PROPERTIES OF HEAT BRIQUETTES PRODUCED FROM VINE CANE WASTE – CASE STUDY REPUBLIC OF MOLDOVA

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Abstract

Vine cane waste is produced yearly by pruning the one year old canes. This process creates a great amount of biomass which is either burned in the field as a waste or can be used as pure mass or with some additives in the form of heating briquettes or pellets. The briquettes produced from vine cane, or its mixtures with other fuel materials, were tested for their mechanical, energy and emission parameters. The Republic of Moldova has a significant lack of energy resources, and the vine cane waste can replace a part of the consumed (imported) energy from Russia and the Ukraine.

Key words: vine cane, vineyard pruning, waste, biomass, heating briquettes, biofuel, renewable energy resources, emissions

INTRODUCTION

Energy production and energy consumption are the most important factors of world development. Nowadays, energy production depends on non-renewable (fossil) resources; however their reserves are almost exhausted. The steadily growing world population and industrial production generates an increased demand for more energy inputs of different kinds.

The Republic of Moldova has few oil and natural gas reserves. There is a small-sized coal industry which produces low-quality bituminous coal. Two rivers (Nistru and Prut) form the Moldovan national borders, however they have a rather limited capacity for producing hydroelectric power. A total of 70% of electrical energy requirements are imported, mainly from Romania (10%), Ukraine (30%) and Transnistru (30%). The Moldovan own production of electricity amounts to about 30%.

The Republic of Moldova has some renewable energy resources, the exploitation of which requires financial and technical support. Wood residues and agricultural wastes are the most important of them. They are mostly used for home heating purposes, but their use in other places is hampered by the very low efficiency of collection and processing. The Moldovan hydropower potential is estimated at 2100 GWh/yr including that of large, medium and small rivers, however, only 150 to 300 GWh have been generated in recent years. Solar energy could become a very important source of energy with a high potential in the future. There is also the almost unexploited potential of wind-generated electricity which, however, requires more sophisticated construction of windmills, due to rather low average wind speeds across the major part of the Moldovan territory. Forests cover about 9% of the Moldovan territory – the smallest proportion of the national territory amongst all European countries.

The majority of the population live in rural communities, where the living conditions are especially difficult during the cold winter months. Traditionally, coal, gas and wood was used as heating fuels in rural areas. After the collapse of the Soviet Union the prices of traditional fuels, including coal, increased dramatically, resulting in the collapse of coal consumption. Supplies of coal to fuel heating systems of public buildings (especially in rural areas) were severely reduced, which often resulted in the closure of public buildings, schools, production plants and markets in the winter period. As a consequence, the district heating plants stopped operating apart from in the biggest cities.

Potential of the vineyard bio-wastes

vineyard pruning is one of the typical winter or spring agricultural operations, which produces a lot of biomass without high additional energy inputs and at low operational costs. Besides, it is an operation which must regularly be performed. There are estimates that in 2007 the world vineyard area was roughly 7.9 billion hectare (FAO, 2008). This situation is relatively stable. For example China wants to play an important role as a wine producer in the future. The Moldovan vineyard acreage amounts to more than 150 000 hectares and this area is steadily growing, while the area under cultivation as vineyards in the Czech Republic amounts to about 19 000 ha.

On the basis of the above considerations it is possible to consider that the biomass of vine cane represents a strategic potential for bio-energy in the Republic of Moldova. This is why this thesis focuses on the utilisation of vineyard waste as a heating medium for rural areas when compared to other sources of energy.

Because of significant variations of the Moldovan climatic conditions, its territory can be divided into four wine producing regions whereby each grows its own special types of vine. Despite the very high energy potential of the vine cane waste its current utilisation is very inefficient in Moldova. This material is mostly burned directly in the field, or is used for traditional bread baking. Some farmers have started to use this waste in its natural form for heating greenhouses – which is again a rather inefficient way to utilise it.

The utilisation of vine cane waste for fuel briquette production promises to lower heating cost and emissions in comparison with conventional fossil fuels. The vine cane can be either mixed with some other agricultural wastes or fossil fuels, or it can be used without any additives. According to the situation in Moldova it was decided to use other crop wastes as additives, such as: straw, hay, wastes from flax production or maize. Such mixed fuels have better mechanical, energetic and emission parameters when compared to the original material.

