Biblid: 1821-4487 (2010) 14; 2; p.69-71
UDK: 634.63, 665.327.3

Original Scientific Paper
Originalni naučni rad

ORGANIC WASTE AFTER WINE AND OLIVE OIL PRODUCTION AS RAW MATERIAL FOR THERMAL ENERGY GENERATION
OTPAD NAKON PROIZVODNJE VINA I MASLINOVA ULJA KAO SIROVINA ZA DOBIJANJE TOPLINSKE ENERGIJE

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ABSTRACT

The olive and grape agro-industrial sectors have a major economic importance in Croatia. Utilization of that kind of waste is legally regulated in the EU, and in the Republic of Croatia with Rulebook of ecological production in plant growing and plant material production it is defined that agricultural waste cannot be reused without prior treatment. Grape marc, as well as olive cake, can be a valuable raw material, and it can be well used in energy generation.

In this paper, the energetic potential of organic wastes after wine and olive oil production will be investigated, with the purpose of obtaining thermal energy. By laboratory pelleting of these organic wastes, a product of high density and better volumetric energy value will be produced, which will result in decrease of transport and storing costs, and better combustion quality when producing thermal energy. The quality of such pellets as biofuel cannot be defined without determining their physical and chemical properties, namely combustion characteristics. The energetic potential of wine grape and olive cake will be determined as well as the possibility for its utilization as an energy-generating product in producing thermal energy.

***Key words**: grape marc, olive cake, pelleting, energetic value, thermal energy.*

REZIME

Industrija proizvodnje vina i maslinovog ulja ima velik značaj za poljoprivredu Republike Hrvatske. Ukoliko se komina nekontrolirano odlaže, može biti opasna za zdravlje ljudi i životinja, uz negativan utjecaj na okoliš, posebice zbog dugotrajne aerobne fermentacije uz razvijanje neugodnih mirisa. Komina masline, koja preostaje ekstrakcijom ulja iz maslina, je kašasta masa ostataka pulpe i koštice ploda, koja sadrži veliku količinu organske tvari, među kojima je i oko 4% ulja zbog kojeg komina masline ima velik potencijal u proizvodnji energije. Vinska komina se sastoji od približno 55-60% vode (ovisno o primijenjenoj tehnologiji), dok ostatak čini suha tvar. Upravo zbog visokog udjela vode, ovaj organski ostatak ima vrlo ograničeno vrijeme skladištenja, od svega nekoliko dana. Iz tog razloga, vinska komina mora proći kroz proces dorade, odnosno otklanjanja suvišne vode (primjerice sušenjem zagrijanim zrakom), kako tijekom dugotrajnijeg skladištenja ne bi došlo do značajnijih negativnih promjena u njezinom kemijskom sastavu. U ovom radu će se istražiti energetski potencijal dorađene vinske i maslinove komine u svrhu proizvodnje toplinske energije. Kao najjednostavniji postupak obrade komine za potrebe energije je peletiranje. Najveći značaj peletiranja biomase u proizvodnji energije je dobivanje proizvoda veće gustoće, bolje volumetrijske ogrjevne vrijednosti, što ima za posljedicu smanjenje troškova transporta i skladištenja. Utvrdit će se energetski potencijal komine nakon proizvodnje vina i maslinova ulja, te mogućnost njezinog korištenja kao energenta u proizvodnji toplinske energije.

***Ključne riječi**: komina, peletiranje, energetska vrijednost, toplinska energija.*

INTRODUCTION

Because of its specificity from agricultural production, organic waste can potentially be harmful for the environment. One of those branches of agricultural production are also wine and olive oil production, in which organic waste, as the most important byproduct has not been adequately taken care of. If disposed improperly, this waste can be harmful for human and animal health and have a negative impact on the environment, especially because of long lasting aerobic fermentation, which leads to development of bad smell (Roig et al., 2005). Since wine making and olive oil industry are more and more inherent in agricultural production of the Republic of Croatia, their utilization becomes a great issue, especially on the islands. For that reason, the need for finding different solutions of treatment and effective utilization of that kind of waste is imposing itself, since present ways of utilization did not give the expected results (Masghouni and Hassairi, 1999). However, the greatest wine makers and olive oil producer's problem are large quantities of organic waste, which, if not treated properly, can present a major risk for the environment, starting with surface and subsurface pollution and unpleasant smell which are developing during its degradation. Namely, large piles of organic waste attract pests and flies and can lead to appearance and spreading of different kind of diseases.

Olive cake that remains after oil extraction from olives is a mushy mass of remains of pulp and fruit seeds, and it contains a large quantity of organic matter, with 4% of oil, because of which olive cake has a great potential for energy production (Niaounakis and Halvadakis, 2006). It is estimated that about 6.8 tons of such waste remains in the EU per year (Taralas and Kontominas, 2006). Approximately 30,000 t of olives are produced in Croatia every year, resulting with around 12,000 t of fresh olive cake. Olive cake consists of fruit peal, pulp and pit parts, and the main chemical components are cellulose, proteins, water, polyphenols and oil. Water content in olive cake varies accordingly to olive processing; when olives are pressed, water content is lower than in the case of centrifuge processing. Protein content is mostly low, and amino acid composition is similar to the one of barley kernel (Niaounakis and Halvadakis, 2006).

