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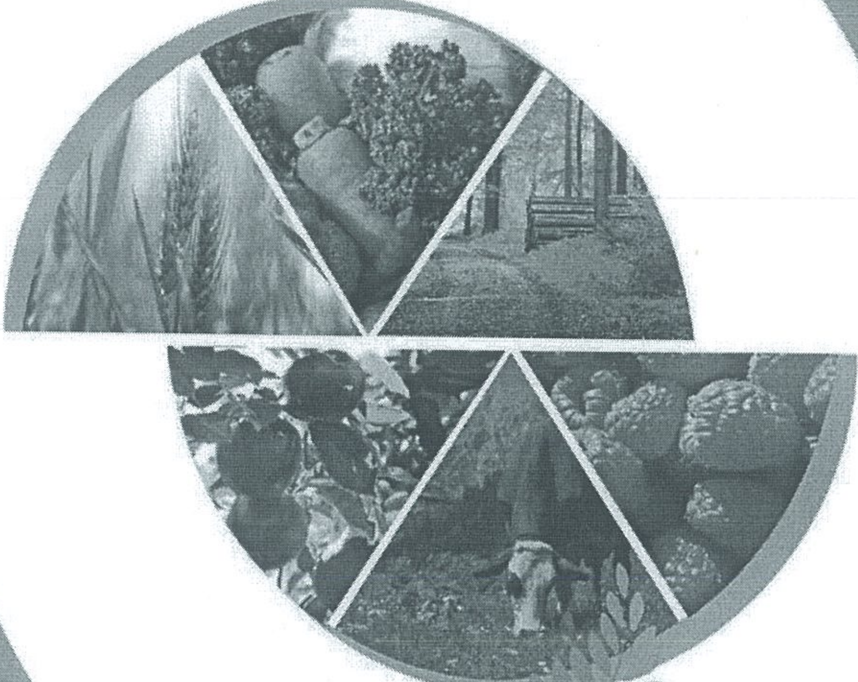

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THE POSSIBILITY OF USING BURLEY TOBACCO STALKS AS A BIOFUEL

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Abstract

The reduction of world`s fossil fuel reserves, as well as concern environmental pollution, encourages the use of renewable energy sources. In the Republic of Serbia, biomass from agriculture represents a significant energy potential. The aim of this paper was to examine the possibility of using tobacco stalks as biofuels, considering that each year, after the harvest of leaves, about 70 000 tons of stalks from all tobacco types remains in the fields. The material used in this study were Burley tobacco stalks, sawdust from beech wood and wheat straw, which were chosen due to the fact that they are already in use as biofuel. In the first part of the experiment the ash content in all samples was determined, which is used to predict the higher heating value (HHV). The HHV as a function of ash content (ash, wt %) was calculated using the equation by Sheng and Azevedo. The experimental determination of the calorific value of all samples in a calorimetric bomb was conducted in the second part of the study. Based on predicted (18208.18 kJ/kg) and experimentally determined HHV of tobacco stalks (17504.44 kJ/kg), as well as comparisons with other forms of biomass, it was concluded that Burley tobacco stalks can be used as biofuel. Experimental values of tobacco stalks are only 9% lower in relation to HHV of beech sawdust. Tobacco stalks and wheat straw have the approximate values of HHV.

Keywords: *burley, tobacco stalks, ash, higher heating value (HHV), biofuel*

Introduction

Energy, as life`s base, affects the living standard and technological progress of each country. However, excessive use of conventional forms of energy, primarily fossil fuel has led to many problems; this practice has polluted the planet and minimized fuel reserves. Owing to the decrease of fossil fuel reserves, substantial use of renewable sources of energy has a large, primarily the economic and ecological impact (Demirel, 2012). Renewable energy sources (biomass, geothermal and solar energy, hydropower and wind power) participate with approximately 14% of total world energy consumption; biomass makes up 62% of that amount (Nakomcic-Smaragdakis et al., 2016).

In the Republic of Serbia, agriculture engages about 10% of the population, while its share in GDP makes almost 11%. At the same time, the increase in agricultural production increases waste products and pollutes the environment. Serbia produces about 12.5 million tons of biomass annually; of these more than 1.7 million tons are the byproduct of agriculture. This biomass usually ends up burned or plowed in the field, which increases the ecosystem pollution and causes significant loss of resources (Jovanović et al., 2009). It is imortant to note that the CEI recommends that by 2020 use of biomass from wood must be reduced and substituted with the biomass from agriculture (CEI, 2013).

