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PROSPECTS FOR THE USE OF SEABUCKTHORN RESIDUES IN THE PRODUCTION OF DENSIFIED SOLID BIOFUELS

Grigore MARIAN, Alexandru BANARI, Boris NAZAR, Andrei GUDIMA, Nicolai DARADUDA, Andrei PAVLENCO

State Agrarian University of Moldova, 56 Mircesti Street, Chisinau, Republic of Moldova

Corresponding author email: marian@uasm.md

Abstract

The paper presents research results of the prospects of using residues from the cultivation of sea buckthorn in the production of densified solid biofuels. The paper aims to evaluate energy and physical-mechanical characteristics of both the wood biomass that results from the cultivation of sea buckthorn and the finished product in the form of pellets. The research was carried out on biomass samples taken from the technological cultivation chain of the Cora sea buckthorn within the Laboratory of Solid Biofuels of the State Agrarian University of Moldova. The research results proved the possibility of using sea buckthorn residues in the production of densified solid biofuels in the form of pellets with the characteristic features that comply with ENPlus 3 standards.

***Key words**: solid biofuels, sea buckthorn, properties, use.*

INTRODUCTION

Our preliminary research on the biomass, obtained from the sea buckthorn production chain has shown that the calories and ash content of the biomass from the sea buckthorn, Cora variety allows using it as raw material for the production of densified solid biofuels (Marian et al., 2020).

Similarly, our research (Marian et al., 2017), as well as other researchers' work indicate that the particle size before densification affects the correct choice of raw material, the quality of solid biofuels as well as specific particle density and mechanical durability (Styks et al., 2020).

The aim of this study is to argue the perspectives of using sea buckthorn residues for the production of densified solid biofuels by thoroughly studying the pellets produced from sea buckthorn.

Based on the analysis of the particle size distribution of sea buckthorn wood biomass carried out after their final crushing and the study of both physical and chemical properties of pellets produced from this raw material, the paper reflects some thoughts on the prospects of using the sea buckthorn biomass as raw material for the production of densified solid biofuels in the form of pellets for both residential and industrial use.

MATERIALS AND METHODS

The following materials were used as subjects of research: the biomass resulting from sea buckthorn pruning (BPSB); the biomass obtained from sea buckthorn harvesting by freezing (BHSB) and solid biofuels in the form of pellets, produced from sea buckthorn residues resulting from tree pruning and culture harvesting by freezing.

The sea buckthorn biomass was collected at the enterprise MONSTERAX-GSG Ltd. from the village of Pohrebea, Dubasari district, Republic of Moldova. The biomass was transported to the Laboratory of Solid Biofuels, State Agrarian University of Moldova where it was dried to the humidity of (8 ± 2) w-%.

The research implied two stages. Initially, at the first stage, we studied the main components of the sea buckthorn biomass, suitable to be used as raw material for the production of densified solid biofuels in the form of pellets. The research was focused on the study of the granulometric distribution of biomass particles after their crushing at the SV 7 hammer mills using 4 and 6 mm sieves.

The particle size distribution was determined by sieving biomass sample, taken after the final crushing for 10 minutes. The sieving was performed at the Retsch 100 laboratory installations according to the SM EN ISO

18135: 2017 standard. The samples were prepared by means of the quarter's method in accordance with the requirements of the SM EN ISO 14780: 2017 standard.

At the second stage, we studied the properties of densified solid biofuels in the form of pellets, produced from the studied sea buckthorn biomass. The pellets with the diameter of 6 mm were produced at the mini semi-automatic pellet production line MGL 200 within the Laboratory of Solid Biofuels, State Agrarian University of Moldova, equipped with a fixed mould, placed horizontally, and two rotating cylindrical rollers.

Both physical and mechanical properties of the raw material and pellets were determined in accordance with current requirements presented in Table 1.

RESULTS AND DISCUSSIONS

In order to study the influence of the biomass particle size from various sea buckthorn residues on the quality level of the finished product in the form of pellets, we analysed the particle size distribution for the biomass resulting from spring pruning of sea buckthorn trees and fruit harvesting by detaching and beating branches in the frozen state (Cimpoies et al., 2018).

The biomass was shredded at the SV 7 hammer mill with both 6 and 4 mm mesh screen. Before crushing, all two types of biomasses were brought to the same humidity, equal to 10 ± 2ºC by keeping all samples in the EV MGGA 1 vacuum conditioning furnace, where they were kept for 60 min at the temperature of 20ºC and the relative humidity of 60 ± 5%.