Grape marc contains approximately 55-90% of water. Because of such high water content, this organic waste has a very limited storing period, only a couple of days. For that reason grape marc needs to be treated, that is it needs to be dried, so it wouldn't go through considerable negative changes in chemical composition, during long-term storage (Gögüs and Maskan, 2006).

Furthermore, problem has arisen due to more restricted European regulations in the last decade; disposal of organic waste containing more than 5% of organic carbon is prohibited.

This kind of waste is disposed at landfills, what makes the whole procedure uneconomical. For that reason, a number of ways for agricultural waste disposal have been proposed in the last couple of years, such as its utilization in feed production. Olive and wine organic wastes are, in general, inappropriate as a ruminant feed, due to their low nutritive value and poor digestibility, as well as high lignin, potassium and phenol content. Hence, other ways of their recycling and reuse are in uplift. On the other hand, due to its high organic matter content and potassium level, as well as considerable levels of nitrogen and phosphorus, this material can be used as a bio-fertilizer, but also in energy generation (Arvanitoyannis et al., 2006a).

At the moment, organic waste after wine and olive oil production is not used that much, although it presents a valuable raw material, and in accordance with the *Rulebook of ecological production in plant growing and plant material production*, in Croatia, agricultural waste cannot be used without its prior treatment. Hence, the possibilities of utilization of this waste as an energy source are being more and more investigated. Energy generation from wine and olive wastes can be accomplished in two ways; biochemically – through anaerobic fermentation with biogas production, and thermo-chemically – through combustion in biomass furnaces.

If grape marc is used in thermal energy production by combustion, one of the major technical and technological problems at its energy exploitation is low energy value by mass unit (low bulk density), which requires large storage rooms. The simplest way to process grape marc for energy generation is pelleting. Pelleting is defined as a thermo-plastic procedure, which modifies the particles by pressing them, where finely parted particles of flowery material are forming compact pellets, suitable for handling. The major significance of biomass pelleting in energy production is obtaining a product with higher density, better volumetric value, which consequently leads to lower transport and storage costs (Celma et al., 2007).

Because of the above-mentioned properties, quality utilization of agricultural organic waste has a great importance in terms of better economical balance in olive oil and wine production. In contribution to agricultural residues utilization goes the fact that the disposal of this kind of wastes at the landfills is charged and it additionally burdens the economical balance of a distinct production (Arvanitoyannis et al., 2006b). Hence, the objective of this paper is a new ecological and energetical approach in dealing with problems of organic waste utilization as a by-product in olive oil and wine production.

According to larger ecological awareness, a new possibility of total utilization of organic waste will be investigated, in a way that the organic waste with lower water content will be used as raw material in thermal energy generation. As agricultural producers mostly don't have experience in preparation and utilization of their waste in energy production, the main objective of this paper is introducing pelleting as an ecological and energetic way of utilization of grape marc and olive cake, which remains after wine and olive oil production. The advantages and disadvantages of pelleting process will be presented, as well as marc pellet utilization in thermal energy production. Today, problems arisen regarding biofuels from agricultural residues utilization are of a great interest; hence the results of this research will contribute to overall scientific cognitions about using biomass as an energy-generating product.

MATERIAL AND METHOD

Grape marc used in this research was a residue after wine production from sort Žlahtina, grown on the Island of Krk, while olive cake used in the research was collected directly from oil factory, and the sort was Istarska Bjelica, grown in an ameliorated plantation in North-western Istria, near Novigrad. Collected samples of wine marc and olive cake were, after chemical composition analysis, dried to 12% moisture content.

Procedures, conducted prior to pelleting process, were drying of high moisture content material followed by milling and conditioning. Drying process was conducted because it significantly increases the energetic value of biomass. For that reason, laboratory drying of organic wastes was conducted at the temperature of 40°C which doesn't have negative influence on the chemical characteristics of wine marc and olive cake. After the process of drying, milling and conditioning, material was pelletized and cooled.

Pellets, produced from biomass by thermal processing, are properly sized with 5 to 15 mm in diameter, and 10 to 30 mm in length. The form of pelletized biomass has a number of advantages during combustion for thermal energy generation, such as automatic raw material input and better combustible characteristics during combustion of pelletized biomass. The quality of a pellet as biofuel cannot be defined without determination of its combustible characteristics, such as higher and lower energy value. For the larger combustion systems, the pellet hardness was of a less importance; however better pellet properties ensure better manipulative properties as well as transport and storing cost reduction.

Physical and chemical properties of biomass have big influence on the pelleting process and quality of the obtained pellets. In order to determine the pellet combustion properties, higher and lower energy value, fixed carbon, volatile matters, coke and combustible matters were analyzed, as well as moisture, ash, carbon, hydrogen, nitrogen and sulphur content, with the analyses of pellet stability and determination of off-gas composition during combustion (ISO 5068; ISO 1171; ISO, 562; ISO 1928).

