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CALORIFIC APPRECIATION OF SOME RESINOUS SPECIES

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Abstract
This paper aims to show some results about using the resinous species as fuels. Some calorific features to characterize the biomass resulting from resinous trees are considered, namely the net and gross calorific value, burning speed, calorific density and combustion speed. The moisture content of biomass is identified as the main factor of calorific influence. All results come to confirm the ability of resinous biomass to be used as fuel. As resulted from the experiments, the biomass of resinous species is as good as any other woody biomass, when used as fuel, because most of the calorific properties are similar, except the calorific density.

Key words*: biomass; resinous species; calorific value; calorific density.*

INTRODUCTION

Biomass is a renewable fuel, because it is the result of photosynthesis (Dhillon and von Wuelhlisch 2012; Prasertsan and Sajakulnukit 2006; Verna et al. 2009). Solar energy (directly or as photovoltaic panels), wind, water, rivers, seas and oceans energy and geothermal energy are also available within the category of renewable resources (Demirbas 2001; Jehlickova and Morris 2007; Lakó et al. 2008). The first biomass category includes woody forest, then biomass of cities (demolition or woody biomass from parks and alleys), municipal waste, animal manure from farm, marine vegetation, agricultural waste (Okello et al. 2013; Omer 2012; Vilcek 2013) etc. Biomass can be used in combination with other fuels (Kazagic and Smajevic 2009), in native state or processed by thermal treatments (Uslu et al. 2008; Wang 2011).

Softwood species are predominant in Europe, and only sometimes they are preceeded by deciduous species (Lundborg 1998). Resinous species are more visible, by their spreads and beautiful appearence. The main resinous biomass is that resulting from felling of forests, but also from their cleaning or thinning stumps. An important biomass results from wood processing in mills, chip boards and fiber boards, oriented strand board, medium density fiberboard, furniture, upholstery, pulp and paper (Gavrilescu 2008, Obernberger and Thek 2004) etc. Currently, a wide range of wooden products uses raw materials from coniferous species (Demirbas and Demirbas 2004). A series of debris results from their processing, that can be harnessed by burning in furnances. Knowledge of calory and energy characteristics of these wood species becomes necessary, in order to evaluate which is the amount of heat released from their combustion.

Biomass of resinous species are less studied in order to be used as fuels (Griu 2014). Abundant studies refer to this kind of biomass when used in the form of pellets or briquettes (Sikkema et al. 2011; Stelte 2011, Moya and Tenorio 2013; Tabarés 2000; Tumuluru 2011). Exploitation and processing practices produce a lot of other types of debris (chops, chips, roots, tops, ends, thin truncks etc), which can be used in natural state as fuels.

OBJECTIVES

The paper's main objective is to determine the calorific value for the biomass of some softwood species. In addition, several other caloric features (specific time, burning rate and caloric density) for combustion of these species are determined, in order to compare them with other species, commonly used for combustion.

METHOD, MATERIALS AND EQUIPMENTS

The determination of calorific value of the biomass resulted from several softwood species was taken into account. Six resinous species were investigated: spruce (*Picea abies*), fir (*Abies alba*), yew (*Taxus bacata*), pine (*Pinus silvestris*), larch (*Larix decidua*) and juniper (*Jeniperus virginiana*). Freshly samples of about 0.6-0.8 g were cut. In order to determine the calorific value and burning time, they were introduced into an adiabatic calorimeter of OXY-1C/Shanghai Changji Geological Instrument Co. /China type. The obtained results (such as raw data and net calorific values) were processed. Based on those data, other calorific parameters, such as the specific time, speed of combustion and calorific density, were determined. The calorimeter provides three distinct periods: fore, main and after. Fore and after periods were subtracted from the total time of combustion, to determine the real time of combustion.

Some relationships to determine the additional calorific characteristics, other than calorific value ones, were used:

- the specific combustion time was expressed as the ratio between the time of combustion and mass of the specimen subjected to combustion:

$$ST = \frac{t}{m} \qquad [\text{min}/g] \tag{1}$$

- the rate of heat removal during combustion, also called the combustion speed, was performed by dividing the net calorific value with the burning time:

$$CS = \frac{NCV}{t} \cdot m \qquad [kJ/\text{min}] \tag{2}$$

- the caloric density was performed through the multiplication of calorific value by the density of species:

$$CD = NCV \cdot \rho \qquad [kJ/m^3] \tag{3}$$

All values obtained by direct determination and by calculation were processed in Excel™ program, and the necessary graphs were obtained.