The particle size distribution was determined by sieving them with vibrating sieves with the following mesh screen dimensions: 0.25, 0.5, 1, 1.4, 2.0, 2.8, and 3.15 mm. The percentage of ground biomass distribution with the indication of the confidence interval is presented in Table 1 and Figure 1.

The experimental results show that the biomass from sea buckthorn pruning, grinded with the use of sieves with mesh sizes of 4 and 6 mm, has a slightly more uniform particle size distribution than the biomass grinded with the use of the same sieve that results from frozen cultures. Thus, the share of BPSB with particle sizes greater than 0.5 mm and less than 2.8 mm is 73.93 w-% in the case of 6 mm sieve crushing and 76.08 w-% in the case of crushing with a 4 mm sieve. In the case of BHSB, this ratio is 70.17 and 72.59 w-%, respectively. This can be explained by the presence of a certain number of leaves, which are difficult to separate from the biomass mixture obtained from harvesting by the cold method.

Moreover, the share of particles larger than 3.15 mm is quite small for all investigated cases, being of the highest values (2.38 ± 0.19) w-% in the case of BPSB grinded with the use of the mesh size of the sieve that equals to 4 mm, and the lowest values in the case of BHSB grinded with the use of sieves with the mesh size of 6 mm.

This shows that grinding can be used with both 4 mm and 6 mm mesh sieves, as over 95% of the biomass has particles smaller than the radius of the pellets that meet the requirements for the raw material used for pelleting.

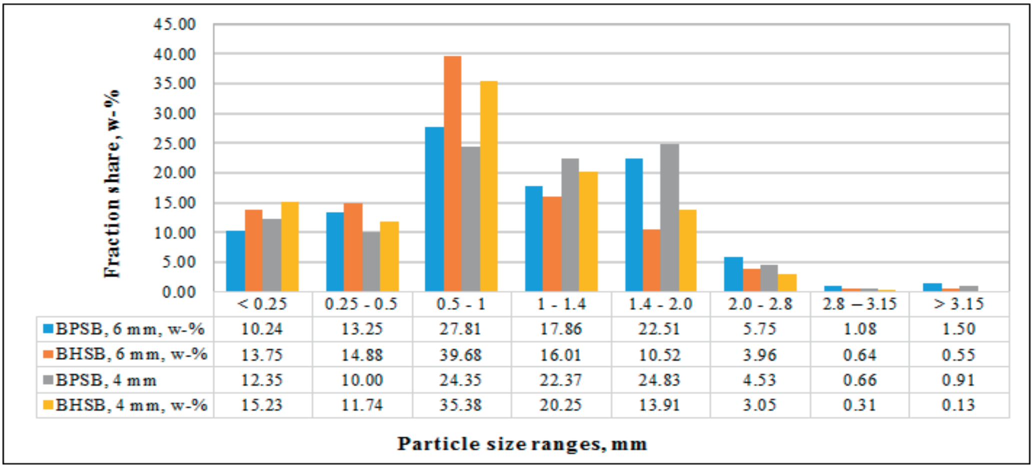
This recommendation is also argued by the fact that the particle content finer than 0.25 mm, when using sieves with the mesh size of 6 mm, is on average lower than when using sieves of 4 mm. This feature is a positive aspect, because very fine particles worsen the conditions for the formation of adhesion bonds between particles and cohesion inside them (Gudima, 2018).

From the point of view of labor productivity, it is more effective to use a sieve with a mesh size of 6 mm for crushing.

Approximately the same particle size distribution is observed in the case of wood residues resulting from the pruning of fruit trees (Gudima, 2018). This paper also mentions that, in the case of natural drying of biomass, the distribution of particles is more uniform which favors better densification of pellets.

Table 1. Particle size distribution of sea buckthorn biomass particles after grinding at the SV 7 hammer mill

Mesh size of the sieve insert	Biomass type	Particle sizes, mm							
		< 0.25	0.25-0.5	0.5-1	1-1.4	1.4-2.0	2.0-2.8	2.8-3.15	> 3.15
		Fraction share, w-%							
4 mm	BPSB	18.67±0.72	18.93±0.98	25.68±0.74	14±0.69	15.1±1.05	5.06±0.27	0.17±0.08	2.38±0.19
	BHSB	8.29±0.55	14.58±0.22	40.54±1.09	24.2±0.87	9.83±0.47	1.63±0.16	0.1±0.06	0.83±0.23
6 mm	BPSB	10.24±0.74	13.25±0.86	27.81±0.66	17.86±0.56	22.51±0.96	5.75±0.22	1.08±0.06	1.5±0.12
	BHSB	13.75±0.62	14.88±0.42	39.68±0.87	16.01±0.66	10.52±0.41	3.96±0.12	0.64±0.04	0.55±0.11



