ASSESSMENT OF FACTORS INFLUENCING POTASSIUM CONTENT IN OSIER PELLETS

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Abstract. Use of the crop biomass in the energy production is one of the preconditions to avoid ecological disasters in future and to compensate growing shortage of fossil energy sources. Ash is the non-combustible component of biomass, and high content thereof leads to fouling problems. Biomass fuels tend to have high ash and potassium content, and as a result ash melts at lower temperatures and leads to dross that can obstruct furnace elements and cause their damage. Pellets prepared within the research had different proportions (1/3, 1/1, 3/1) of reed canary grass variety "Marathon" and energy wood – osier. The research indicated the lowest potassium content (0.34 %) in osier biomass, while the highest (0.67 %) – in reed canary grass biomass. When osier is added to the reed canary grass pellets the potassium content rises. The lowest potassium content was observed in pellets having biomass proportion 1/3 – it is the most suitable for the pellet production. As compared to the pellets made solely from osier, the potassium content in pellets made from reed canary grass /osier in mentioned proportion increased by 24.75 % and combustion ability decreased by 0.09 %. The aim of the study was evaluation of factors influencing potassium content in energy crop pellets.

Keywords: reed canary grass, osier, potassium, lignin, ash, combustion ability, pellets.

Introduction

On a global scale, reduction of fossil raw materials results in the growing need for the renewable energy resources. 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, noteworthy and negative trend in the production of pellets in Europe, including the Baltic States, is the lack of traditional raw materials that are obtained from the wood processing industry [2]. Currently wood products (firewood, woodchips, and pellets) are the most popular renewable fuels in Latvia. However, also regeneration of wood resources is limited in time and space. In many countries cultivation of various plants is recommended as an alternative to the thermal energy production [2-3].

Use of the reed canary grass (henceforth RCG) for the heat production is characterized by major problems in burning process, such as potassium corrosion in superheaters; reduction of ash melting point; high quantities of ash that may affect mechanism of pyrolysis. Herbaceous fuels (also RCG) contain potassium as their principal ash-forming constituents. Potassium is the dominant source of alkali in most biomass fuels [4]. Due to the fact that one of the most significant indicators characterising biomass fuels is potassium, in order to deal with the high potassium content problem, the study covered research of osier characteristics, as it has lower potassium content.

Potassium is vital to many plant processes. It is a key plant nutrient and present in varying amounts depending upon the type of biomass, its growing conditions and time of harvest [5]. Potassium is the macronutrient required by plants in the largest amount after nitrogen [6]. The potassium requirement for optimum plant growth is in the 1-5 % of dry matter weight range, depending on species, while the potassium concentration in mature plants generally does not exceed 2 % of dry matter.

Potassium content differs among various fuels: coal 0.003, peat 0.8-5.8, wood without bark 0.02-0.05, bark 0.1-0.4, forest residues (coniferous tree with needles) 0.1-0.4, willow 0.2-0.5, straw 0.69-1.3 [7], fuel peat 0.02.

Several researches have discovered that potassium content in biomass depends on the harvest time – it is lower in the biomass harvested later (Table 1).

The non-combustible content of biomass is referred to as ash. High ash content leads to fouling problems, especially if the ash is high in metal halides (e.g., potassium). Unfortunately, biomass fuels, especially agricultural crops/residues, tend to have a high ash with high potassium content. As a result, the ash melts at lower temperatures, resulting in "clinkers" that can jam furnace elements.

Studies on the content of RCG biomass the most suitable for the pellet production (RCG biomass with osier biomass) due to the best combustion ability, lignin content and ash content will result in the most effective solution.

Table 1

Potassium content in biomass of RCG and various grass plants

Vegetation/grass species	Region	Reference	Harvesting period	Potassium, in % of dry matter
Meadow foxtail and Reed Canary Grass, communities,	Germany	Kasper (1997), [8]	June August/September	0.6-1.78 0.21-0.9
Five semi-natural grassland communities,	Germany	Tonn et al. (2007), [9]	August February	1.0-1.5 0.3-0.4
Reed Canary Grass	Sweden	Landström et al. (1996), [10]	August April–May	1.12 0.25
Reed Canary Grass	Sweden	Burvall (1997), [11]	July– October March–May	1.23 0.27
Reed Canary Grass	England	Christian et al. (2006), [12]	December/January January/February	0.3-0.4 0.1-0.3
Switchgrass and Reed Canary Grass, north	China	Xiong et al. (2008), [13]	September April	0.3-1.35 0.21-0.27
Switchgrass and coastal panic grass	England	Christian et al. (2002), [14]	September–November November–February	0.26-0.84 0.11-0.44
Reed Canary Grass	Latvia	Lazdiņa et al. (2008), [15]	Autumn-harvested Spring-harvested	1.2 0.27
Reed Canary Grass Wood pellets Straw pellets	Finland	Alakangas (2005), [16]	Autumn-harvested Spring-harvested	1.2-2.3 0.3-0.5 0.02-0.15 0.69-1.3