RESULTS AND DISCUTION

Based on the obtained values for the gross and net calorific value of combustion, the graph from Fig. 1 was designed. The lowest calorific value was noticed for fir and the highest one for yew. It generally increases by the resin content of the species. In this respect, it is known that the heat output of the resin is about 32-36 MJ/kg, when compared to wood that is 17.5-18.9 MJ/kg (Griu 2014). As a general idea, the calorific values of resinous wood obtained from experiments are comparable to those of hardwood for fire (beech and hornbeam), sometimes even above these values.

Wood species with high resin content, such as yew, have high calorific value (20835 kJ/kg) and others with low resin content, such as fir, have low calorific value (19117 kJ/kg), as seen from Fig. 1.

Another important feature of the burn combustion is the specific time, expressed in min/g, in order to not depend on each specimen mass. This feature is different from one species to another (as seen in Fig. 2), depending on the structure, chemical composition (Shulga et al. 2008), density, and resin content etc.

The linking between the calorific value and burning time is expressed by the speed of combustion (Fig. 3). The importance of this characteristic is seen in the use of biomass (as hot water or steam, obtained in stoves or performant furnance), when it is associated with the oxygen amount.

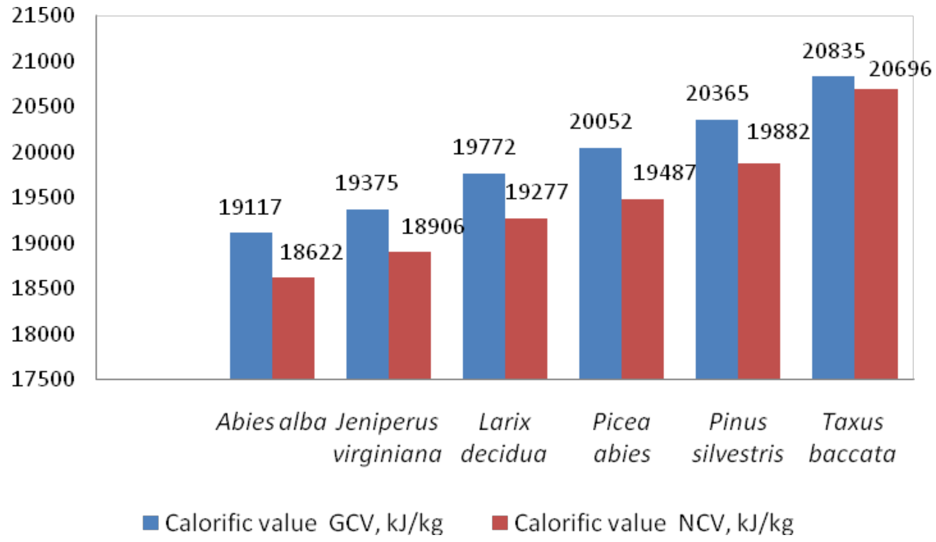

Fig. 1.
Gross calorific value and net calorific value for some resinous species

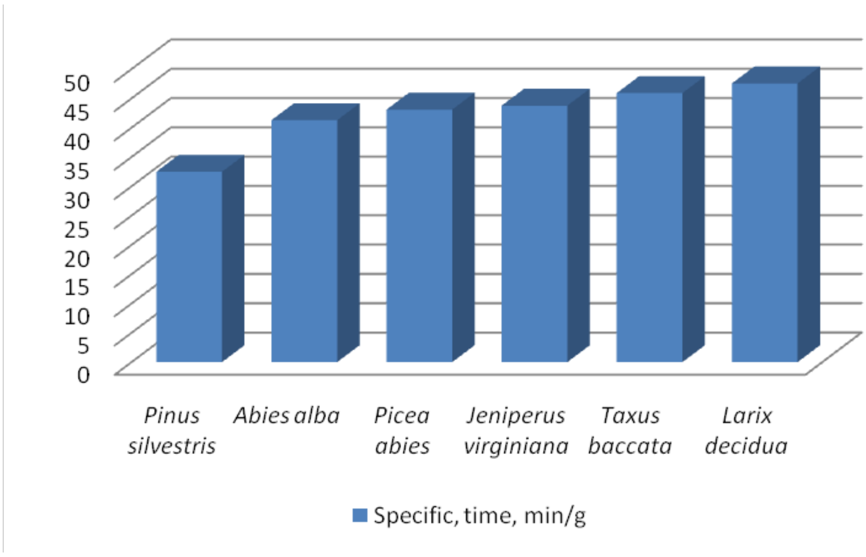

Fig. 2.
Specific time of combustion

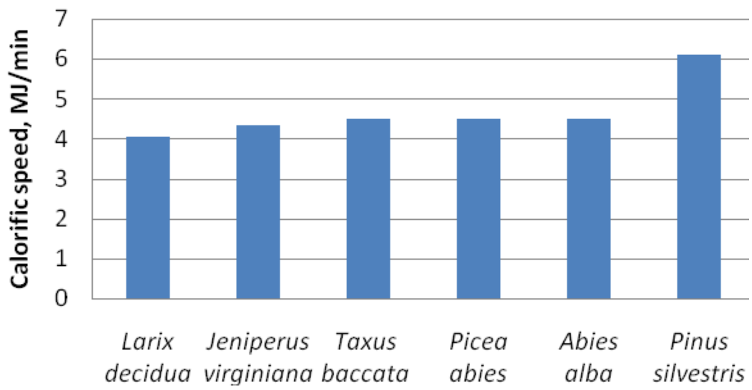

Fig. 3.
Calorific speed of some resinous species

The most important factor that influences the calorific value of woody biomass is the moisture content (Nielsen 2009) which varies in large limits of 0-200%. The calorific values for moisture content of about 0, 10, 20 and 50% were determined according to the working methodology, as seen in Table 1.

Table 1

Calorific density of two resinous species (larch and yew)