Standards used for evaluation

the Austrian standard ÖNORM M 7135 (2002) and German DIN 51731 (1996) can be used for the evaluation of heat briquette properties. Thus the testing results were compared to these standards (Table 1).

Tab. 1: Standard ÖNORM M 7135 (2002) and DIN 51731 (1996) – heat briquettes

Analytic Index	Unit	ÖNORM M 7135	DIN 51731
Length	cm	≤5 x D	< 5
Diameter	cm	4 ≤ D < 10	0.4 to 1
Water content	%	≤ 10.0	≤ 12.0
Heat value*	$MJ.kg^{-1}$	≥ 18.0	17.5 to 19.5
Ash content*	%	≤0.50**	≤ 1.5
Nitrogen content*	%	≤ 0.30	≤ 0.3
Sulphur content*)	%	≤ 0.04	≤ 0.08
Chlorine content*)	%	≤ 0.02	≤ 0.03
Particle density	$g.cm^{-3}$	≥ 1.12	1.0 to 1.4

MATERIALS AND METHODS

The biomass used for this research was from the late-winter pruning. The briquettes made of vine cane could be used as an alternative fuel to other fossil fuels. Because the vine cane can be mixed with other agricultural wastes they can be a valuable support for rural sustainability (economic, energetic) in the Republic of Moldova. The vine cane is pruned every year which offers regular supply with a valuable biomass.

The material used for tests was gathered in the Czech Republic and also in the Republic of Moldova which was for comparison reasons.

Vine cane pruning is a crucial component of the grape production system which provides a mechanism for maintaining the vineyard training system and selecting the fruiting vine branches. The annual pruning removes the previous year's fruiting canes leaving one-year-old canes only. The training system is designed to encourage the production of new fruiting canes at specific positions on the vine – the branches. The pruning of grape vines can be done at any time between the late winter days to the spring. For example, in Moldova's southern region the common time for pruning is at the end of February and the beginning of March. Any later pruning usually provokes the vines to "bleeding" from the injuries caused by the cut (it is not harmful to the vine).

There are plenty of methods used for training vines which vary according to the region, type of grapes and to the equipment used for pruning. The average mass yield from the vine plant depends on different factors, the most important of them being sufficient precipitation during the vegetation period.

To measure the amount of pruned vine cane, we used a common digital scale and a canvas sack. In order to obtain representative results, we pruned three trunks, one at the beginning, one in its middle and one at the end of the vineyard. The typical natural feature of the vine cane biomass is relatively high and includes a very variable amount of the water. This is a very serious obstacle for energy utilisation, because higher moisture content in the fuel generates the following:

- *Decrease of the ratio between available heat and biomass weight (heat of combustion);*
- *Evaporation of the higher humidity consumes a part of the heat (decrease fuel efficiency);*
- *Dramatic decrease of the boiler efficiency causing higher emissions and chimney energy losses.*

Because of the above, it is necessary to know the actual content of humidity in the pruned vine cane. The optimal water content for biomass briquette production is 10–15 per cent. Because the water content in biomass can vary from 15 to 50 and more percent, the vine cane biomass must be dried – and ideally, naturally. Any energy inputs into the drying process raises the price of the final product.

The classic laboratory drier ECOCELL 111 was used to determine the water content in the crude vine cane, while the laboratory scale BOECO BBL 51 was used for weight measurements. After being gathered in the vineyards, the vine cane was sorted according to the variety and year of pruning. The sorted groups were numbered and crumbed into small pieces to be dried. Before the drying process started, the weight of the fresh (humid) biomass was measured, and again after drying in the electric drier. The material was dried at a temperature of 105°C for 3 days.

