Study the Physical Properties of the Fruit Pomace for Energy Use

Joanna Pasternak and Paweł Purgał

Abstract The world economy in the production of electricity and heat, is increasingly based on the use of renewable energy sources to replace partially or totally fossil fuels. Biofuels provide an opportunity for energy production in many sectors while maintaining ecological conditions. Having regard to energy security in all regions of the country and the guarantee of sufficient resources for energy production, it must be constantly searched for new and locally available raw materials for the production of environmentally friendly fuel, whose physico-chemical parameters will fully implement efficient combustion or incineration. Fruit processing plants offer post-production waste, which can be used as biomass. At the turn of the last years they developed a number of kilns, whose aim is to get the plant product with a humidity below 15%. Laboratory tests conducted at Kielce University of Technology, demonstrated the possibility of using agro biomass as a component of the mixtures of waste wood for their energy efficiency. Analytical moisture, heat of combustion, calorific value, and ash participation were analyzed. It has shown the difference in the residue of the same mixture at two temperatures of incineration. The possibility of increasing the amount of biomass as a renewable source of energy becomes a reality, both in industry and in private farms. To stop the process of environmental pollution, which has recently been intensified more and more, one should be more broadly interested in the use of post-production waste of plant origin, available on the domestic market.

Keywords Fruit pomace · Calorific value · Ashes

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1 Introduction

Waste other than the dangerous one has a wide application in the combustion process. Industrial plants, community thermal power stations and individual customers are interested in natural fuel, provided that it has sufficing energy properties. Agricultural and food-processing waste was composted or used as fertilizer for years. However, such solutions have often been wearisome for the local environment on account of unchecked effects of fermentations. The implementation of new technologies of initial drying or dryings of biological waste let for acquiring components for producing biofuel, intended for combustion processes or co-burn. During the production of the fruit preserves two types of waste are made. One type is waste stock, generated by long-term storing of raw materials, semi-finished products or final goods. The other type is waste produced during the appropriate food-processing process. In Poland 3 million of tons of different fruit is used annually for the food production [1]. The pomace which until recently were a threat to the local environment, at present constitutes the valuable raw material of the secondary application. These are components with the rich spectrum of carbohydrates, white, fibre, fats and pectins which are a base of the composition of dried fruit in the food, pharmaceutical and cosmetic industry. The poor quality pomace is used as valuable additions to animal fodders. Simultaneously, there is a need for constant monitoring of combustion processes with the contribution of biomass, on account of the productivity of the energy generation process. Findings of fruit pomace physical characteristics in laboratories of the Świętokrzyski Technical University Examinations, conducted in laboratories in the Department of Geomantic Environmental Engineering and Energetic in Kielce have shown, that every kind of biomass is characterized individually by dependent characteristics. Tested samples of the pomace fruit were acquired from the local drying room located in Świętokrzyskie area. Demonstrating is a purpose of research, that the fruit pomace as waste, can constitute the component to the biomass, intended for the combustion process. Literature data, concerning the research on physical parameters of the fruit pomace, show that results of the dried fruit heating value are developing on the level 23.29 MJ/kg [2]. Examinations, conducted in the laboratory of the Świętokrzyski Technical University, are diversifying the checked values of fruit biomass—from 22.55 MJ/kg for the pomace of pears to 26.53 MJ/kg for the raspberry pomace. Publications containing the research widest spectrum, are giving calorific values of the chosen fruit pomace: apples 15.94 MJ/kg and the blackcurrant 20.86 MJ/kg [3].

2 Analytical Damp

The test material is a mixture of fruit pomace and sawdust in the proportion of 50–50% of the test sample. Sawdust from the sawmill contained 30% of deciduous and 70% coniferous wood. Examinations of the pomace were carried out for samples about 1 g mass and the fraction below 0.16 mm. The initial moisture content of the samples did not exceed 15%. All pellet samples were analyzed subjected to a drying process at 105 °C to stabilize the mass. The level of the analytical damp was established, using the drying method for 1 g mass samples of biomass with the accuracy to ±0.001 g. Every kind of biomass was being dried simultaneously in three melting pots. M_{ad} did calculations according to the model [4] (Fig. 1).