Note: w-% - weight-percentage; BPSB - biomass from sea buckthorn pruning; BHSB - biomass from sea buckthorn harvesting

Figure 1. Biomass particle sizes distribution of Cora Sea buckthorn sawdust

The study of pellets made from sea buckthorn residues shows that the qualitative parameters of pellets made from BPSB are within the specifications of ENPlus 3, and those made from BHSB are partially within the requirements of ENPlus 3. Thus, according to the ash content, BPSB pellets are classified in A1 class with a dry base ash content of 1.16 w-% and can be used for residential use, and those of BHSB that result from combustion, show 2.89 w-% of ash estimated in the dry base and can be used only for industrial use (St., 2016).
In terms of calorific value, the pellets produced from BPSB comply with the A1 class ENpPlus 3 standards, and those from BHSB have a lower calorific value than the one recommended by ENPlus 3 requirements. Thus, BHSB in its raw state (without the addition of other types of biomass), does not guarantee that the obtained pellets will be certified according to ENPlus 3 standards neither for residential nor for industrial use (St., 2016, pp. 9-11, Tables 1 and 2).

As to other qualitative parameters, the pellets produced from BPSB and BHSB meet the ENPlus standards except for the Sulfur content, because the pellets produced from BHSB exceed the quota provided by the ENPlus standards by 0.05 w-%.

CONCLUSIONS

This study has carried out a qualitative analysis of the biomass from the technological chain of sea buckthorn (the Cora variety) cultivation and processing. We studied the biomass obtained from tree pruning and fruit harvesting by means of freezing as well as the finished product in the form of pellets. Based on the analysis of the particle size distribution of the grinded biomass, it has been established that the particle size distribution is quite uniform in the case of crushing with the use of sieves with both 4 mm and 6 mm mesh sizes.
The analysis of pellets produced from BPSB and BHSB showed that the pellets produced

from BPSB meet the requirements of the ENPlus standards, and those produced from BHSB partially comply with them.

Based on the obtained data, one can state that the biomass received from sea buckthorn pruning is an important source of raw material with a prospect of being used for the production of ENPlus 3 certified pellets. BHSB can only be used as a mixture component with other types of biomasses that have better quality characteristics or can be recommended as a raw material for other purposes, for example, in biogas production.

Table 2. Properties of pellets produced from sea buckthorn residues, Cora variety

Property class/method of analysis	**Efficient values**		**ENPlus 3 Class**	
	BPSB	**BHSB**	**BPSB**	**BHSB**
Moisture, M_r, w-%, ISO 18134-3	10.90±0.08	10.38±0.08	A1	A1
Ash, A_d, w-%, ISO 18122	1.16±0.02	2.89±0.024	A2	I3
Ash, A_r, w-%, *by calculation*	1.29±0.02	3.21±0.024		
Gross calorific value, $q_{v, gr, d}$, MJ/kg,ISO 18125	20.39±0.12	19.58±0.11	A1	-
Net calorific value, $q_{p, net, d}$, MJ/kg,ISO 18125	19.09±0.12	18.82±0.11		
Net calorific value, $q_{p, net, m=10\%}$, MJ/kg, ISO 18125:2017	16.75±0.11	16.21±0.11		
Carbon, C, w-%, ISO29541	48.86±0.4	49.98±0.4		
Nitrogen, N, w-%, ISO29541	0.83±0.04	0.98±0.04	B	B
Hydrogen, H, w-%, ISO29541	5.93±0.2	5.94±0.2		
Sulphur, S, w-%, ISO29541	0.05±0.01	0.06±0.01	A2	-
Oxygen, O, w-%, *by calculation*	41.34	40.15		
Mechanical durability, DU, w-%, ISO 17831-1	97.71±0.28	98.62±0.3	A1	A1
Particle density, DE, kg/m^3, ISO 18847	1.09±0.02	1.09±0.02		
Bulk density,kg/m^3, ISO178828	689±2	689±2	A1	A1
Fines, $_d$, w-%, ISO 17830	0.39±0.02	0.35±0.02	A1	A1

Note: $_r$ - as received; $_d$- dry basis; $_{v, gr, d}$ - constant volume of the dry basis; $_{p, net, d}$ - constant pressure of the dry basis; $_{p, net, m=10\%}$ - constant pressure of the 10% moisture.

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