Research regarding the quality of bioethanol obtained from the sugarbeet cultivated in an experimental field from Transylvania region

Simona-Clara BARSAN¹, Ancuta-Maria PUSCAS¹, Emil LUCA², Georgia Mihaela SIMA³

¹INCDO-INOE2000, ICIA, 67, Donath St., 400293, Cluj-Napoca, Romania
(e-mail: centi@icia.ro)
²University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania
³Bucharest Chamber of Commerce and Industry, Bucharest, Romania

Abstract

The paper presents some of the results obtained in the experiences carried out within the sugar beet experimental field located in Viisoara village, Cluj County. In the agricultural year 2007 – 2008, one conducted several researches on sugar beet crop technology and its influence on the energetic parameters of the obtained bioethanol.

The bioethanol samples obtained from each of the experimental plots were analyzed in laboratory conditions at the Research Institute for Analytical Instrumentation Cluj-Napoca. One determined all energetic parameters of each bioethanol sample, according to the SR EN 15376 requirements, in terms of using the bioethanol obtained during the carried out research as a component of automobile fuel, according to SR EN 228:2008 standard.

The energetic parameters of the bioethanol obtained in laboratory conditions, by fractional distillation, were mostly in the limits required by SR EN 15376 and therefore considered to be satisfactory.

One concluded that the experimental factors (such as irrigation regime, fertilization and sugar beet variety) as well as their graduations do not have any influence on the characteristics of bioethanol, but only on its obtained quantity.

Key words: sugar beet, bioethanol, energetic parameters

Introduction

The planet’s traditional energy sources are represented by fossil fuels (oil, gas and coal), radioactive compounds and other sources, such as sun, waterfalls, wind etc., which allow the production of mechanical work and heat. Out of these, the fossil fuels are considered as the main energy source, but they are irreversibly limited.

The decrease of the fossil fuels deposits, the continuous increase of the crude oil barrel price and the high level of environmental pollution resulted from burning conventional fuels are the premises for replacing hydrocarbon based fossil fuels with renewable energy sources. Thus, several variants have been proposed for partial or total replacement with bioethanol and biodiesel (Naghiu et al., 1997).

Bioethanol is by far the most important biofuel, due to, on one hand, its well defined technological processes and, on the other hand, the wide range of the used raw materials (Naghiu et al., 1997). Obtaining bioethanol from sugar beet is the most advantageous, because the production of bioethanol from any other raw materials involves higher costs, having here in view the energy consumption and the further higher technical and technological requirements for hydrolysis. Therefore, the goal of the carried out research is a complex one; besides analyzing the influence of the irrigation regime and fertilization level on sugar beet productions in the conditions of the Transylvanian Plain, one intended to analyze their effect on the energetic parameters of the obtained bioethanol.
In view of achieving higher quality sugar beet productions, the application of different crop technologies in Transylvania is the answer for reinforcing the need for analysing each energetic parameter of the final product, namely the bioethanol (Naghiu et al., 2003). Moreover, continuous research made in the agricultural field as well as in the biofuels sector contribute, on one hand, to the development of appropriate technological measures, for ensuring proper management of water needs in relation with plants demands and, on the other hand, to meet the ever-increasing needs of the biofuels market. (Naghiu and Burnete, 2005).

Material and methods

The experiences conducted on the sugar beet crop in order to determine the influence of the technological factors on the energetic parameters of the obtained bioethanol were carried out in the experimental field located in Viișoara Village, Cluj County, on the left bank of the Aries river. In terms of physical-geographic location, the studied area is a part of the Transylvanian Depression - S-SW extremity of Transylvanian Plain; the geographical coordinates of the experimental field are 46°34′16″N and 23°53′44″E, situated at an altitude of 382 m.

Following the Koppen classification system, the studied area is located in the D.f.b.x. climate province (D= boreal climate, rainy, with cold winters and snow; f= sufficient precipitation through the year; b= average temperature of the warmest month below 20°C; x= precipitation at the end of winter), characterized by a rainy climate with cold winters and precipitation through all year, registering a maximum at the end of spring and a minimum at the end of winter (Luca and Nagy, 1999).

