THE COMPARISON OF RAPESEEDS' OILS FROM HYBRID AND OPEN-POLLINATED VARIETIES BY THEIR HEATING VALUES IN THE ASPECT OF DIESEL UTILIZATION

Eszter Sárközi, László Jánosi
Institute for Mechanical Engineering Technology,
Faculty of Mechanical Engineering, Szent István University, Gödöllő, Hungary
www.geti.gek.szie.hu

Abstract The rape is one of the suitable plant species for biofuel feedstock in Hungary. Currently there are over 100 admitted rape sorts recorded in Hungary and their oils' application as biodiesel proposes new aspects of evaluation. From references it is noticeable that there are differences in the physical and chemical properties of the various rape sorts' oils and rapeseed-methyl-esters. Our aim is to analyze the differences in the quality of the various rape sorts' oils and to determine the most appropriate rape sort in the viewpoint of technical utilization. In the course of present research work we have measured the heating values of 21 various rapesorts' oils -12 from open-pollinated varieties and 9 from hybrids- and examined the differences between them. The outcome values dispersed in the range of the heating values found in the references, but the differences between them are less then the predicted, the variance and the coefficient of variation are reasonably slight, so the examined rape sorts' oils are similar in the viewpoint of the heating value. Furthermore, the energy content of the rapeseed oils is independent of the type (hybrid or open-pollinated variety) of the plant.
Keywords rapeseed oil, heating value, biofuel

1. INTRODUCTION

In the EU the energy sector for transport has two main challenges: the import dependency of energy sources and the environmental issues. Nearly all the energy used in the EU transport sector comes from oil and the import dependency of crude oil is extremely high, it was 83,7% for the EU-27 in 2006 [1]. Securing energy supplies for the future is not only a question of reducing import dependency, but including diversification of sources and technologies. The another important question is the environmental effects of the utilization of fossil fuels. In the EU transport is responsible for an estimated 21% of all greenhouse gas emissions that are contributing to global warming, and the percentage is rising. In order to meet sustainability goals, in particular the reduction of greenhouse gas emissions agreed under the Kyoto Protocol, it is essential to find ways of reducing emissions from transport [2].

Considering these issues the incremental utilization of renewable energy sources become a strategic aim of the European Union with the objectives of diversifying fuel supply sources, developing long-term replacements for fossil oil and reducing greenhouse gas emissions. Part of it the EU ordered that 5.75% (on energy content basis) of fossil fuels will be replaced by alternative fuels from renewable resources of the yearly consumption by 2010 [3].

One of the potential methods of the large scale biofuel production and utilization is the transesterification of the vegetable oils. Through the transesterification with glycerine secession the vegetable oil's triglycerid chains are decomposing and altering into vegetable oil-methyl-ester which is similar to the diesel oil in physical properties. In Europe one potential feedstock plant of biodiesel production is rape. Just in Hungary there are 104 sorts of rape in the National Sort Catalogue [4] and this number is increasing year by year. The differences of the various rape sorts were examined basically only by the aspect of agricultural utilization such as grain and oil yield; oil, glucosinolate and protein content [5]. New viewpoints of the evaluation have arisen with the industrial use of vegetable oils therefore our further object is to evaluate the different rape sorts's oil and determine the most appropriate rape sort for biodiesel stock in technical aspect.

The energy content is one of the most important parameters of the rapeseed oil in the viewpoint of use as biofuel feedstock. The energy content of the oil can be defined by the low heating value (LHV), which can be calculated from the measurable high heating value (HHV), the water content and the hydrogen content. In the references several data [6,7] can be found of the low heating value of the rapeseed oil from 36,87 MJ/kg [8] to 37,62MJ/kg [9]. In this work we examined the low heating value of 21 rape sorts' oils in order to explore the differences between them and to rank the sorts by the oil's energy content.