According to data from the National Statistical Office of the Republic of Serbia, the main agricultural product in Serbia, wheat, was cultivated on 589922 ha in 2015. On average wheat yielded 4.1 t/ha, which made more than 2.4 million tons. In 2015, tobacco were cultivated on 5012 ha; with an average yield of 1.8t/ha, so total production of tobacco in Serbia amounted to 8700 tons (Statistical Yearbook of the Republic of Serbia, 2015).
Tobacco leaves are indispensable in cigarette production, but the tobacco stalks are considered to be a biodegradable waste. The Waste Catalogue (2010) issued by the Ministry of Environment and Spatial Planning and the Environmental Protection Agency of the Republic of Serbia classify them as non-toxic waste. It should be noticed that tobacco stalks yield about 22 000 stalks/ha, and solely in 2015 the total number was greater than 115 million stalks, they represent a significant possible resource. So far, these stalks had no monetary value. However, in recent years, researchers have intensively studied the chemical composition of tobacco stalks and concluded that they are suitable for the production of numerous commodities like paper, cardboard, textiles, cotton, flax, other plant fibers, pesticides, and organic fertilizers (Chaturvedi et al, 2008; Kapadiya et al., 2010; Martin et al.,2008; Shakhes et al., 2011). Depending on the chemical composition of tobacco stalks, they could be utilized in briquettes or heating pellets production. These preliminary results are very noteworthy since useful energy is obtained and waste products decreased simultaneously (Kulić et al. 2011; Malnar et al., 2014; Radojičić et al., 2014; Radojičić et al., 2014).
The higher heating value indicates whether a substance can be used as a fuel. It is established experimentally or mathematically. Experimental assessment of HHV requires particular equipment, but mathematical caloric value computation needs only the biomass chemical composition data, which are easily achieved with the available laboratory equipment. Many researchers have studied the biofuel higher heating value based on the fundamental chemical structure (Demirbas, 1997; Sheng and Azevedo, 2005; Yin, 2011). Comparing with other formulas the formula which links the ash content and HHV ($HHV = 19.914 - 0.2324 \cdot Ash$), proposed by Sheng and Azevedo (2005), provides the highest reliability. It is typically used in practice to predict the biomass HHV; therefore, we applied it in this study.
This study investigate the possibility of using tobacco stalks as biofuels , and how they compare to other sources of biomass. We underline that, unlike other biomass sources, Burley tobacco stalks are dried along with leaves, so they do not prescribe an additional investment of energy for drying raw materials. Predicting tobacco stems HHV made the basis for the cost-effectiveness study of biofuels in Serbia, largely as a heat source for Virginia type tobacco drying.

Materials and methods

In this study, we used briquettes made of Burley tobacco stalks, beech wood sawdust, and wheat straw. Compressing reduced the volume of biomass about 10 times; the produced briquettes were easily transported, stored and incinerated. Since beach wood chips are the most commonly used base for briquettes, we chose them for this study. Wheat straw is selected because wheat is one of the major agricultural products in the Republic of Serbia and it is already used as biofuel. All raw materials are from the same agricultural area in Serbia (Sabac region). The tobacco stalks were taken from the tobacco production company after the drying and after removing the tobacco leaves. This experiment was significant because the briquettes are made without using any binding materials. Briquettes are made on the machine Comafer Dinamic, Italy.
For the experimental determination of ash content and calorific value of the samples, briquettes were milled (Mill Fritsch, Germany) and homogenized. The samples were sifted in a vibrating sieve and the particles 0.5-1mm in diameter were isolated and subsequently analyzed. Moisture

content was given in a standardized method (EN 14774-2, Solid biofuels. Determination of moisture content. Oven dry method. Total moisture. Simplified method) in the oven, Binder FD 240, Germany. Ash content is determined by ignition at 550°C in a furnace, Nabertherm Controller C6, Germany (EN 14775 Solid biofuels. Determination of ash content).

Based on the moisture content, the results were given relative to the sample`s dry matter. Ash content was utilized to predict the higher heating value (HHV) of the test material. The calculation was used with the Sheng and Azevedo (2005) equation:

$HHV = 19.914 - 0.2324 \cdot Ash$ (1)

To determine the experimental values of thermal power, briquettes were burned in an oxygen bomb calorimeter - Calorimeter, IKA C5000, Germany (EN 14918, Solid biofuels. Determination of calorific value). Experimental values were then compared with the values predicted by ash content.

All analyses were repeated five times. However, to simplify we showed only the mean values.

Results and discussion

Table 1 represents the results of this study.

Table 1. Content of moisture, ash and HHV of samples

Sample	Tobacco stalks	Beech wood sawdust	Wheat straw
Moisture content (%)	9.96	7.72	8.24
Ash content (%)	7.34	0.60	8.06
Prediction of HHV (kJ/kg)	18208.18	19774.56	18040.86
Qg (kJ/kg)	15761.00	17612.00	16063.00
HHVexp (kJ/kg)	17504.44	19085.39	17505.45

The moisture content in the tested samples ranged from 7.72% to 9.96%. The higher moisture content of the samples would represent the problem since it would be necessary to consume energy for drying them. Also, the higher moisture content would cause a lower calorific value of samples, and would affect the quality of combustion.

The content of mineral substances in most plants is about 3%. Combustion of mineral substances creates an ash, which accumulates in the oven. Compared to fossil fuels, biomass produces a very small amount of ash during combustion. Also, the ash content is negatively correlated with the high heating value of the fuel; it is considered that an increase of 1% of ash reduces the calorific value by 200 KJ / kg (Monti, 2008). The data in Table 1 show that sawdust has the lowest and wheat straw has the highest ash content. The tobacco stalks briquettes have 7.34% ash content; this data match the data from other literature (Radojičić, 2011). The results is true for wheat straw briquettes which have 8.06% of ash (Brkić et al., 2007).

