2 Comparative Analysis of Brazilian Residual Biomass for Pellet Production

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2.1 Introduction

Brazil is an important producer and the largest exporter of sugar, ethanol, coffee, orange juice, and tobacco. The country's availability of land, water and labour has allowed for increased production and exports. Continuing the trade expansion and diversification of markets and products remain at the core of Brazil's agricultural growth strategy (Valdez et al. 2006). The increase in crops generates a biomass residue surplus. It is known that approximately 30% of the sugar cane production is bagasse (Rosillo-Calle et al. 2007) and 22% of rice is constituted of husks (Eriksson and Prior 1990). This residual biomass can be transformed into a valuable fuel, becoming an important local energy source. There are several conversion technologies for biomass, based on the type, available residues and the market demand. Pressing of residues increases storage and transport efficiency. Pellets, briquettes, or any other pressed form can be used as a fuel. Recent research shows different combustion technologies for biomass: gasification, pyrolysis and combined heat and power (Rosillo-Calle et al. 2007).

In Germany, Austria and Scandinavian countries, the compressed biomass, mostly wood pellets, is widely used for household heating. Moreover, the conversion of pellets into electricity has also been studied in decentralized power plants (Thek and Obernberger 2002). In Brazil, where heating is not necessary due to a tropical climate, the demanded product of biomass conversion is electricity. Here hydropower accounts for approximately 77% of the energy supply (Ministério de Minas e Energia 2008). Nevertheless, it has been documented that Brazil's annual production of sugar cane bagasse can supply inhabitants with as much electricity

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as Brazil's largest hydropower plant Itaipú (Ministério de Minas e Energia 2008). Other kinds of residue, like wood saw dust and coffee husks, also have a great potential, either for covering the local energy demand or for export in form of pellets.

The aim of this work is to study and evaluate the implementation of pellet production using residues like rice husks and sugar cane bagasse for energy generation in Brazil. Some properties of residual biomass were analysed at the Brandenburg University of Technology (BTU) in Cottbus, Germany. The first parameters investigated were moisture, ash content, calorific value, and ash melting point. The analysis helped the authors to determine optimal pellet mixtures of different raw biomasses with their best characteristics. Besides, the resulting blends were also based on the geographical and agricultural aspects of the crops. The conversion of biomass into pellets and pellets into energy could be applied for Brazilian biomass. This potential should foster research towards new power plant technologies for decentralized energy generation. Furthermore, the socio-economic feasibility of pellet production should be taken into consideration.

2.2 Situation Description

In Brazil, agricultural production is located within the humid and warm semitropical latitudes of the South and Centre-West regions (Figure 2.1). The urban centres, as well as the good access to the main ports, facilitate the access to markets for producers (Schnepf et al. 2001). The Federal State of Rio Grande do Sul is the core of irrigated crop acreage and produces an important share of Brazil's rice. The Federal State of Minas Gerais is the leading producer of coffee. The main sugar cane production is located on the Federal State of São Paulo, which has modern industrial technology and the lowest production costs. Besides that, sugar cane crops are closer to consumers, to research centres, and to the ethanol machinery sector. During the last five years, ethanol production has been growing and exports increasing. According to the Instituto Brasileiro de Geografia e Estatística, the yield of 2007 was of approximately 550 million tonnes of sugar cane, of which around half was used for ethanol production (15.3 billion of litres). In 2007, there were 70,000 farmers planting sugar cane all over Brazil and 393 ethanol plants, distributed mainly to the Centre-south region (IICA 2007).

The fast-growing tree species *Eucalyptus sp.*, originally an Australian plant, occurs all over Brazil's geographical regions (Müller et al. 2005). Most of the post-lignite mining areas are reforested with this tree species. Opposing the current environmental policy in Brazil, areas where native vegetation was illegally exploited have been recovered with *Eucalyptus sp.* monoculture (Müller et al. 2005). *Eucalyptus sp.* wood is mostly employed in the paper industry, as charcoal in the pig iron furnaces and broadly used for carpentry.