The utilisation of agricultural wastes is sometimes constrained, due to their uneven and troublesome characteristics. The process of biomass compaction into a higher density than the original raw material is known as densification (or briquetting). Converting residues into a densified form has the following advantages:

– *increase of the net caloric value per unit volume;*
– *such a product is easy to transport and store;*
– *this process helps to solve the problem of residue disposal;*
– *the produced biofuel is uniform in size and quality.*

The raw materials must be properly prepared before briquette production is started. As stated above, the gathered raw material (vine cane) was dried in its natural form as pruned from the vines. After its water contents had reduced (less than 20 per cent) the cane was chopped by a wood chopper. For this operation a disc wood chopper (crusher) PEZZOLATO – 110 MB at the Research Institute of Agricultural Engineering was used. When the same process was done in Moldova, the Bystron wood chopper (crusher) PIRBA was used at the State Agrarian University of Moldova. The raw material had to be chopped in order to obtain pieces of around 10 mm in diameter. For further material processing a HAMMER MILL ŠV 15, company STOZA with sieves with a hole diameter 15 mm was used

The properly prepared material, with water content lower than 15 per cent was than pressed into briquettes. The only available briquette press machine was the HLS 50, from Briklis Ltd., and located in the Research Institute of Agricultural Engineering. An alternative briquette press was the BrikStar 50, also from Briklis, Ltd., and located in State Agricultural University of Moldova.

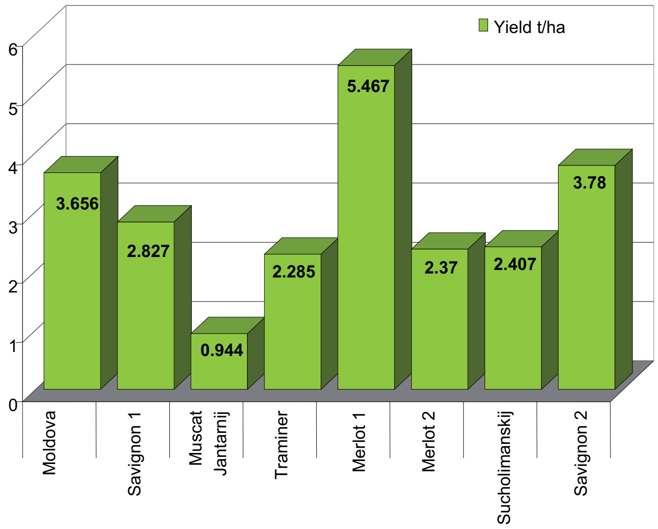
The raw material was pressed in a pure state or with different waste materials as available from rural areas. This material was: *straw*, *hay*, *flax residue* and *maize*. Mixtures of different wastes or agricultural wastes with fuels (coal powder), often improve the calorific and burning properties of materials which are normally not very combustible. The additives can increase the amount of bio fuels.

After the briquettes were produced their properties were measured – especially to obtain the fuel heating efficiency. The testing of vine cane briquettes was divided into three steps:

– testing the mechanical properties of the briquettes;
– energetic properties of the briquettes;
– fuel emission parameters.

1. Mechanical cohesion is a very important mechanical property in terms of the abrasion resistance. A low level of cohesion can cause many problems when handling, transporting and storing briquettes. The briquettes produced were tested for mechanical cohesion with a universal shredder press ZDM – 5, available at the Faculty of Engineering, Czech University of Life Sciences Prague. The measurement was tested by increasing the pressure on the press between two parallel plates. The plates were applied at a speed 6 mm per minute until there was a visible destruction of the material. The parameters of the briquettes measured were the change of diameter and length, both before and after pressing. The change of weight could also be measured (16).
2. The energetic properties of fuel produced from vine cane briquettes is an important characteristic for every quality fuel, and influences their future utilisation. The briquettes produced were tested in the laboratories of the Institute of Chemical Technology Prague. The analysis of the briquettes concentrated on the: contents of water, volatile and non-volatile substances, and ash contents. Other analyses of the same rank were the total heat value and fuel efficiency as well as analyses of the contents of some chemical elements such as C (carbon), H (hydrogen), O (oxygen), N (nitrogen), S (sulphur), and Cl (chlorine). These properties are important for trouble-free function of burning equipment (17) (18).
3. The last parameters tested were the gaseous emissions. For burning vine cane briquettes some types of classical heat storage stove were used. The stove had to be homologized according to the Czech State Norm EN 13229. When burning, the emissions were analyzed with a TESTO 350 XL emission analyzer, equipped with standard sensors for testing of O_2 (oxygen), CO (carbon monoxide), CO_2 (carbon dioxide), NO (nitrogen oxide), NO_2 (nitrogen dioxide) and NO_X (nitrogen oxides). All the results were compared to the CSN EN 13229 technical standard (19).