RESULTS AND DISCUSSION

When fresh, grape marc and olive cake cannot be pelletized. Because of that the latter material has to be dried to approximately 12% of moisture content, so the pelleting process could be efficiently conducted, even without the use of additional binders. The researched material was dried in a laboratory drier to the above mentioned moisture content, and then milled on the hammer mill, in order to obtain adequate samples for the pelleting process that followed. Carbon, hydrogen, nitrogen and sulphur content were determined after drying and milling (Table 1).

Table 1. Analyses of total carbon, hydrogen, nitrogen and sulphur

Sample	Total nitrogen (%)	Total carbon (%)	Total sulphur (%)	Total hydrogen (%)
Grape marc	1,86	50,93	0,32	5,45
Olive cake	0,83	58,70	0,19	6,62

Only dry and cold pellets have the mechanical properties necessary for manipulation without serious damages and usage as a fuel. Such pellets are obtained after cooling in a refrigerator. Table 2 shows the pellet, moisture content, density and energetic value. The obtained values of moisture content and density are within the limits available in the literature data.

Energetic (heating) value of a fuel is the amount of heat released after complete combustion of a fuel, when off-gases are cooled to a temperature of air and fuel input. As can be seen from the Table 2, researched samples had energetic value which were even greater than that released after combustion of dark coal (17,000 kJ/kg), which indicates that both organic wastes are highly valuable energy-generating products. Another benefit of such energy production is the fact that by producing energy from biomass, i.e. from renewable sources, the producers have the right to a stimulated price by selling the energy they produce. Today, when fossil energy supplies are decreasing, it is abso-

lutely necessary to find new energy sources, which can be found in biomass waste such as agricultural organic wastes, which also leads to their further utilization.

Table 2. Density, water content and energy value of produced pellets

Sample	Pellet density (g/cm^3)	Water content after peletting (%)	Lower energetic value (MJ/kg)
Grape marc	1,265	6,24	19,26
Olive cake	1,345	7,35	20,47

It is very important that by combusting grape marc and olive cake, no sulphur is released, as it has a negative influence on environment and it makes dross after burning. If there is SO_2 in off-gasses released during combustion, it can cause problems if the plant is build inside of inhabited area, due to its unpleasant smell (Brkic and Janic, 2002) In that case, released gasses have to be purified, which makes the whole procedure less economical. High volatile content in dry, and almost ash-free mass, enables a flawless usage in furnaces. Table 3 shows the chemical composition of investigated sorts of grape marc and olive cake.

Table 3. Chemical composition of the investigated sorts of marc and cake

Content	Grape marc pellets	Olive cake pellets
Moisture (%)	6,09	7,55
Ash (%)	4,92	0,86
Volatiles (%)	71,18	74,46
Combustibles (%)	91,98	91,77
Cfix (%)	20,80	17,31
Coke (%)	25,72	17,99

Results obtained in this research are implying that the value of organic residues,, obtained after wine and olive oil production, should be included in calculation of wine and olive oil production cost–effectiveness. That kind of fuel, of course, demands a special furnace. However, by knowing all parameters mentioned above, a proper furnace, in which the biomass will be optimally utilized, can be chosen. Direct biomass and organic residues combustion, is an established technology for biomass conversion in thermal energy on the commercial level.

Hot gasses, which are released after biomass combustion in a controlled environment, can be used directly for drying, but their heat is more often transferred to the air, water or steam. Combustion is conducted on the grille, which enables mixing of fuel and controlled airflow. Grills are constructed in a way so that biomass is inserted at the one end and burnt in a layer, which is gradually moving towards a system for ash disposal on the other end; this technology enables utilization of different types of fuels with different properties (moisture content and particle size).

Today's development is directed towards a maximal greenhouse gas decrease, and that tendency has led to development of a new technology of burning in a fluidized bed, as an alternative for systems with a grille. In a fluidized bed plant, fuel burns in a layer of inert material with airflow input. The layer is constantly mixing which brings to fast combustion and heat exchange, where problems caused by difference between fuels are diminished (El Bassan, 1991; Beronja, 1994).

CONCLUSIONS

Grape marc and olive cake quantities, which remain after wine and olive oil production, give convincible reasons for cost-effective commercial utilization as a renewable energy source. Elaborated procedures of their utilization for energy generation may become an additional source of income for wine and olive oil producers and help them have a positive economical production balance. In accordance with the energetic potential and optimum treatment, grape marc and olive cake are expected to have an excellent work effect in modern systems of thermal energy production for heating private and business facilities. By applying pellet production and its utilization technology, energy effectiveness of agricultural producers will be improved. Moreover, domestic energy production will be increased, with a positive effect on the environment, new market will be opened and general development of the rural areas will be promoted.

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Iso methods: ISO 5068 (Determination of moisture content); ISO 1171 (Determination of ash); ISO, 562 (Determination of volatile matter); ISO 1928 (Determination of gross heating value).

CEN methods: CEN/TS 15104:2005 (Determination of carbon, hydrogen and nitrogen content) CEN/TS 15289:2006 (Determination of sulphur content).

Received:31.03.2010. Accepted:03.04.2010.