Specie	MC, %	Density, kg/m^3	NCV, kJ/kg	Calorific density, kJ/m^3×10^{-6}
Larix decidua Mill.	0	636	18906	12.02
	10	689	17015	11,72
	20	742	15124	11,22
	50	888	9100	8,08
Taxus baccata L.	0	650	20696	13,45
	10	705	17679	12,46
	20	758	15589	11,80
	50	911	9319	8,48

A drastic decrease of the calorific value with increasing of the moisture content was observed. In this regard, when moisture value is over 90-100%, the combustion becomes inefficient, because all the energy is consumed to remove water from wood. The biomass must have a certain moisture content (typically 10-20%, but not more than 40-50%), because a part of it, in the form of H^+ and OH^- dipoles, participate in the reaction of combustion. Fig. 4 shows the influence of moisture content on the calorific value (a) and caloric density (b) of resinous species.

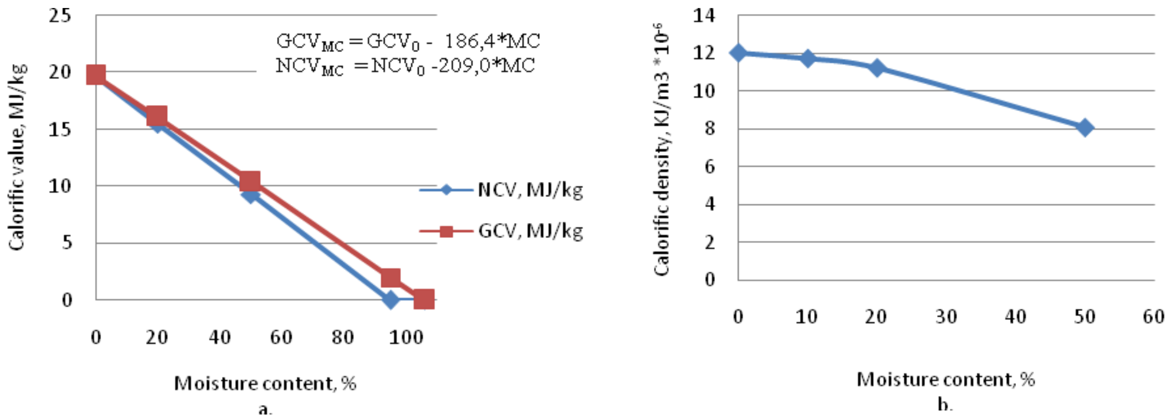

Fig. 4.
Influence of moisture content on calorific value of yew (a) and calorific density of larch (b)

The influence of moisture content on the calorific value of resinous species is similar to that of hardwoods, the GCV and NCV equations being even similar. It is clearly noticed that the GCV and NCV for 0% of moisture content are always equal. Caloric density of resinous species is reduced in comparison to that of deciduous trees, usually by the density value, with the reduction rate of 20-40%.

CONCLUSIONS

The biomass resulted from softwood species is as good as that of hardwoods considering its calorific value. Even if the calorific density is lower than that of firewood from beech and hornbeam, there is compensation by early age harvesting and large amount of logs per ha. Therefore the species of resinous biomass join to hardwoods and can be used sometimes separately, but especially in combination with the heavy hardwoods. Even if stoves and furnaces are charged more frequently than in the case of broad-leaved species, resinous biomass is more and more used, especially for houses located beside resinous forests.

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