Findings show that no kind of the examined pomace exceeded the 5.5–6.8% of the analytical damp. Adding sawdust slightly picked up level of the damp of individual blends by about 0.5% with the exception of the raspberry pomace, which demonstrated the fall in the checked parameter in comparison to the other blends.

3 The Heating Value and the Calorific Value of Fruit Biomass

Marking heating value of the chosen fruit pomace and their blends with sawdust, was conducted in Laboratory of Environmental Biology and the Microclimate in the Department of Geomantic Environmental Engineering and PŚK Energetic. 1 g mass samples were burnt in the KL-12 bomb calorimeter. For calculating average heating values, quantities were chosen, which didn't differ between themselves

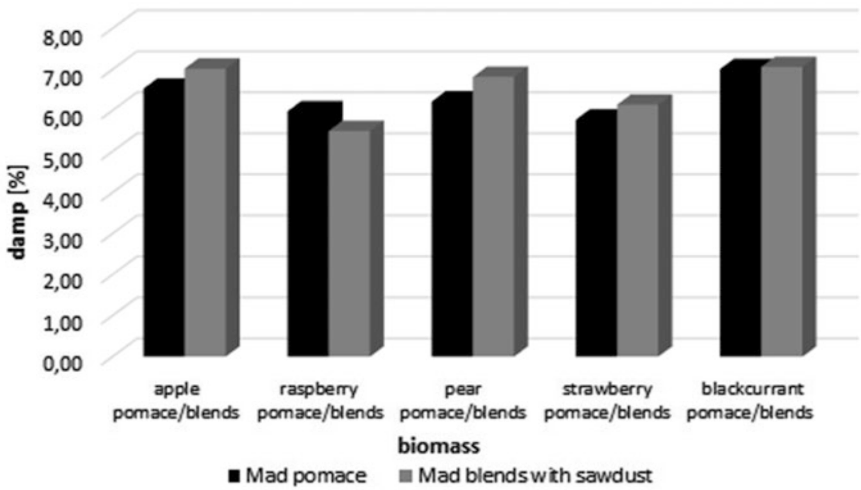

Fig. 1 Analytical damp in pomace and blends with the participation of the 50% sawdust

more than about 120 J/g according to standard guidelines [5]. The KL-12 calorimeter automatically converted the heating value of the tested sample into its calorific value. Complete burn of the fruit pomace in the environment of clean oxygen was characterized by a lack of remains after burning them, and average values were counted for relative results of the heating value of samples of the acceptable difference according to the norm in question. According to the definition, the calorific value is a quantity of heating given off at the complete and total burn of the unit of fuel, taking into account that after the completion of the burn, water stays in the form of steam, it is the parameter significant for the that kind of target audience of biomass [6] (Fig. 2).

The heating value of the blackcurrants pomace and their blends is developing relatively on the comparable level. In case of strawberries and raspberries, their blends are characterized by lower values to 1 MJ/kg. Only adding sawdust to the apples and pears pomace caused an increase in the heating value of blends.

Taking into consideration the fact, that there is lack of ability of some pomace pelleting on account of their looseness at low humidity level, blends with the participation of the 50% sawdust were subjected to attempts using sawdust resin of a tree as binder of the natural origin. Examinations conducted on the samples of blends have shown the same high level of the calorific value the in comparison to achieved results for very pomace (Fig. 3).

The calorific value resulting from the experimentally measured heating value is proportionally lower for every sample. The examined pomace has a calorific value in the scope from 21 to 25 MJ/kg. Demonstrated calorific values of blends exceed the value 21.5 MJ/kg but the standing out raspberries pomace with sawdust combination exceeds even 24 MJ/kg.