Figure 1: Average yield of vine cane pruning in south of Moldova (Region Albota and Taraklija) – Spring 2008 in t/ha (region Albota and Taraklija)



RESULTS AND DISCUSSION

The vine cane was collected in two regions in the south of Moldova – Albota and Taraklija. Both regions are typical agricultural lands with vine production as a main crop. Figure 1 show the results of field collection.

The yield from different varieties with different typical properties of growth varied from 0.944 up to 5.467 tons per hectare. These results were affected by a very dried season in the year 2007. We believe that the yield could be 20% higher.

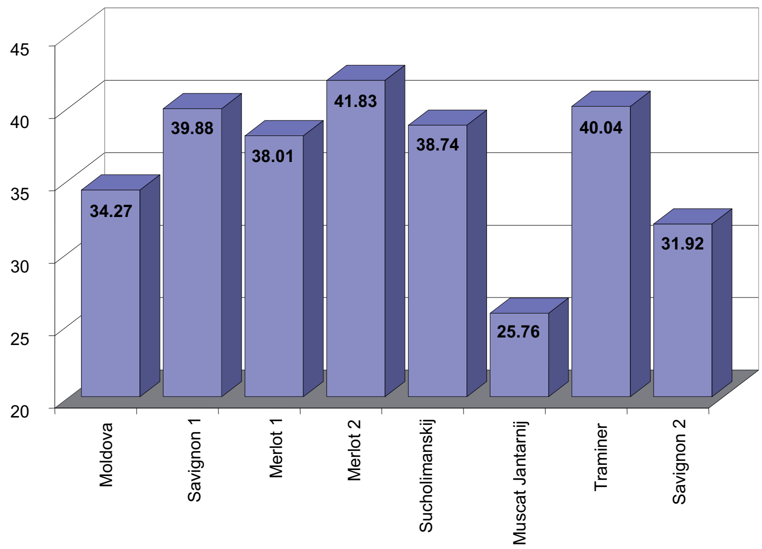
In Figure 2 we see the content of water in vine cane directly after pruning procedure.

This results show a lower content of water when compared to wood or other wooden biomass, but we suggest that these values were affected by the same factors as the yield of biomass.

Figure 3 represents the moisture content in vine cane material which was collected from pruning in spring 2007. This material was pruned one year before and was exposed to wetter conditions directly in the field, piled in a 1.5 meter high heap for approximately a whole year.

The content of water in vine cane which was naturally dried under an open sky can reduce the cost of vine cane briquette production. Usually the drying process by biomass preparation is one of most expensive processes.

Figure 2: Moisture content in biomass – pruning year 2008



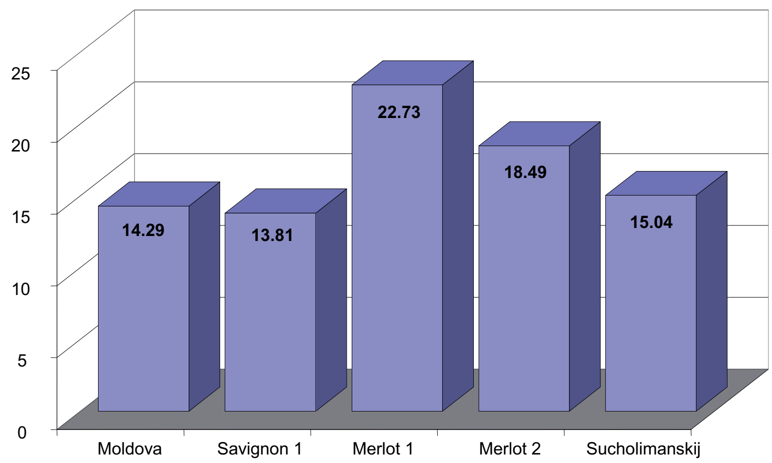


Figure 3: Moisture content in biomass – pruning year 2007 (%)

To increase the amount of biomass, and to use other agricultural wastes, we used hay, straw, maize straw and flax.

After pressing various different mixtures of vine cane, mechanical testing was performed. In Figure 4 and 5 the mechanical properties of heat briquettes from vine cane and its mixtures can be seen.

The next parameters which we estimated were fuel – energetic properties of vine cane fuel briquettes. We transferred the testing material to a laboratory of the Institute of Chemical Technology Prague. They provided us with complete information about the content of water, volatile and non volatile combustible, chemical compounds and ash content (Figure 6).

