small quantities, and the skills needed to operate the equipment were easy to learn. In addition, the binders selected are available in the market, are not expensive and provide a strong bond.

The rice was ground to a fine powder in a hammer mill, then the binder and water were mixed with the rice husk to form a paste, which was put into a briquetting machine. Finally ‘the briquette’ was dried to reduce the humidity. This could be done either directly in the sun or in electrical drier. The pilot briquetting plant at the PUCP used a hammer mill, a vibratory sieve, a manual press machine and an electrical drier. Its production capacity is about 30 kg per hour.

The physical and thermal characteristics of rice husk briquettes are presented in Table 2.

Combustion efficiency is an important characteristic as it express the quality of combustion. It is calculated as the total burnt material (initial weight – weight of ash left) divided by the theoretical maximum of combustible material (Eq.1 and Eq. 2). The results are given in Table 2.

Table 1 Analysis of rice husks

	Mass	Dry
Carbon (%)	34.61	38.43
Hydrogen (%)	3.79	2.97
Nitrogen (%)	0.44	0.49
Oxygen(%)	41.58	36.36
Sulphur (%)	0.06	0.07
Volatile matter (%)	55.54	61.68
Fixed carbon (%)	14.99	16.65
Ash (%)	19.52	21.68
Humidity (%)	9.95	0.00
Calorific value (kJ/kg)	13 800	15 324

$$\eta_{\text{combination}} = \frac{m_i - m_f}{m_{cb}} \quad \text{Eq. 1}$$

$$m_{cb} = \left[m_{rice}(1 - \%ash)\right] + \left[m_{yucca}(1 - \%ash\right] \quad \text{Eq. 2}$$

Briquetting the residues improves their burning characteristics and also produces fuel pieces that are similar in size and weight. At the same time, problems of dust are reduced during handling, transportation and combustion and handling and storage problems are alleviated.

Cost of briquetting

The technical study on rice husk briquettes has been completed, and work is now being done on the economical aspects. Although the final production costs, and selling price are not yet determined, indicative manufacturing costs are given below.

Item	Cost/Quantity
Plant production	30 Tonnes/month
Capital investment (approximately)	US$10,000
Fixed cost for maintenance and operation	US$1550 per month

The plant is mainly manually operated, to create employment in rural areas. Based on the above mentioned fixed operating costs, which would include the cost of employing six people each working an eight hour per day, the manufacturing cost for the briquettes is US$50 per tonne. This assumes that capital was available for the equipment and no depreciation on the machinery.

Rice husk stoves

Using information from the International Rice Research Institute in Philippines (IRRI), some models of rice husk stoves have been developed that use rice husk and rice husk briquettes as a fuel.

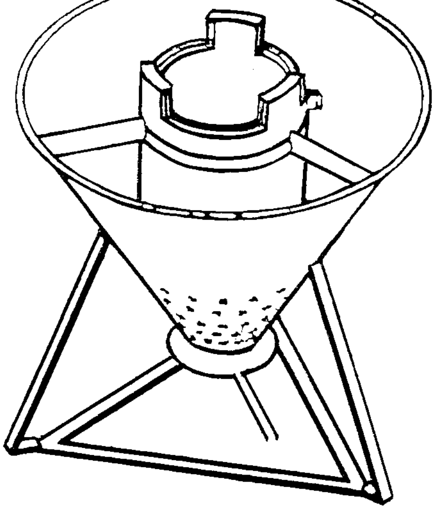

Figure 3 The Voila 2 stove

In 2001 the Voila 1 rice husk was built, similar to RHS-STD-001 IRRI stove. A further development, the Voila 2 rice husk stove (based on the Voila 1), consists of an open cone made of cast iron, with holes at the bottom, and an ash tray under it (Figure 3). A cylindrical flame guide, made of a refractory material, is placed into the cone. Pots are supported on the stove on three ledges welded onto the wall of the cylinder. To light the stove crumpled paper is placed at the ashport before filling with husks.

In operation, the flames and gases first heat the base of the pot and then the walls. Table 3 presents the main characteristics of the stove.

Stove testing

The testing procedures developed are in accordance with the International Standards for Testing of Woodburning Cookstoves. The efficiency of stove is defined as the ratio of the energy transferred to the water, divided by the energy liberated by the burning fuel. For the Voila 2 stove, the efficiency was found to be 20%.

Table 2 Technical characteristics of rice husk briquettes

	Briquette code	BR1	BR3	BR7	BR8	BR10	BR12
Composition	Rice husk(%)	100	70	70	60	85	85
	Clay (%)	0	0	10	0	15	15
	Bentonite (%)	0	20	0	40	0	0
	Yucca starch (%)	0	10	20	0	0	0
Shape		Cylindrical					
Diameter (mm)		40	40	40	40	40	50
Height (mm)		40	40	40	40	40	40
Pressure (PSIG)		6430	3570	5000	3570	5000	8000
Bulk density (kg/m3)		562	803	667	965.5	800	760
Time of ignition (min)		8	18	8.5	18	10	12
Max. calorific value (MJ/kg)		13 800	8280	13 000	13 000	11 730	11 730
Combustion efficiency (%)		97	94	91	80	97	98

Table 3 Voila 2 – a rice stove model

Dimensions	Diameter = 505 mm High = 520 mm
Weight (kg)	12.4
Materials	Iron and clay
Fuel	Rice husk