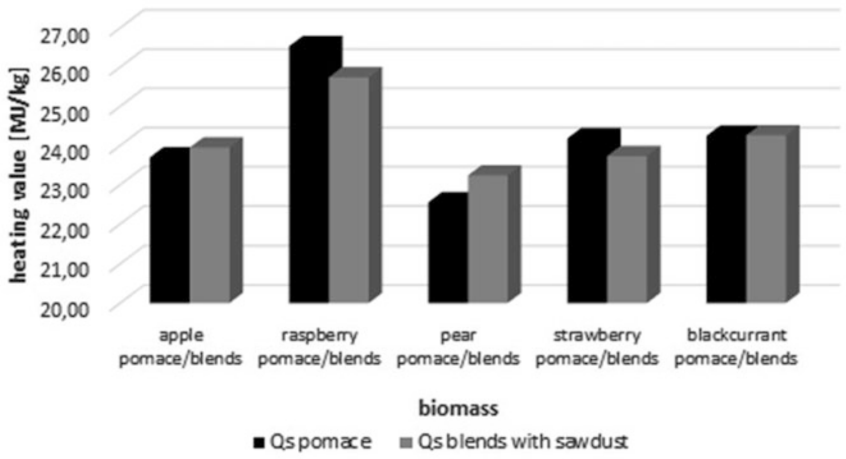

Fig. 2 Heating value of fruit pomace and their blends with sawdust

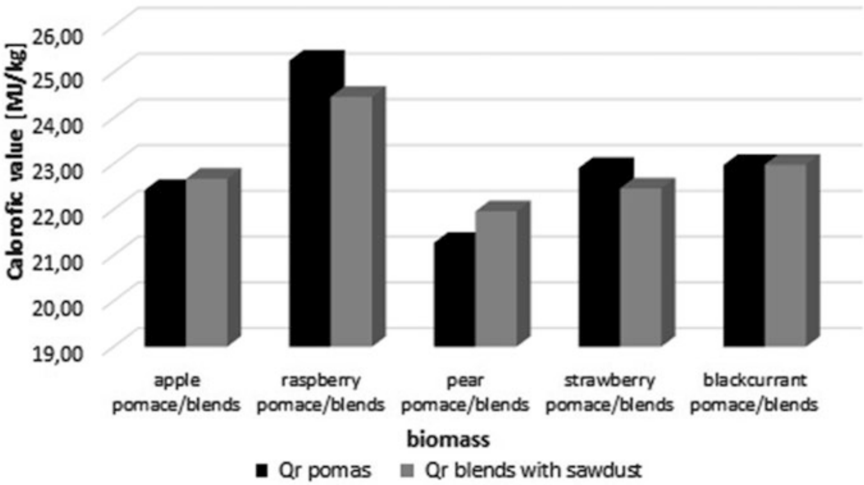

Fig. 3 Calorific value of fruit pomace and their blends with sawdust

4 Examining the Content of Ashes

Reducing samples of the pomace to ashes was conducted in temperature 550 °C [7] and in temperature 815 °C [8] or the technology of the co-burn of biomass with coal, according to guidelines of norms, concerning solid fuels and biomass. Norm PN-EN ISO 18122:2016, "Solid biofuels. Marking of the content of ash", make the low temperature of reducing biomass samples to ashes towards guidelines of the PN-ISO 1171 Norm: 2002, "Solid fuels. Marking of ash", where the hard bituminous or lignite coal is described fuel. Biomass was treated methodically as fuel parametric close to the lignite coal, and therefore individual test procedures developed by laboratories gave the temperature of reducing to ashes 600 °C, examining ashes for biomass consumed in hot water boilers. Temperature 800 °C was allowed, when examinations were conducted paying special attention to the co-burn with coal [9]. The gradation of measuring temperatures in thematic norms results from differences of the chemical composition of fossil fuels and biomass.

Examining the amount of ashes after burning the sample in 550 °C was carried out according to the following methodology

- 1 g biomass amount every was put in the stove in the room temperature.
- the stove was evenly being heated to 250 °C within 30–50 min.
- samples were left in temperature 250 °C through 60 min.
- after this time heating was being continued to temperature 550 °C for 30 min. raising temperature evenly 10 °C/min.
- the sample was left in temperature 550 °C for 120 min.
- melting pots were weighed on the laboratory scale after reducing biomass to ashes with the accuracy 0.1 mg.