Fig. 2.1. Map of Brazil showing the regions Minas Gerais, Sao Paulo and Rio Grande do Sul which are respectively leading coffee, sugar cane and rice production (Source: www.limasolucoes.com.br/images/mapaBrasil.gif)

2.3 Materials and Methods

Four types of Brazilian biomass - rice and coffee husks, sugar cane bagasse and sawdust from *Eucalyptus sp.* wood - were investigated. The residues were collected in the Federal State of Minas Gerais, where the Federal University of Viçosa, a partner university, is located. The coffee husks were from a large-scale farm located in the region called Zona da Mata. Rice husks and sugar cane bagasse were also collected in the same region, although from small-scale agriculture. The local furniture and carpentry industry uses mostly *Eucalyptus sp.* wood, producing a high quantity of sawdust, which was also used in the experiments. The research consisted of three steps:

- Collection, drying and transporting of samples
- Analysis of biomass properties
- Pelleting

During the months of May and June, the residues were collected, stored and dried in order to decrease moisture content and avoid decomposition. Thereafter, the samples were packed and transported to Germany with a moisture content value of approximately 13%. The analysis of the transported material was carried out in August at the BTU Cottbus. This investigation covered some chemical-physical aspects, such as: moisture content, ash content, heating value and ash melting point. These preliminary results are important to characterize the efficiency of the pellets as a fuel. Although the elementary analysis and the emission analysis of CO_2, SO_2, NOx and dust are not included here, further investigations are planned.

Thereafter, the agglomeration properties of the residues have been investigated by pellet formation. The pelleting process was performed with the Laborkompaktor Bepex L 200 / 50 G + K compressor producing approximately 20 kg of pellets per hour. This was carried out after crushing and moistening (17.5%) the material.

The initial task was to verify the feasibility of converting the above mentioned residues into pellets.

2.4 Results and Discussion

The results presented in this paper are part of an extensive research process, analyzing the viability of pelleting Brazilian biomass. Since some experiments are still in process, we described the preliminary properties of the residues. The water content analysis of the studied biomass was used to determine the processing feasibility of the material. After the harvest, the biomass moisture varied from 14 to 16%. Such high moisture content can cause the decomposition of the material and increase the transport costs. Hence, reducing the water content of the biomass was a necessary step before pelleting. In Brazil, drying the residues was done with minimum costs, due to the availability of space and workforce. However, processing biomass with high moisture could be a time, energy and money consuming activity. The biomass was exposed to air and constantly revolved for approximately six weeks during the dry season. The material could be then transported with a moisture value of maximum 13%. Figure 2.2 shows the moisture content for different types of residues. Coffee husks and saw wood had satisfactory moisture values after the drying period. Sugar cane bagasse presented the lowest value despite its high juice content. Considering that bagasse and rice husks presented moisture content varying from 7 and 9% respectively, this biomass would need a shorter drying period.

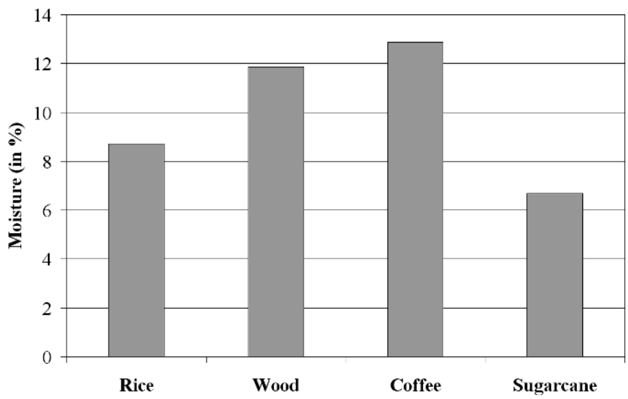

Fig. 2.2. Moisture content for different types of residues

The percentage of ash formed by the combustion process related to the total water free weight of the used material and is a relevant parameter for determining the pellet mixtures. As shown in Figure 2.3, rice husks presented high ash content. This hinders the economic feasibility of the fuel, due to the high costs of removing and transporting the ashes. Nevertheless, the development of a blend using lower quantities of this material could be feasible.

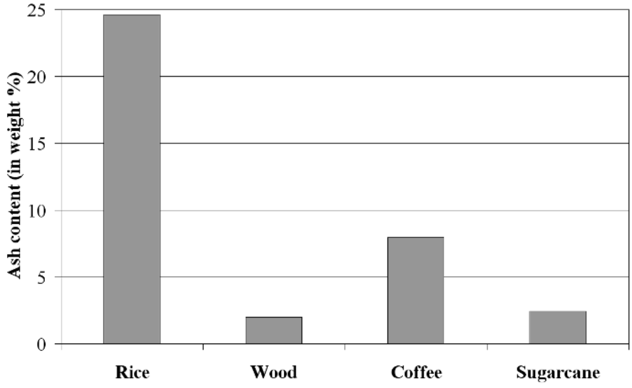

Fig. 2.3. Ash content (water free) for different types of residues

The lower heating value shown in Figure 2.4 was used to define how much energy is generated per amount of dried biomass. Rice husks presented the lowest heating value. This was due not only to its high ash content (Figure 2.3), but also due to its low quantity of elementary carbon (36.5%) and hydrogen (6.3%) compared to the other biomass. In contrast, *Eucalyptus sp.* wood presented the best heating value. This was due to its low ash content (Figure 2.3) and high quantity of elementary carbon (46.9%) and hydrogen (8.1%) in water free conditions.

