PRODUCTION OF REED CANARY GRASS-WOOD PELLETS

Rasma Platace[1], Aleksandrs Adamovics[1], Janis Kalnacs[2]
[1]Latvia University of Agriculture; [2]Institute of Physical Energetics, Latvia
rasmins@inbox.lv, aleksandrs.adamovics@llu, jkalnacs@edi.lv

Abstract. Grass biomass is a perspective source for fuel production; however, low heating values thereof require new strategies for biomass preparation. One of the solutions to obtain biomass pellets with higher heating value is to mix grass biomass with timber. Therefore, this research covered biomass of reed canary grass and timber of birch, osier, grey alder, poplar, and hybrid aspen. The research aimed at evaluating the possibilities to mix grass biomass with timber biomass and finding the proportions of the components most suitable for pellet production. The research allowed concluding that the best combination of the components is 1 (wood) / 3 (RCG). Such a proportion is due to the higher calorific value of timber and higher ash and chlorine content of grass. When biomass is used for the production of thermal energy, the main problems arising in combustion should be addressed to, therefore, to reach the aim set for the research the highest and lowest heating values, ash content, chlorine content, as well as calorific value ($MWh \cdot t^{-1}$) of the biomasses were found. The research allowed concluding that too high ash and chlorine content in reed canary grass biomass may be reduced by addition of timber. Moreover, mixing reed canary grass with wood allows diminishing the chlorine content almost by half. As compared to grass, timber has more suitable characteristics for pellet production, however, mankind is running short of wood resources, therefore consumption thereof may be reduced by use of grass biomass, i.e. by adding perennial grass to timber pellets.

Keywords: grass biomass, wood biomass, ash, chlorine content, heating value, ash melting temperature, pellets.

Introduction

On a global scale, resulting from the reduction of fossil raw materials, the need for renewable energy resources is growing. Although production of energy from forestry products is traditional, increase in the fossil energy prices has led also to the beneficial production of energy from agricultural produce – biomass [1]. An overall negative trend for production of fuel pellets that should be considered is the lack of traditional raw materials (saw-dust from conifers), obtained from the wood processing industry waste [1].

Heating value is one of the key fuel quality indicators. The highest heating value of energy crops depends upon the chemical composition of the plants and usually is slightly lower than the heating value of wood [2]. Heating value of fuel largely depends upon the moisture content thereof [3]. Chlorine (Cl) is an element undesirable in biomass combustion, since it causes corrosion of combustion units even at very low temperatures (100-105 Cº) [4]. Upon combustion, chlorine forms gaseous HCl, Cl_2, or KCl and $NaCl$ compounds leading to corrosive salts [5]. Ash melting and sintering temperature is of a great significance for good performance of a boiler, since ash during combustion melts and clogs the air inlets, and incombustible minerals emitted from the torch land on the walls of the boiler furnace and when melting form (glass) homogenous cover reducing the heat exchange. Low ash melting temperature causes ash sintering and in automatic boilers damages the ash extraction systems [6].

When grass biomass is used for production of thermal energy, the main problems in the combustion process, i.e. the ones related to the moisture content, ash content, calorific power and ash melting temperature, should be described.

The aim of the research was evaluation of the possibilities to mix grass biomass with timber biomass and finding of the combinations most suitable for pellet production.

Materials and methods

The study will cover the research in reed canary grass (*Phalaris arundinacea* L.) to be used for fuel (pellet) production. Reed canary grasses (RCG) are perennials yielding for 8-10 years, the plant length up to 1.5 m, they are modest in terms of the requirements for soil and may grow in marginal soils, moreover, they are suitable for cultivation in moisture meadows, with a strong root system and excel also with durability against draughts cold tolerance.

The field trial was carried out in the Research and Study farm “Peterlauki” (56º53’N, 23º71’E) of the Latvia University of Agriculture, in sod calcareous soils pHKCl 6.7, containing available for plants

P 52 mg·kg^{-1}, K 128 mg·kg^{-1}, organic matter content 21 to 25 g·kg^{-1} in the soil. Total sowing norm in versions: 1000 germinant seeds per 1 m^2. Swards were cut two times during the vegetation season. Fertiliser used until now was mineral (ammonium nitrate, complex N: P: K).