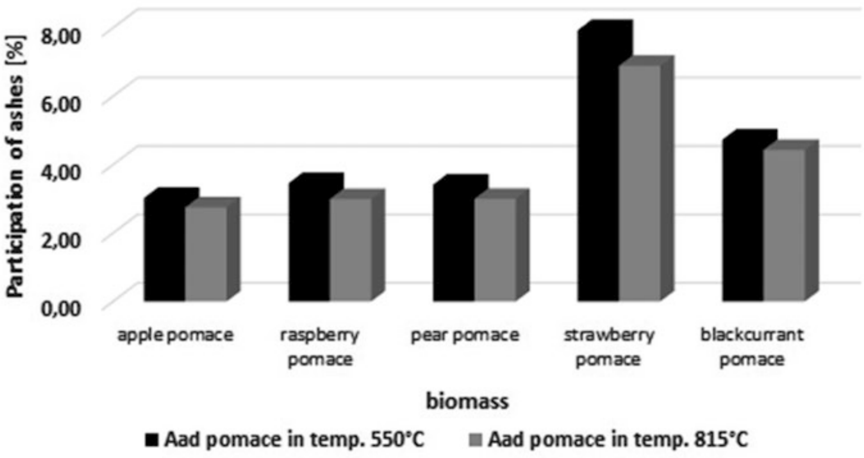

Fig. 4 Participation of ashes in the fruit pomace in the process of reducing to ashes in temperature 550 and 815 °C

- every time finishing off the sample was conducted by 1 h and repeat weighing.

Examining the amount of ashes after burning the sample in pace. 815 °C was carried out according to the following methodology

- 1 g of biomass every was put in the stove in the room temperature.
- the stove was evenly was being heated to 500 °C within 60 min.
- samples were left in temperature 500 °C for 60 min.
- after this time heating was being continued to temperature 815 ± 10 °C.
- a sample was left in temperature 815 °C for 60 min.
- melting pots were weighed on the laboratory scales after reducing biomass to ashes with the accuracy 0.1 mg (Fig. 4).

In case of biomass burning an amount of ashes is essential. The process of reducing the fruit pomace to ashes was conducted comparatively in two temperatures. Amount of ashes, at applying the standard procedure in temperature 550 °C, proved to be higher than the amount in temperature 815 °C. The biggest amount of ashes remained from the strawberries pomace, because almost a 8% after applying the methodology of reducing to ashes for biomass, while for remaining samples developed in the scope 2.8–4.5%. Increasing the temperature of the combustion process of the fruit pomace resulted in lowering remains of samples from 0.5 up to the 1.0% (Fig. 5).

Putting remains together after the process of reducing pomace to ashes and their blends with sawdust in the participation of the 50%, shows a significant reduction of ashes amount in case of blends. The larger difference was observed for the strawberries pomace and their blends with sawdust, where the difference of

