Influence of Treatment and Storage of Rapeseed on its Properties as a Raw Material for Biodiesel Production

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Summary

In order to reach targets set by the EU in the 2003/30/EC Directive, in Republic of Croatia in the last years the emphasis was put on cultivation and treatment of rapeseed hybrids as the crucial raw material for biodiesel fuel production. Since in the Republic of Croatia such researches are in the very onset, the aim of this paper was to determine the yield of three rapeseed hybrids, 'Artus', 'Baldur' and 'Titan', as well as to establish their properties after drying and storage, which are critical for biodiesel production.

In this research, drying curves of three investigated hybrids' seed were determined. The impact of drying temperature on oil content and on free fatty acids content was determined as well. It was found that Baldur hybrid had the highest oil content, followed by 'Titan', and 'Artus' with somewhat lower oil content. Moreover, hybrid Artus had the lowest free fatty acid content, irrespective of the drying air temperature, while the free fatty acid content in hybrids 'Baldur' and 'Titan' was 30% higher. It was evident that the oil content and free fatty acid content are hybrid property of particular hybrids. Furthermore, the impact of storage conditions, hybrid type and temperature on rapeseed's oil content and free fatty acid content was determined. It was found that controlled storage conditions provided better quality of rapeseeds.

The conclusion of this research is that the characteristics of rapeseed hybrids corroborate viability of sowing this crop and its usability as raw material for oil production, and thus, for biodiesel production.

Key words

rapeseed, raw material, storage, biodiesel production

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Introduction

Biodiesel is engine fuel produced from rapeseed oil or other vegetable oils through the process of esterification with methanol (Van Gerpen, 2005). It has the same properties as the standard diesel produced from mineral oils and can be used as the mineral diesel substitute or can be blended with it. Increasingly demanding ecological standards, as well as the obligation to reduce greenhouse effect gas emission, have given a powerful boost to production and usage of biodiesel in European countries. The Government of the Republic of Croatia gave support to biodiesel production in the frame of the National Energy Program (BIOEN).

Biodiesel is produced out of various kinds of vegetable oil, but also out of cattle tallow and used edible oil from households and restaurants (domestic waste) (Dunn and Knothe, 2001; Knothe and Dunn, 2001). The choice of the raw material depends on the specific conditions and circumstances of particular countries (climate, inhabitants' customs, usual crops etc). Nevertheless, the most important raw material for biodiesel production is rape (82.82%) as well as sunflower (12.50%). It is important to mention that biodiesel production in the world is constantly increasing. Whereas in 1991 only 111,000 tons of biodiesel fuel was produced, in 1998 the production amounted to 1,366,000 tons and in 2005 this production grown to three million tons. Basic reasons for such a rapid growth are agriculture, environment and economy in general.

Application of biofuels in production processes plays a significant role in making such a system of agriculture possible. Generally speaking, biofuels nowadays represent the most valuable renewable energy source and have a considerable environmentally friendly potential because of their biodegradability and contribution to sustainability (Puppan, 2002; Demirbas, 2007).

Most of the countries within the European Union as well as majority of the transition countries initiated biodiesel production in the previous decade. This tendency will be continued in the future, which is proved by the European Commission's proposal 2003/30/EC (EC, 2003) concerning alternative fuels in road transportation, as well as measures for promotion of biofuels. The document proposes the following measures:

- member countries of the EU have the right to apply a differential tax rate to biodiesel, in order to facilitate the use of biodiesel
- the share of biodiesel used in transport in each EU member state should amount as follows:

2008	2009	2010	2020
4.25%	5%	5.75%	20%

In order to accomplish the above mentioned goals, all of the countries have instituted incentive measures primarily related to subsidies for production of crops for biodiesel production and favourable taxing system for utilization of biodiesel.

Of course, in order to reach the set targets in the EU, in the last years the emphasis was put on cultivation and treatment of rapeseed hybrids as the crucial raw material for biodiesel fuel production. Since in the Republic of Croatia such researches are in the very onset, the aim of this paper is to determine the yield of three rapeseed hybrids, 'Artus', 'Baldur' and 'Titan', as well as to establish their properties after drying and storage, which are critical for biodiesel production.

Material and methods

Research included three hybrids of rapeseed, 'Artus', 'Baldur' and 'Titan', grown in Eastern Slavonia, in vicinity of Đakovo. The experimental field was divided in a way that each of the observed hybrids in three replications was grown on a lot of 240 square meters. Two-meter wide passage areas were left between the experimental lots and replications. The sowing was carried out in the third decade of August. After full application of agricultural measures, the crops were harvested upon inspection, i.e., after checking up the colour of crops when most of husks were dark yellow. Seeds' moisture content was another factor which determined the harvest timing.