With an aim to find optimal production of solid fuel (pellets), a mixture of grass biomass and timber was used. Grass biomass was mixed with the following timber biomass: birch (*Betula pendula* Roth.) from naturally renewed birch coppice of hylocomiosa type in Baldone site of Zemgale forest management; osier (*Salix spp.*) – from Mārupe plantations; grey alder (*Alnus incana* (L.) *Moench*); aspen (*Populus tremula* L.); and hybrid aspen (*Populus tremuloides x Populus tremula*). Timber biomass in a form of dry matter powder was produced at the Latvian State Forest Research Institute “Silava”. Chemical and physical characteristics of grass and timber biomass, as well as of samples thereof were analysed in the Waste and Fuel Research and Testing Laboratory “Virsma” Ltd.

The pellets were made from 100 % natural ingredients – wood biomass and chopped RCG biomass. They have a cylindrical shape and they are approximately as thick as a pencil. The pellets were made of single components and two components. Single-component pellets: (I) wood, (II) RCG and two-component pellets: (I) in proportion 1/3 (1 wood +3 RCG); (II) in proportion 1/1 (1 wood +1 RCG); (III) in proportion 3/1 (3 timber +1 RCG).

Within the pellet manufacturing process, energy plant biomass is chopped and ground in the laboratory mill ЭМ-3А УХЛ 4.2, and afterwards powder produced in a mill is formed into a pellet with the hand press “IKA WERKE”. In accordance with the standards, the following parameters were identified: moisture volume – Wa (LVS EN 14774), ash content (error ±0.05 %) for dry materials – A (LVS EN 14775), gross and net calorific value – Qgross (error ±1.0 %) and Qnet (error ±0.05 %) according to LVS EN 14918, as well as ash melting temperature in the oxidizing atmosphere (LVS EN 15370-1), Chlorine (Cl) content according to LVS EN 15105 (error ±0.05 %). The parameters were defined in the Ltd “Virsma”. For each sample three parallel experiments were carried out, repeating each tested combination three times. Statistical calculations and graphs were made using *MS Office Excel*.

Results and discussion

Calorific value is one of the most important indicators characterising the fuel quality. The highest calorific value of the samples made of RCG and timber biomass varies between 15.25 MJ·kg^{-1} and 17.7 MJ·kg^{-1}. The lowest calorific value of RCG and timber samples accounts from 15.12-17.25 MJ·kg^{-1} (Fig. 1). While the highest calorific value of timber samples was observed for the samples of birch and osier – 18.7 MJ·kg^{-1}.

Also in other researches the highest calorific value of both dry timber and grass varies between 17 MJ·kg^{-1} and 21 MJ·kg^{-1}, while the lowest – between 16 MJ·kg^{-1} and 20 MJ·kg^{-1}. The calorific value of timber is slightly higher than one of grass biomass [2; 7]. The standards for biofuel from grass (LVS EN ISO 17225 – 6:2014) indicate that the calorific value should comprise 16.3-19 MJ·kg^{-1}.