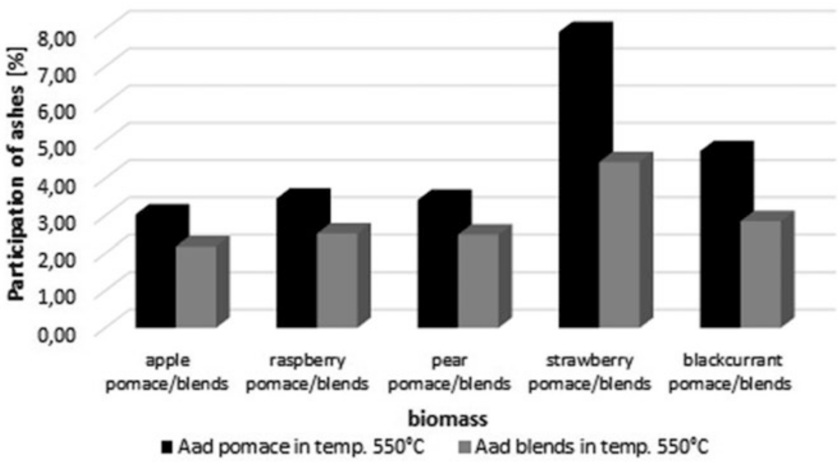

Fig. 5 Participation of ashes in fruit pomace and blends in temperature 550 °C

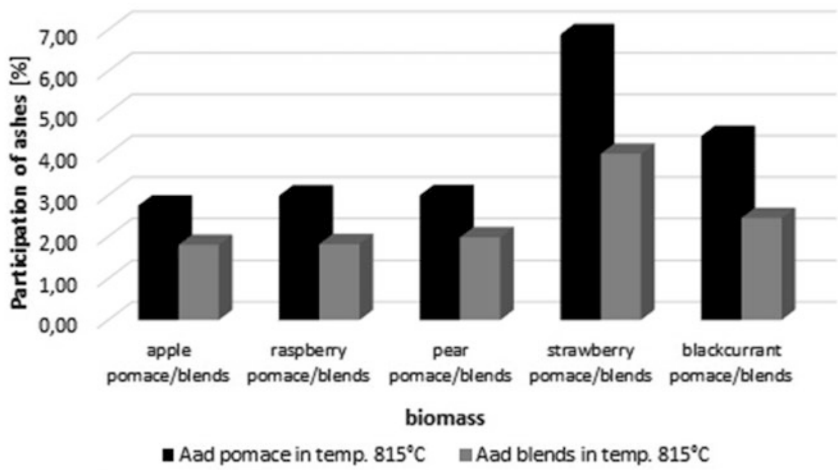

Fig. 6 Participation of ashes in fruit pomace and blends in temperature 815 °C

achieved remains amounted for 2%. In case of remaining samples the gradation was between 0.5 and 1.0% (Fig. 6).

Increasing the temperature of reducing to ashes to 815 °C caused lowering the amount of ashes, left after blends burning, in comparison to very pomace, subjected to the same process. The mixture with the strawberry pomace was different around 3%, while remaining blends were characterized by lower remains of ashes in comparison to the remains from the pomace in the scope from 1.0 up to the 2.0%.

Temperature differences about 265 °C of described processes, determine the remains in the form of ashes, whose amount is decreasing in the diversified way depending on the sample type. In both cases, a lot of ash remains from the strawberry pomace, in spite of their low level for the analytical damp.

The least amount of ashes were found in melting pots, where the apple pomace was tested. Attempts to reduce to ashes were conducted with checking for gaining the difference of results not larger than the 0.1%—in compliance with the requirements norm [7]. Comparatively, according to literature data, the content of ashes in biomass exceeds the 7% at the combustion temperature above 700 °C [9].

5 Fractions of Samples of Biomass Subjected to Burning to Ashes

Every examination of the biomass samples subjected to high temperature of reducing to ashes should be preceded by the measurement of the analytical moisture content. It is quantity which participates in calculations of the amount of ash, remaining after given fuel burning. The norm concerning the drying method, shows the fraction of the research material below 0.2 mm [4]. Grinders for biomass grinding often have the smallest mesh sieve size of 0.425 mm, therefore there is a need to use additional sieve to adapt the fraction to standard methodology exists. However, preparing the fruit pomace samples, it can be noticed, that on the sieve remain stones which don't participate neither in the process of the drying or reducing to ashes. It concerns the currants, strawberries, or raspberries pomace. The publications, concerning the process of preparation of biofuels samples, are pointing out to impediments of different kind, often connected with the structure of the research material, where differences in findings result derive from [10]. "It is not possible to get the analytical modicum of 0.2 mm. And so a compromise attempt is necessary between the size of the grain of the sample and the repetitiveness of results" [11]. The latest norm concerning reducing biomass to ashes already shows other fraction of analytical-material, "1 mm or smaller" [6]. However, reducing to ashes the same sample, for which the percentage share of the dampness was determined, we are still dealing with the fraction shown for the drying method. The research cycle which was carried out in laboratories of the Świętokrzyski Technical University, was done for uniform fraction—below 0.16 mm.

6 The Summary and Conclusions

The research on physical characteristics of the fruit pomace shows that after the process of the drying from 15 to 7% for pomace, they are possible to use as solid biofuel. Preliminary attempts, determining the energy efficiency of food-processing waste, confirm the thesis, that they can constitute a product ready to burn or can be used as the high-energy addition. Willingness of applying the fruit pomace to the burn including sawdust without using other binder than resin is being shown to be authoritative, when the participation of the pomace will be smaller than the 50% in relation to the permanence pelet whether of briquette. This is a way to utilize post-production waste, characterized by exaggerated combustion heating value from 22 to 26 MJ/kg, due to the sugar content of the fruit pomace. When analyzing the amount of ash of the selected blends, the temp 550 °C is in the range of 2.18–4.44%. In co-combustion with coal at 815 °C the amount of ash is in the range of 1.80–4.00%. Innovative technological solutions of the structure of biomass stoves enable the maximum use of that kind of fuel to energy purposes. Selection of the kind of biomass for composing fuel about parameters of the burn maximizing the energy efficiency of the process, at limited emission of exhaust fumes as well as including the economic calculation, is becoming a task for further deliberations in this respect.

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