2. EXPERIMENTAL METHODS

21 different rape sorts were chosen for this evaluation, all grown in Hungary. These are:

- open pollinated varieties (OPV): Bristol, Dante, Eleonora, GK Gabriella, GK Helena, GK Lilla, GK 704, GK 1103, Mohikán, Rasmus, Strauss, Viking
- hybrids: Artus, Baldur, Elektra, ES Saphir, Hybrid Star, Tenno, Titan, Trabant, Triangle.

The oilseeds were pressed separately by a small scale compactor. After the pressing the oils were filtered.

The high heating value (HHV) was measured by an IKA C2000 calorimeter by DIN 51900 standard. The water content was measured by a Mettler- Toledo HG73S Halogen Moisture Analyzer. The hydrogen content was measured by a WLD varioMacro CHNS elementar. The low heating value was counted from the following equation:

$$H_u=H_o- (wt\%_H*9+ wt\%_{H2O})*0,2449 \qquad (1.)$$

To compare the hybrid and open-pollinated group of rape sorts we have made a two sample t-test [10]. The null hypothesis of this test is that these two sample groups are similar. The assumptions of the application of the t-test are the following:

- the samples are independent,
- the groups has standard normal distribution,
- the deviation of the two groups are similar.

It can be stated that the samples of the two groups are independent as they are a parameter of different rapeseed oils. As the hybrid group has 9 and the open-pollinated group has 12 elements, a standard normal distribution test cannot be done, we can only presume that the distribution is normal.

The similarity of the deviations was verified by an F-test. In the course of the test we calculated an F_{calc} value by the (2.) formula which was compared with the corresponding critical value (F_{crit}) [10]. If F_{calc} is less than F_{crit}, then the deviations of the two groups are similar.

$$F_{calc}= s_{12}/ s_{22} \qquad (2.)$$

In the t-test a calculated t_{calc} value (3.) was compared with a critical t_{crit} value at a 5% rate of statistical significance. If t_{calc} is less then t_{crit} then the two groups are significantly different.

$$t_{calc} = \frac{x_{mean} - y_{mean}}{\sqrt{\frac{Q_x + Q_y}{n+m-2} * \frac{n+m}{n*m}}} \qquad (3.)$$

3. RESULTS AND DISCUSSION

The results of the measurements of high heating value and hydrogen content are shown in Table 1 and Table 2 below, as well as the calculated low heating values. The water content is not shown as it was undetectable.

Table 1. Rapeseed oil properties

Rapesort	Hybrid (H) /Open-pollinated variety (OPV)	High heating value [MJ/kg]	Hydrogen content [wt%]	Low heating value [MJ/kg]
Artus	H	40,004	10,507	37,688
Baldur	H	40,024	10,832	37,636
Bristol	OPV	40,022	10,881	37,624
Dante	OPV	40,046	10,719	37,684
Elektra	H	40,114	10,705	37,754
Eleonóra	OPV	40,086	10,790	37,708
ES Saphir	H	40,004	10,638	37,659
GK 1103	OPV	40,049	10,803	37,668
GK 704	OPV	40,068	10,793	37,689
GK Gabriella	OPV	40,020	10,795	37,640
GK Helena	OPV	40,056	10,832	37,669
GK Lilla	OPV	40,034	10,661	37,685
Hybrid Star	H	40,007	10,659	37,658
Mohikán	OPV	40,129	10,888	37,729
Rasmus	OPV	40,094	10,833	37,706
Strauss	OPV	40,173	10,815	37,789
Tenno	H	39,967	10,886	37,567
Titán	H	40,114	10,956	37,699
Trabant	H	39,971	10,762	37,599
Triangle	H	39,929	10,724	37,565
Viking	OPV	40,013	10,947	37,600

Table 2. Rapeseed oil properties

	Minimum	Maximum	Mean	Variance	Coefficient of variation
High heating value [MJ/kg]	39,929	40,173	40,044	0,004	0,001
Hydrogen content [wt%]	10,507	10,956	10,782	0,012	0,010
Low heating value [MJ/kg]	37,565	37,789	37,667	0,003	0,002

The low heating value data are slightly greater than the values in the references, they stayed in the range between 37,56 and 37,78 MJ/kg with the mean of 37,67 MJ/kg.