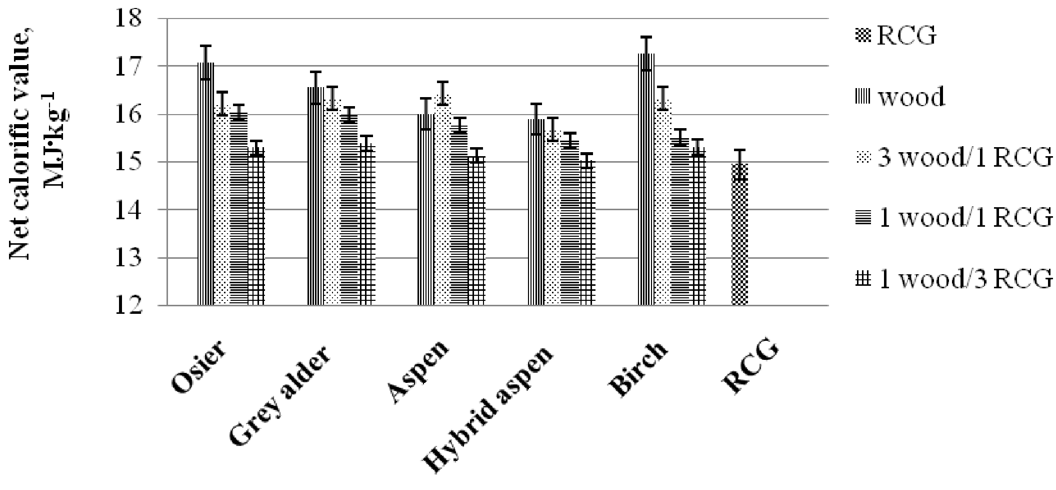

Fig. 1. **Net calorific value of reed canary grass and timber pellets, moisture content:** osier – 7 %; gray alder – 7.7 %; poplar – 7.4 %; hybrid aspen – 8.5 %; birch – 8.5 %; reed canary grass – 8.5 %

Too high Cl content (forming HCl) may form dioxides [8], especially if it exceeds 0.2 %. Therefore, it is important to achieve as low Cl content as possible. The standards for biofuel from grass (LVS EN ISO 17225 – 6:2014) [9] state that timber biomass contains 0.008-0.012 % Cl, while in RCG biomass it is increased and the amount permitted comprises 0.02 %. The research showed slightly higher Cl content in the biomass.

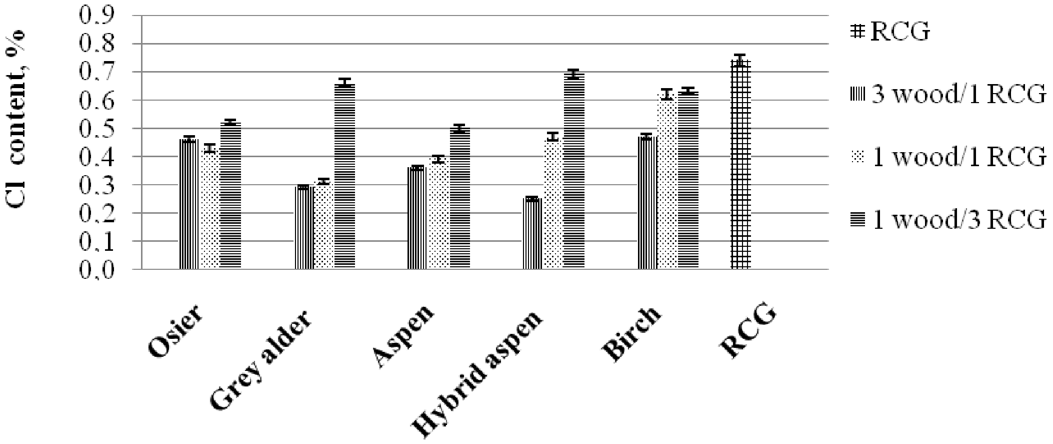

Fig. 2. **Chlorine content in reed canary grass and timber pellets**

Ash content in grass biomass in notably higher than in timber [6]. In this research, higher ash content was recorded in RCG biomass – 7.3 % (Fig. 3). Ash content in timber biomass accounts from 0.6 % in birch to 2.3 % in hybrid aspen. The lowest ash content was recorded in the samples from osier in proportion 3/1 with RCG – 2.6 %, while the highest in the samples with hybrid aspen – 3.8 %.

The standards for biofuel from grass (LVS EN ISO 17225 – 6:2014) [9] indicate that the acceptable ash content is 1.5 %, and even mixing timber with RCG results in too high ash content.