The research resulted in finding potassium content in RCG and osier pellets, correlations with lignin content, combustion ability and ash content, as well as in suggestions on optimum biomass content and proportions for the pellet production.

Materials and methods

Research objects: reed canary grass (*Phalaris arundinacea* L.), energy plant – osier (*Salix viminalis* L.).

Samples (RCG variety "Marathon" at N-90 kg·ha^{-1} dose of chemical fertilizer) for the study were taken at Latgale Centre of Agriculture Science on 06.10.2010. Whereas cultivated energetic plant osier variety "Tordis" (*Salix schwerinii* χ *S. viminalis*) χ *S. viminalis*) was collected in the Vežaičiai Agricultural Research Institute Centre (Lithuania) on 15.10.2010.

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

Within the pellet manufacturing process the 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".

Potassium content in pellets was measured in the Agricultural Scientific Laboratory for Agronomic Analyses of the Latvia University of Agriculture in compliance with the LVS EN ISO 6869:2002, lignin content in accordance with the LVS EN ISO13906:2008, ash content – with the ISO 5984: 2002/Cor 1: 2005. Combustion heat of the energy plant biomass pellet samples was determined calorimetrically with a calorimetric capsule IKA C 5003 in Klaipėda University Scientific Research Laboratory, in compliance with the LST CEN/TS 14918:2006 standards. For each sample three parallel experiments were carried out.

Results and discussion

The research indicated the lowest potassium content (0.34 %) in osier biomass, while the highest (0.67 %) in RCG (see Fig. 1). Potassium content in unfertilised RCG pellets comprises – 0.33 %, in samples treated with P80K120 it constitutes 0.34 %, whereas in samples treated with N – on average 0.29 %. Among various component proportions the lowest potassium content (0.42 %) was recorded in RCG pellets in proportion 1/3 with of osier.

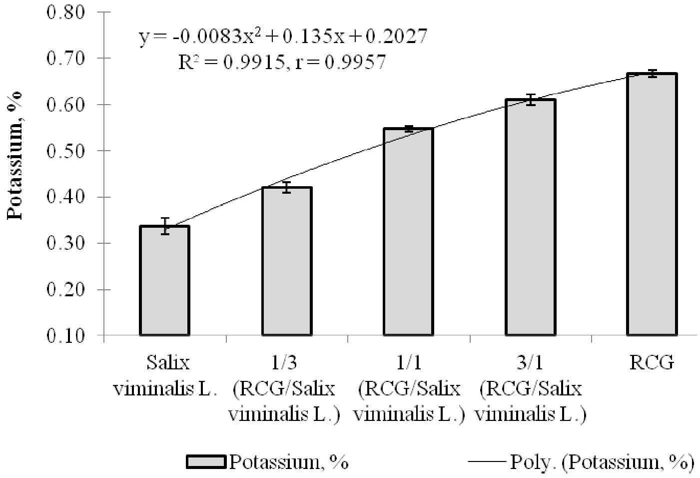

Fig. 1. **Potassium content in RCG an osier pellets**

Regression analysis (n = 15) of RCG/osier pellets showed that 1 % rise in the potassium content (x) decreases the lignin content (y) by 16.822 % (Fig. 2). Whereas potassium and lignin content showed close linear correlation (r = 0.9965). Potassium content in biomass pellets rises as lignin content reduces.

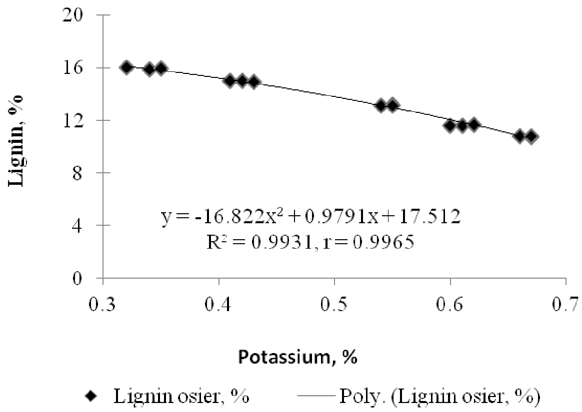

Fig. 2. **Potassium and lignin content correlations in energy crop pellets**

When adding RCG to the osier pellets the lignin content drops – it was the lowest in pellets having component proportion 3/1. Lignin content in mentioned pellets reduced by 27.12 %, as compared to the pellets solely from osier; and regression analysis (n = 5) showed that 1 % increase in the potassium content (x) diminishes the combustion ability (y) by 3.0622 % (Fig. 3).