Table 2 shows content of most important chemical compounds in some materials and prepared fuel briquettes.

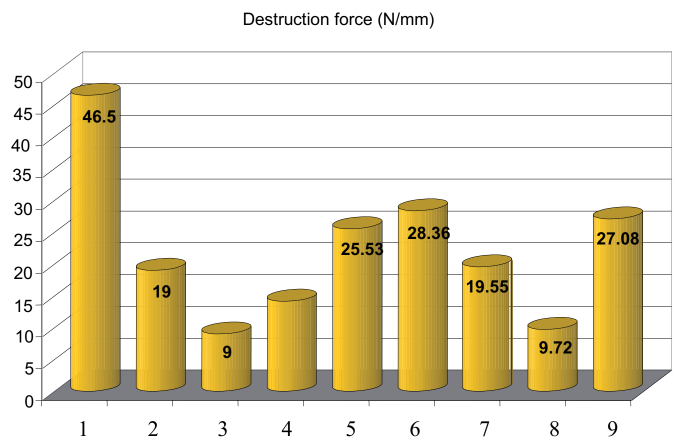


Figure 4: Mechanical properties of vine cane briquettes and its mixtures

1 = Wooden Briquettes BIOMAC
2 = Hay
3 = Straw
4 = Vine cane scrap
5 = Vine cane shredding
6 = Vine cane scrap + hay (ratio 1:1)
7 = Vine cane scrap + straw (ratio 1:1)
8 = Vine cane shredding + hay (1:1)
9 = Vine cane shredding + straw (1:1)

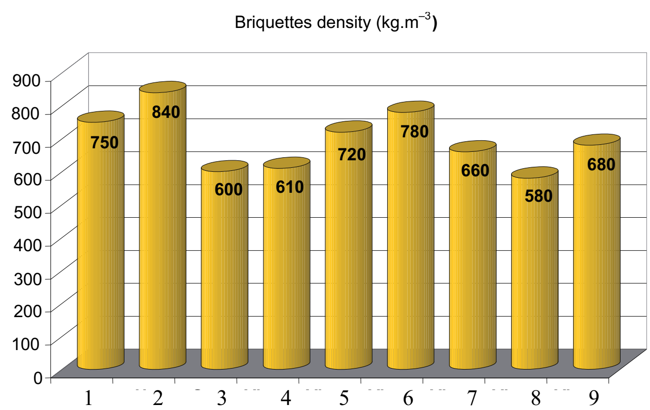


Figure 5: Mechanical properties of vine cane briquettes and its mixtures

1 = Wooden Briquettes BIOMAC
2 = Hay
3 = Straw
4 = Vine cane scrap
5 = Vine cane shredding
6 = Vine cane scrap + hay (ratio 1:1)
7 = Vine cane scrap + straw (ratio 1:1)
8 = Vine cane shredding + hay (1:1)
9 = Vine cane shredding + straw (1:1