The soil on which the experiences were carried out is typical for the analyzed area, namely chernozem leachate on marl clay, with ground water above 10m depth, which makes it proper for sugar beet cultivation, knowing that it is medium supplied with nitrogen (Luca et al., 2008).

The experiences aimed to analyze the behavior of 3 sugar beet varieties (Libero, Clementina and Leila) in 2 different irrigation regimes (non-irrigated and irrigated at the minimum threshold of 50% of the active humidity interval), at 3 different fertilization levels (NPK 250 + 55 kg N/ha, NPK 250 + 65 kg N/ha and NPK 250 + 75 kg N/ha), Luca and Nagy, 1999.

The experiences included a total number of 3 repetitions, with a number of 18 studied variants, consequently resulting a number of 54 experimental plots (Saulescu, 1959; saulescu and Saulescu, 1967).

In order to determine the energetic parameters of the bioethanol, from each of the 54 experimental plots, one prevailed sugar beet samples, which were weighed and introduced in labeled bags. Every sample was prepared and submitted to the fermentation process. During the fermentation process, one applied both Ethanol Red yeast (Saccharomyces cerevisiae), used especially at industrial level in order to obtain alcohol due to its high tolerance to alcohol and E 491 emulsifier.

Samples weighing 15 kg each were introduced in barrels labeled according to the 3 experimental factors taken in view, namely the irrigation system, fertilization and sugar beet variety. The dilution was carried out by using fresh hot water at a temperature of 70 -80°C, in a 2:1 ratio (2 parts water to 1 part sugar beet pulp) in order to facilitate extraction. After cooling the mixture at a temperature of 30°C, one introduced yeast and everything was thoroughly mixed for homogenization.

In order to characterize the bioethanol obtained from the sugar beet cultivated in the experimental field of Viișoara, one used the following methods:

- Actual alcoholic strength determination by pycnometry (EC/2870/2000);
- Methanol and higher alcohols determination by gas chromatography (EC/2870/2000);
- Water Determination Test (Karl Fischer Method) (SR EN 15489:2008);
- Inorganic chloride determination by ion chromatography (SR EN 15492:2009);
- Copper determination by graphite furnace atomic absorption spectrometry (SR EN 15488:2008);
- Total acidity determination by light indicator (SR EN 15489:2008);
Phosphate determination by ammonium molybdate spectrophotometric method (SR EN 15487:2008);
Non-volatile matter determination by gravimetric method (SR EN 15691:2009);

**Results and discussion**

The bioethanol samples obtained from each of the experimental plots were analyzed in the laboratories of the Research Institute for Analytical Instrumentation of Cluj-Napoca. For each sample, one determined the ethanol characteristics according to the SR EN 15376 requirements.

The determination of bioethanol and higher alcohols was performed by gas chromatography, using Agilent 7890N gas chromatograph with a flame ionization detector, GC-FID, where the separation was realized by using the DB-WAX polar capillary column.

The alcohols identified and analyzed in the bioethanol samples are presented in table 1. As the IF1S1 sample (I- irrigated; F1- fertilized NPK 250 + 55 kg N/ha, S1 – Libero variety) was recorded as the highest in bioethanol content, its chromatogram of the compounds is illustrated in figure 1.

<table>
<thead>
<tr>
<th>Table 1. Methanol and higher alcohols identified and analyzed in bioethanol samples</th>
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<tbody>
<tr>
<td>Retention time (minutes)</td>
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<tr>
<td>4.160</td>
</tr>
<tr>
<td>7.993</td>
</tr>
<tr>
<td>9.700</td>
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<tr>
<td>13.942</td>
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</table>

**Fig. 1. Chromatogram analysis of methanol and higher alcohols for the bioethanol sample IF1S1 (I- irrigated; F1- fertilized NPK 250 + 55 kg N/ha, S1 – Libero variety)**

The bioethanol was obtained each time from an initial quantity of 15 kg sugar beet (used as a sample for fermentation).