Reed canary grass/osier pellets indicated close linear correlation (r = 0.8501) between the potassium content and combustion ability. Potassium content in mentioned pellets, along with the lower combustion ability, is growing. When RCG is added to the osier pellets the combustion ability reduces; it was the lowest for pellets having component proportion 3/1, and was 2.3 % lower, as compared to the pellets made solely from osier.

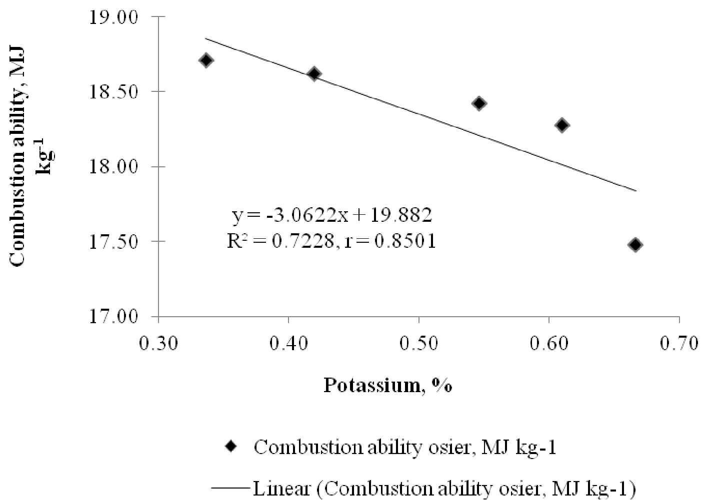

Fig. 3. **Potassium content and combustion ability correlations in energy crop pellets**

Regression analysis ($n = 5$) of RCG/osier pellets showed that 1 % increase in the potassium content (x) rises the ash content (y) by 7.8312 % (see Fig. 4). Mentioned pellets indicated close linear correlation between the potassium content and ash content ($r = 0.9709$). Potassium content in biomass pellets rises along with the growing ash content.

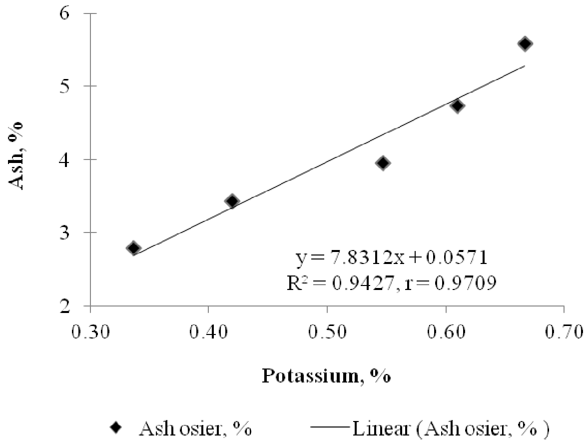

Fig. 4. **Potassium and ash content correlations in energy crop pellets**

When adding RCG to the osier the potassium content increases, still the lowest was observed for the proportion 1/3 – the proportion of components most suitable for the pellet production. Combustion ability of pellets made from osier reduced by 0.09 %. Potassium content in pellets having such a proportion of components rose by 24.75 %, as compared to the pellets made solely from osier; moreover this is the proportion indicating the highest potassium content. It would be advisable that not more than 25 % of RCG is added to the pellets.

Conclusions

1. The research indicated the lowest potassium content (0.34 %) in osier biomass, while the highest (0.67 %) in reed canary grass – the amount advisable for the pellet production.
2. The proportion of components that is the most suitable for pellet production was found at combination 1/3 (reed canary grass + osier), as it has the lowest potassium content (0.42 %) that will not cause problems in heating systems during the burning.
3. Higher potassium content in reed canary grass osier pellets reduced lignin content and combustion ability, while ash content in biomass grew – that is not desirable in the pellet production, therefore the best solution would be production of pellets from reed canary grass biomass mixed with wood (sawdust and woodchips).

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