After the harvest, hybrid seeds were dried in the dryer in thick layer at air temperatures of 40 °C, 60 °C and 80 °C, with a control sample (naturally dried seeds). The seeds were dried out up to the point of reaching 7% moisture content in average. The seeds were stored in the storage facilities without and with atmosphere control; air temperatures were 10 °C (chamber 1) and 4°C (chamber 2). Just before storing oil content and free fatty acids (FFA) content in seeds of the observed hybrids were determined.

During the harvest, digital scale was used to measure the amount of harvested mass. Seeds' moisture content after harvest, drying and storage was determined by the ISO 665:2000 method. Rapeseed was dried in the dryer of make Seting-Inženjering Delnice. A 15 cm thick sample was dried on a one-time basis in quantity of 10 kg. The air temperature regulation was automated and controlled by PT1000 probes. The results were mathematically expressed as exponential equations. Oil content was determined by ISO 659:1998 method, and free fatty acids content was determined using the AOCS method.

Results and discussion

The harvest was carried out by the middle of June with the following moisture contents in particular hybrids:

Table 1. Equation of seed moisture loss in investigated rapeseed hybrids

Hybrid	Temperatures					
	40°C	R^2	60°C	R^2	80°C	R^2
Artus	$y = 19.016\ e^{-0.0096x}$	0.9719	$y = 19.622\ e^{-0.0249x}$	0.9544	$y = 9.6436\ e^{-0.0159x}$	0.8869
Baldur	$y = 16.519\ e^{-0.0103x}$	0.9511	$y = 16.161\ e^{-0.0328x}$	0.8201	$y = 10.604\ e^{-0.0284x}$	0.9123
Titan	$y = 16.294\ e^{-0.0104x}$	0.9658	$y = 16.021\ e^{-0.032x}$	0.9137	$y = 8.0271\ e^{-0.0139x}$	0.8992

Legend: y – seed moisture (%), x – drying period (min)

'Artus' 18.2%, 'Baldur' 16.4% and 'Titan' 16.2%. The seed yield of 'Artus' was 4,840 kg ha^{-1}; of ,'Baldur' 4,888 kg ha^{-1}, and of 'Titan' 5,160 kg ha^{-1}, calculated to 7% moisture.

Rapeseed's moisture loss at different air temperatures is given in Table 1.

Mathematical models of investigated hybrids' seed drying in the dryer determine drying curves or, moisture content in seed during the drying process and drying speed, and thus the time required for dryer adjustment in terms of capacities and energy. The investigated hybrids show no statistically marked differences related to drying.

After drying at observed drying temperatures and in order to determine the impact of drying temperature on oil content and free fatty acids content, mean values of the given parameters are shown in Table 2 and are calculated at 7% moisture content.

By correlating the oil content and the drying air temperature, we determined that the drying practice, i.e., air temperature level, has not significant influence on oil content in seeds. Oil content is a hybrid property of each particular hybrid. Table 2 shows that Baldur hybrid had the highest oil content, followed by 'Titan', and 'Artus' with somewhat lower oil content. Figure 1 shows the results obtained.

In biodiesel production, the FFA content is one of key values. The increased FFA content has negative influence

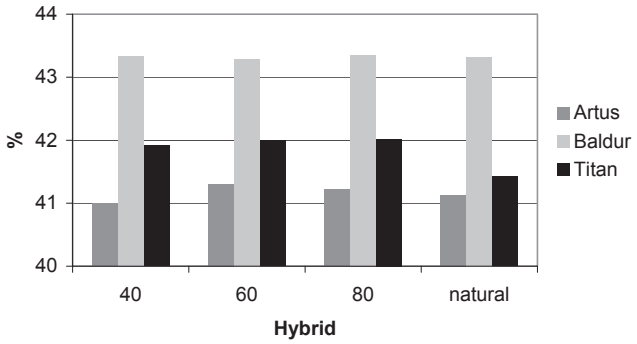

Figure 1. Oil content (in %) in hybrid rapeseed after drying

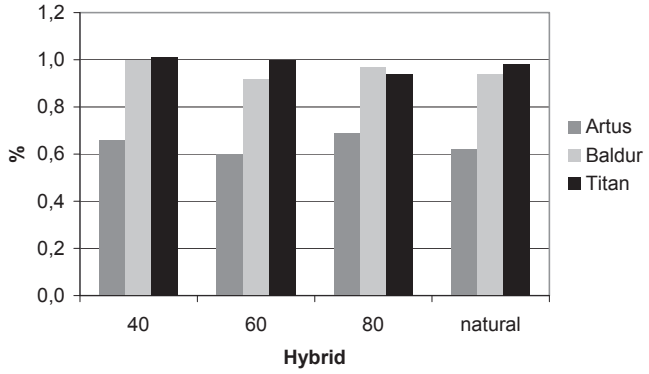

Figure 2. FFA content (in %) in hybrid rapeseed after drying

Table 2. Oil content and free fatty acid (FFA) content after drying of rapeseed hybrids