The quantities of bioethanol obtained were between 1.381 l/15 kg sample, respectively 1.473 l/15 kg sample. Knowing the fact that one can obtain 6.62m³ bioethanol from an average yield of 61.7 t/ha (Bioethanol in Deutschland, Landwirtschaftsverlag Munster), it results a transformation coefficient of 0.107. Within the experiences, the transformation coefficient obtained was lower (0.092 – 0.098), due to several factors:

− non-use of nutrients during fermentation, such as those containing nitrogen which increase the efficiency of bioethanol production;
− distillation carried out in laboratory conditions, without any correction of the liquid obtained.
Conclusions

The values of the bioethanol and higher alcohols content - % (m/m)- determined from samples collected from the experimental plots were situated just above the minimum values allowed by SR EN 15376 – 98.7% (m/m) -, concentration which was obtained through repeated fractional distillation.

The content of higher saturated alcohols (C3-C5) registered a value of 2.0% (m/m), which is way below as compared to the maximum value allowed by SR EN 15376.

In the case of methanol, the determinations were chromatographically performed by using the instrumentation of the Research Institute for Analytical Instrumentation of Cluj-Napoca and its values were below the maximum allowed limit, namely 1.0 % (m/m). For the determination of water content in samples, one used the Karl Fischer apparatus; the repeated fractional distillation, in laboratory conditions, did not allow the decrease of the existing water content in samples below 0.298 % (m/m), which represented the highest registered value. However, the water content in the analyzed bioethanol samples was below 0.300 % (m/m), which represents the maximum value allowed by SR EN 15376.

The determination of inorganic chloride in the obtained bioethanol was performed by using the ion chromatography, by comparing the chromatographic peak of the chromatogram obtained for the sample to be analyzed in aqueous solution to the calibration curve plotted with standard solutions. In this situation, the values were quite high, reaching the maximum level allowed by SR EN 15376 – 20.0 mg/l.

The copper content determined by atomic absorption spectrometry with graphite furnace, resulted in relatively high values, but all below 0.1 mg/kg, which represents the maximum value allowed by the above mentioned standard.

The phosphorus determination within the bioethanol samples obtained from sugar beet was expressed as orthophosphate mass and was carried out by spectrometry using ammonium molybdate. The obtained values were below the detection possibilities of the apparatus (0.058mg/l), therefore, it could not be compared to the limits allowed by the standard. The sulfur determination was performed by fluorescence in ultraviolet, the obtained values being in a range of 6.6 – 10.0 mg/kg, according to SR EN 15376.

The value of the total acidity of the bioethanol samples was determined by titration with a potassium hydroxide solution and using phenolphthalein as color indicator, in order to determine the titration end point. The total acidity was then expressed in equivalent of acetic acid, the resulting values being below the SR EN 15376 limit – 0.007% (m/m), with one single exception – for the NF1S1 sample (N- non-irrigated, F1- fertilized NPK 250 + 55 kg N/ha, S1 – Libero variety), which exceeded the standard maximum allowed value. This situation is explained by the NF1S1 long period of time for fermentation, which favored the start of the acetic fermentation in the detriment of the alcoholic one.

The determination of the total dry extract or total dry residue, which includes all non-volatile matter in the specified physical conditions, was carried out by using the gravimetric method; the recorded values were below the detection limits of the analytical balance (1.2 mg/100 ml).

In the best interest of an efficient alcoholic fermentation, several conditions must be met, such as appropriate trimming of roots before grinding and strictly compliance with the temperature range of the dilution water etc. Also, for future experiences, it is recommended to use a growth factor to stimulate yeasts evolution, as well as the use of nitrogen compounds during the fermentation process to obtain a satisfactory yield of bioethanol.

As a final conclusion, the energetic parameters of the analyzed bioethanol samples framed within the limits imposed by SR EN 15376.

The values obtained in laboratory conditions by fractional distillation, which was several times repeated for achieving the minimum standard limit concentration, suggest that the experimental factors (such as irrigation regime, fertilization and sugar beet variety) and their graduations do not have any influence on the characteristics of bioethanol, but only on its obtained quantity.

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