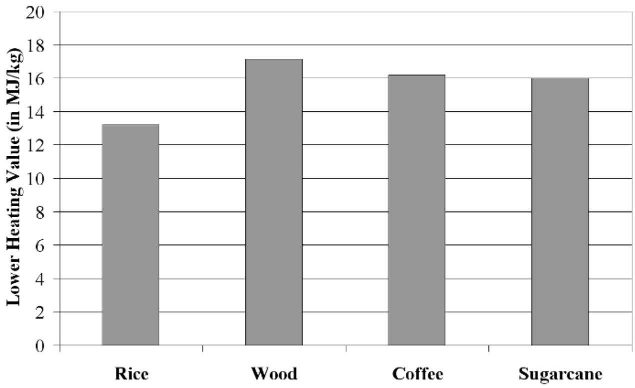

Fig. 2.4. Lower heating value for different types of residues

The ash melting point has a direct effect on the slag formation. Furthermore, the melting of ashes at low temperatures may cause corrosion in the furnaces. As shown in Figure 2.5, rice husks have a comparably low ash melting point. This allied to its high ash content limited the use of this residue in the biomass mixtures.

On the other hand, sugar cane bagasse, sawdust and coffee husks presented satisfactory ash melting points. This enables the use of these biomass types as main components in the pellet mixtures (Table 2.1).

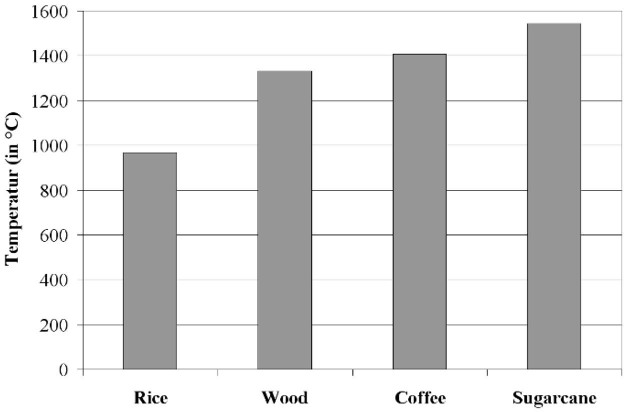

Fig. 2.5. Ash melting point

The broad geographical occurrence of *Eucalyptus sp.* and its outstanding properties would allow this species to be used as main component in the pellet mix. However, its poor agglomeration characteristics limited the use of sawdust in the mixtures to a maximum of 40%. Moreover, rice husks could not be compressed at all due to the limitations of the available devices and due to its unsatisfactory ash content and melting point.

Table 2.1. Brazilian pellet biomass mixtures

Material	Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
Sugar cane	80%	60%	-	-	50%
Coffee husks	-	-	80%	60%	50%
Eucalyptus sp. saw dust	20%	40%	20%	40%	-
Rice husks	-	-	-	-	-

Sugar cane bagasse can be used as main component in the pellet blends due to its outstanding ash melting point and satisfactory heating value, however the location of the crops should be taken into consideration. Mostly, sugar cane grows near to coffee plantations and to *Eucalyptus sp.* trees, but not to rice. Furthermore, sugar cane bagasse and coffee husks have compatible physical-chemical properties. This allows the production of a 50/50% coffee-sugar blend pellet with suitable physical properties and crop logistics.

2.5 Conclusions

Although the resulting pellets presented technical and physical- chemical limitations, improvement of both processing and physical properties is possible. For example, the percentage of *Eucalyptus sp.* sawdust weight could be increased in the pellet blends using an industrial scale machine. However, conversion of residues into pellets as well possible utilisation methods are also dependent on the purpose for using the mentioned goods. Sugar cane bagasse pellets combined with the application of new technologies for its combustion in decentralized energy systems could be one alternative. On the other hand, unprocessed bagasse could be efficiently used in a combined system for heating and power generation. Considering the increasing production of sugar cane, another option is the export of surplus pellets. All the alternatives mentioned could be applied, supporting local economies by generating jobs and opening new markets. Nevertheless, it is up to the society to accept the viable technologies, adapting them to the existing socio-economic and environmental conditions. These are issues to be further investigated in socio-economic feasibility studies.

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