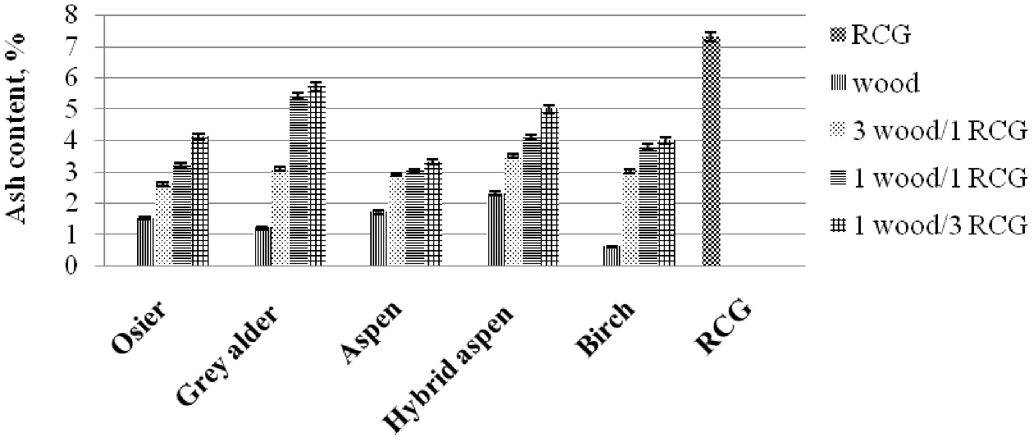

Fig. 3. **Ash content in reed canary grass and timber pellets**

Ash melting temperature, when estimating all four standard values thereof, varies notably, even within the limits of one biomass or group, but mainly the deformation temperature exceeds 1200 ºC that allows using this fuel in both household and industrial boilers [6].

For timber biomass, the starting ash melting temperature accounts for 1390-1460 ºC. For RCG biomass, the starting ash melting temperature is slightly lower 1240 ºC (Fig. 4). In the pellets made of biomass mixture the most suitable ash melting temperature was recorded for grey alder in proportion 3/1 with RCG – 1305 ºC.

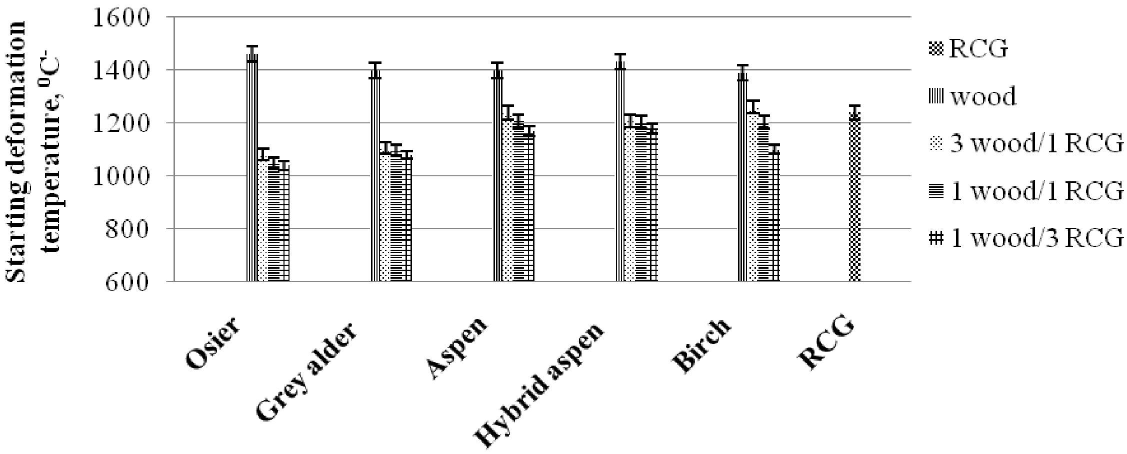

Fig. 4. **Starting deformation temperature of reed canary grass and timber pellets**

Conclusions

1. The highest combustion ability was recorded for reed canary grass pellets in proportion 1/3 with timber – 17-17.7 MJ·kg^{-1}, therefore, it is appropriate to grow and to use reed canary grass as an alternative energy source.
2. The highest calorific value was observed for osier, grey alder and birch reaching 17.5 MJ·kg^{-1}, whereas the lowest calorific value was recorded for the pellets from aspen with reed canary grass in proportion 1/3.
3. Reed canary grass biomass tends to have too high chlorine content, while addition of timber biomass allows lowering it almost by half: in the pellets made of hybrid aspen in proportion 3/1 with timber the chlorine content comprises 0.25 %. Therefore, it is advisable to mix grass biomass with timber instead of using solely reed canary grass.
4. Melting temperature of the RCG ash at the beginning of the deformation phase comprises 1240-1265 ºC, thus it may be concluded that reed canary grass–timber pellets are suitable for heating, since they may ensure qualitative operation of the boiler.
5. The best ratio of components for production of pellets is a combination 1/3, since the ash content in such pellets accounts for 2.6-3.8 %.

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