Figure 6: Energy parameters of some fuel briquettes

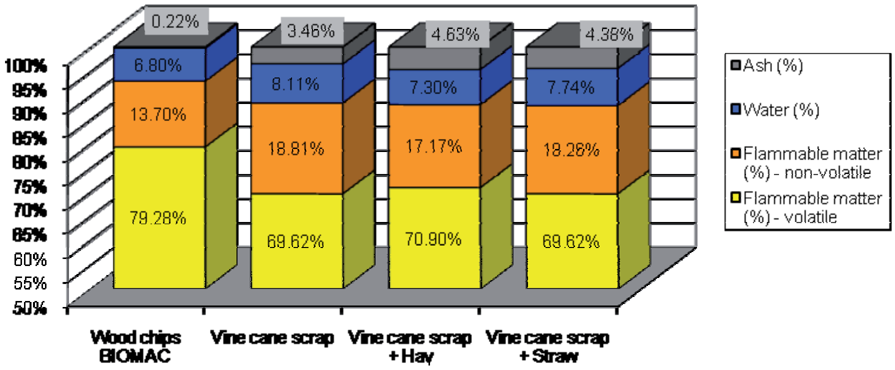
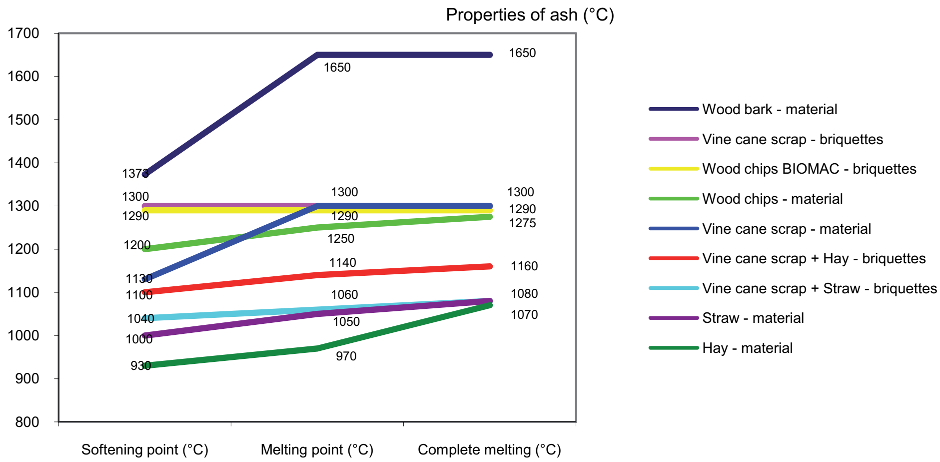


Figure 7: Properties of ash by different material and fuel briquettes



This results show that the biggest differences between the tested material and fuel briquettes appear to be the content of ash, water, sulphur and chlorine. It should be noted that all the tested parameters are in tolerance with Austrian and German standards.

Tab. 2. Content of some chemicals in raw material and fuel briquettes (%)

	Ash	Water	Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Chlorine
Önorm M7135 (2002)	0.50	10.00	no data	no data	no data	0.30	0.04	0.02
DIN 51731 (1996)	1.50	12.00	no data	no data	no data	0.30	0.08	0.03
Wood chips BIOMAC – briquettes	0.22	6.80	46.69	6.81	39.46	0.10	0.02	0.03
Vine cane scrap – material	3.21	8.33	43.88	6.22	37.68	0.61	0.04	0.18
Vine cane scrap – briquettes	3.46	8.11	44.70	6.42	36.38	0.89	0.04	0.07
Hay – material	5.08	4.63	42.86	6.34	40.57	0.44	0.08	0.20
Vine cane scrap + Hay – briquettes	4.63	7.30	43.67	6.49	37.28	0.58	0.05	0.13
Straw – material	5.01	4.65	42.85	6.20	40.64	0.57	0.08	0.25
Vine cane scrap + Straw – briquettes	4.38	7.74	44.21	6.41	36.70	0.52	0.045	0.077

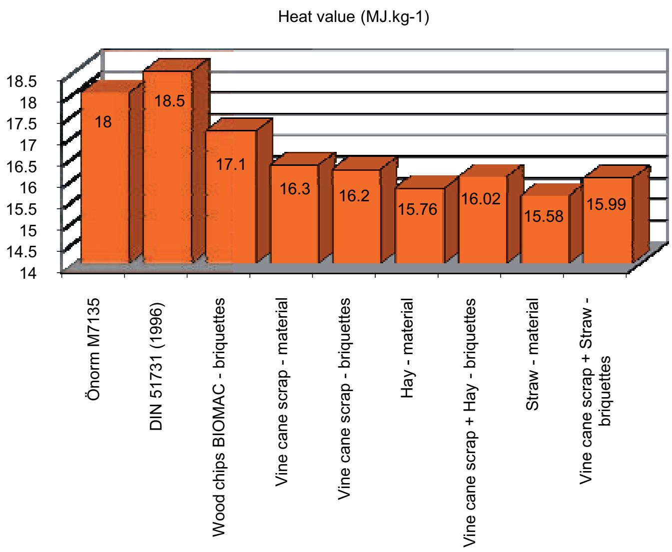


Figure 8: Comparison of heat value by different material and fuel briquettes

Figure 9: Concentration of CO emission by 13% O_2 (mg/m^3)