We compared the heating value of the hybrid and open pollinated variety rapeseed sorts with t-test at 5% ratio of statistical significance. Firstly the adaptability of this method was checked by F-test. The result of the F-test can be found in the Table 3.

Table 3. The results of the F-test

	Variance of hybrid samples	Variance of OPV samples	F_{calc}	F_{crit} (p=5%)	Adaptability
Low heating value	0,00395	0,00246	1,602	2,95	**appropriate**

As the deviations of the two groups are the same due to the F-test, the t-test can be applied. The table 4. contains the results of the t-test.

Table 4. The results of the t-test

	Hybrid group			OPV group			t_{calc}	t_{crit} p=5%	Significant difference
	x_{mean}	m	Q_x	y_{mean}	n	Q_y			
Low heating value	37,647	9	0,032	37,682	12	0,0271	-1,43	2,093	**NONE**

On the basis of the results of t-test it can be stated that there is no significant difference in the low heating value between the hybrid and the open pollinated variety rapeseed oils.

4. CONCLUSIONS

From the results and discussion, the following conclusions can be declared:

1. The calculated low heating values of the 21 rape sorts stayed in the range which can be found in the references with the mean value of 37,67 MJ/kg. So the rapeseed oil has 12,3% less energy content then the diesel oil (with the high heating value 43MJ/kg), which means greater fuel consumption and less effective power using pure rapeseed oil or rapeseed-methyl ester than diesel engine fuel compared with fossil diesel oil.

2. As the variance and the coefficient of variation are very slight of the low heating value data, it can be declared that these rapeseed oils are similar in the viewpoint of hydrogen and energy content. Even so these slight differences are worth considering as the fuel consumption of the internal combustion engine is very important.

3. The hybrid rape sorts and the open-pollinated rape sorts are not different in their oils' heating values, so in the viewpoint of the energy content of the oils, it is indifferent that the rapeseed oil comes from hybrid or open-pollinated variety.

NOMENCLATURE

H_u	low heating value	MJ/kg
H_o	high heating value	MJ/kg
$wt\%_H$	hydrogen content	%
$wt\%_{H2O}$	water content	%
s_{12}	the variance of the first group (the higher value)	-
s_{22}	the variance of the second group (the lower value)	-
x_{mean}	the mean of the first group	-
y_{mean}	the mean of the second group	-
n	the number of the element of the first group	-
m	the number of the element of the second group	-
Q_x	the sum of squares of the first group	-
Q_y	the sum of squares of the second group	-

REFERENCES

1. European Commission, D.-G. f. E. a. T. (2009), EU energy and transport in figures, Statistical pocketbook 2009
2. COM(2006)34 (2006), An EU Strategy for Biofuels
3. Directive 2003/30/EC (2003), Directive of the European Parliament and Council on the promotion of the use of biofuels or other renewable fuels for transport

4. MgSzH- Hungarian Central Agricultural Office (2009), Szántóföldi növények nemzeti fajtajegyzék 2009. http://www.ommi.hu
5. MgSzH- Hungarian Central Agricultural Office (2005), Államilag elismert káposztarepce fajták eredményei 2005. http://www.ommi.hu
6. Vaitilingom, G., C. Perilhon, et al. (1998), "Development of rape seed oil burners for drying and heating." Industrial Crops and Products 7(2-3): 273-279
7. Hancsók, J. (2004), Korszerű motor- és sugárhajtómű üzemanyagok III. Alternatív motorhajtóanyagok. Veszprém, Veszprémi Egyetemi Kiadó
8. Labeckas, G. and S. Slavinskas (2006), "Performance of direct-injection off-road diesel engine on rapeseed oil." Renewable Energy 31(6): 849-863
9. AltIn, R., S. Çetinkaya, et al. (2001), "The potential of using vegetable oil fuels as fuel for diesel engines." Energy Conversion and Management 42(5): 529-538
10. Hajtman B. (1968), Bevezetés a matematikai statisztikába, Akadémiai Kiadó, Budapest