Hybrid	Drying temperature	Oil content (%)	FFA (%)
Artus	40	41.00	0.66
	60	41.30	0.60
	80	41.22	0.69
	Natural	41.12	0.62
Baldur	40	43.33	1.00
	60	43.29	0.92
	80	43.34	0.97
	Natural	43.32	0.94
Titan	40	41.92	1.01
	60	42.00	1.00
	80	42.02	0.94
	Natural	41.43	0.98

on biodiesel fuel combustion, which reflects on the internal combustion engine performance. The free fatty acids content in the observed hybrids is shown in Figure 2.

The hybrid 'Artus' has the lowest FFA content, irrespective of the drying air temperature, while in hybrids 'Baldur' and 'Titan' the FFA content was 30% higher. It is evident that, like the oil content, FFA content is a hybrid property of particular hybrids.

Also, after one year of storage, the impact of storage conditions, hybrid type and temperature on rapeseed's oil content and FFA content was determined. The results are shown in Tables 3, 4, and 5.

These data show that controlled conditions storage provide better quality of rapeseeds. However, if the influence of storing at 4°C in comparison to 10°C is observed,

Table 3. Oil content and FFA content (in %) in relation to storage conditions after one year period

Store-house	Oil content (%)	FFA (%)
Natural	39.74b ± 1.08	1.20a ± 0.18
Chamber 1	40.91a ± 0.91	1.13a ± 0.20
Chamber 2	40.85a ± 0.71	1.06a ± 0.20
Mean value	40.50 ± 1.04	1.13 ± 0.20
P value	0.005 **	0.20 NS
LSD	0.76	0.16
cv	2.58	17.44

Table 4. Oil and FFA content (in %) in relation to hybrid type after one year period

Hybrid	Oil content (%)	FFA (%)
Artus	40.33ab ± 0.84	0.92b ± 0.17
Baldur	41.09a ± 0.84	1.26a ± 0.09
Titan	40.10b ± 1.21	1.21a ± 0.11
Mean value	40.50 ± 1.04	1.13 ± 0.20
P value	0.046 *	< 0.0001 ***
LSD	0.81	0.11
cv	2.58	17.44

Table 5. Oil and FFA content (in %) in relation to drying temperature after one year period

Drying temperature	Oil content (%)	FFA (%)
40°C	40.29a ± 0.87	1.10ab ± 0.21
60°C	40.26a ± 1.13	1.04b ± 0.24
80°C	41.04a ± 1.08	1.11ab ± 0.15
Natural	40.42a ± 1.05	1.27a ± 0.12
Mean value	40.50 ± 1.04	1.13 ± 0.20
P value	0.36 NS	0.08 NS
LSD	0.99	0.18
Cv	2.58	17.44

it can be determined that there are no significant differences among them. Their oil contents and FFA contents are approximately equal. Also, Table 5 shows that drying temperatures are not related to lowering the oil and FFA contents. Thus, we can say that this is also a hybrid property, which is particularly evident in hybrid Baldur: its oil content during the storage period dropped by 2%, while its FFA content increased. It is evident that the rapeseed yield and oil content cannot be the only indicators for the rapeseed production for biodiesel, and that storage properties of the seed must be taken into account as well.

Conclusion

The following conclusions may be drawn from the own researches on rapeseed hybrids 'Artus', 'Baldur' and 'Titan', as raw materials for biodiesel production:

Average yield of examined hybrids reduced to 7% moisture content, was as much as 4.9 tons per hectare. The yields this high are due to efficient cultivation know-how and high quality seed of rapeseed hybrids.

Mathematical modelling of drying made it evident that in the observed hybrids there were no statistically significant differences in moisture loss from seed, within the range of examined drying air temperature levels.

Oil content in seeds is reduced in storage. At the same time, FFA content increases, especially in outdoor storage, while in controlled storage there were no major variations.

From this research we concluded that the characteristics of rapeseed hybrids corroborate viability of sowing this crop and its usability as raw material for oil production, and thus, for biodiesel production.

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