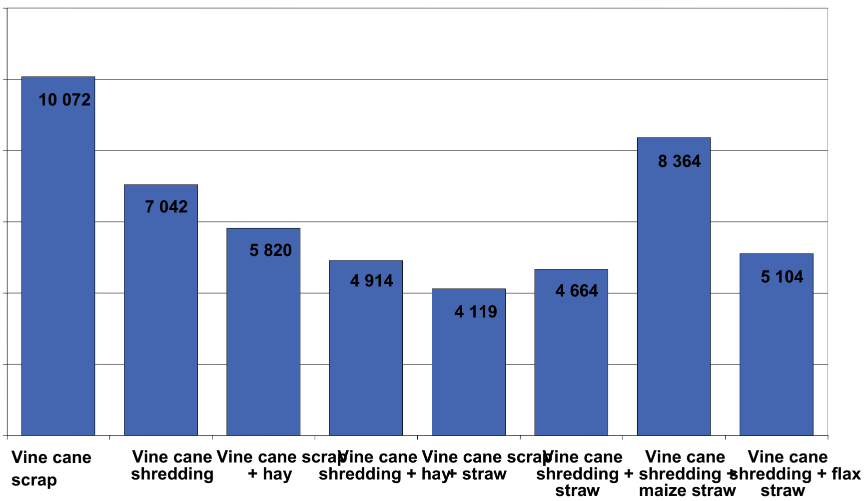
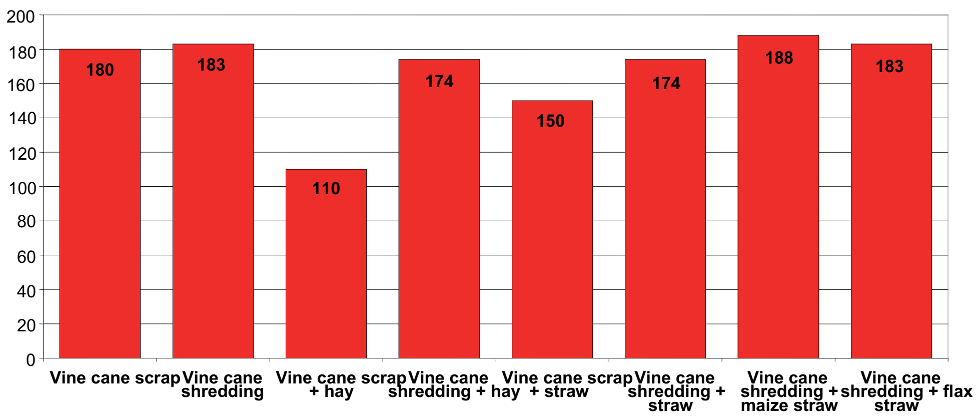


Figure 10: Concentration of NO_X emission by 13% O_2 (mg/m^3)



The control of emission CO and NO_X is important from the standpoint of greenhouse gasses and from the standpoint of quality of burning. The results in Figure 10 show that fuel briquettes from mixed material have a lower concentration of CO then pure vine cane material. Tested fuel briquettes from mixed material show parameters given by class 2.

It is important to assess the concentration of NO_X. Regarding its use for a common stove with lower heating output, there are no limits for the concentration of NO_X, and all tested fuel briquettes show values lower than 200 $mg.m^3$.

CONCLUSION

According to the results of the research and their discussion the following can be considered:

– the vine cane waste can be competitive raw material for fuel briquettes production; the potential of this very good substitute for the expensive fossil fuels can be estimated on 450 000 tons collected every year in Moldova. It can be augmented by mixed fuel briquettes in the ratio 50 : 50 (vine cane with hay, straw, or maize straw);
– through mixing the vine cane with low quality agricultural waste materials such as hay and straw the quality and quantity the fuel briquettes can essentially improve in terms of contents of ash, sulphur and chlorine; the hay and straw additives reduces contents of water in fuel briquettes, too;
– average heating value was lower than the classical wooden briquettes (over 16 MJ/kg);
– measured briquettes showed optimal CO emissions in a range of the classes 2 to 3; they showed a very low CO emissions, too.
– on the basis of the above conclusions a follow up of preparation and testing of other agricultural waste materials has been recommended, such as sunflower straw and rape straw. Also energy plants as hemp and sorrel should be considered for further research activities. The influence of raw material particle size on quality of fuel briquettes should also be object to testing and assessment.

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