Based on the ash content we predicted the HHV values of the samples. According to the literature, the calorific value of biomass from agricultural production is between 13000 and 18000 kJ/kg (Brkić et al, 2007). The calorific value of wheat straw, reduced to the dry weight, is about 15800 kJ/kg; sawdust has a caloric value of 18600 kJ/kg, and tobacco stalks about 18000 kJ/kg (www.agroinfotel.net). Predicted HHV values of the samples based on ash content were slightly higher than in the literature. The wheat straw HHV was 14.3% and sawdust HHV 6.3% higher than the values reported in the literature (Malnar et al., 2014), while the tobacco stalks HHV was almost the same. Differences in HHV were the result of the different chemical composition of samples, which depend on the production area agro-ecological characteristics from which they are taken.

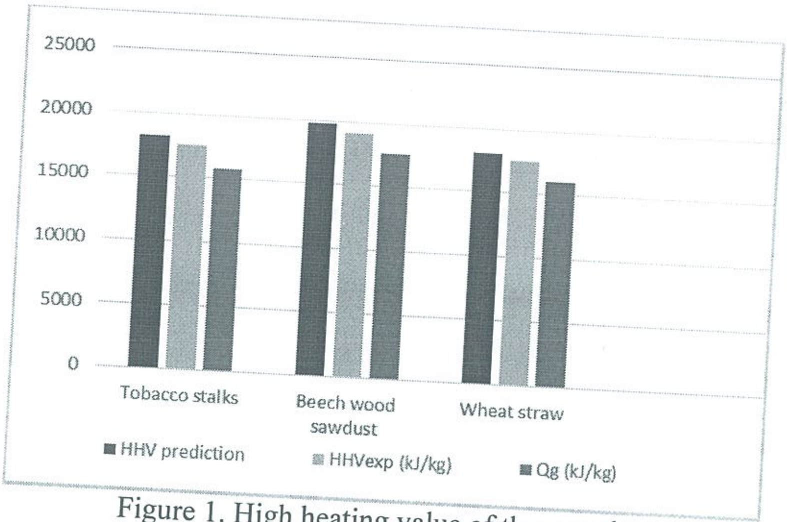

Figure 1. High heating value of the samples

Experimentally, in the caloric bomb, the results of the samples thermal power (Qg) were obtained (Qg) in deliverable state (with certain moisture content). Experimental data show that biomass has about 10% lower Qg value than the chip (Table 1, Figure 1). The comparison of only the biomass from agricultural production, tobacco stems have about 2% lower calorific value than the wheat straw. This result was expected because tobacco stalks had a slightly higher moisture content. Since the heating value of tobacco stalks does not deviate significantly from the heating value of the wheat straw, already used as a biofuel, it can be concluded that the tobacco stems can be used for the same purposes.

To simplify the comparison, the calorific value of samples (Qg) were calculated relative to the dry matter of the sample (HHV exp in Table 1). HHV values obtained experimentally are, on average lower about 3.86% for tobacco stems, 3.49% for sawdust, and 2.97% for wheat straw compared to the predicted HHV values. From the low deviation of the theoretical from the experimental HHV values, it can be concluded that the formula which connects the HHV with the ash content has high reliability, which confirms results from the literature (Sheng and Azevedo, 2005). The paramount importance has the fact that the experimental tobacco stalks HHV value is only 9% lower than the sawdust HHV. Between tobacco stalk HHV and wheat straw HHV has no significant difference.

The results of this study, HHV values determined experimentally and predicted from the ash content, confirm that it is possible to use tobacco stalks as biofuel. This will increase their economic value while reducing environmental pollution caused by their inadequate disposal or destruction in fields with fire. As a benefit, it opens the possibility of reduced investments in fuels (gas, oil fuel, electricity) for drying other types of tobacco, especially tobacco Virginia type.

Conclusion

The aim of this study was to determine the possibility to utilize Burley tobacco stalks as a biofuel, through determining HHV, and comparing it with other forms of biomass already used in Serbia.

Research has shown that Burley tobacco stalks have a low moisture content, which means that no additional energy is necessary for their drying and that certainly increases their energy efficiency. It was experimentally proved that the Burley tobacco stalks have a high HHV (17504.44 kJ / kg), which does not deviate from the wheat straw HHV, and is only 9% lower than the sawdust HHV. The high calorific value of tobacco stalks, in combination with other parameters, shows that they constitute a suitable raw material for the production of energy briquettes. Briquetting is a way to create a significant energy product from monetary insignificant tobacco stalks and solve uncontrolled waste disposal at the same time.

The fact that the tobacco stalks could be used for the production of briquettes founded the way for new research of their profitability as a drying agent for other types of tobacco, primarily the Virginia tobacco.

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