

# Animal Fats Perform Well in Biodiesel.....

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**T**he limitation of available sources for petroleum exploration is a strong motivation to focus on renewable energy. An alternative to fossil diesel is the production of environmentally friendly biodiesel. According to European Commission regulations, by 2010 at least 5.75 percent of the annual fuel consumption in Europe will have to be substituted by renewable fuels like biodiesel. Biofuels have a great potential to decrease environmental pollution and improve emission behavior of engines.

In late 2001, SARIA Bio-Industries GmbH, an enterprise of the Rethmann group, started their own biodiesel production in Malchin, Germany, to make use of the animal fat left as a by-product at their nearby rendering factory. The applied production process, developed and built by BDI Anlagenbau GmbH, enables SARIA to annually produce 12,000 tons of biodiesel from animal fats at the highest quality according to the

European standard, EN 14214. The Malchin biodiesel production plant was the first of several common biodiesel projects between SARIA and BDI and meant the beginning of a successful cooperation, which includes research projects, between these companies. One such project investigated the differences between rapeseed oil methyl ester (RME) and animal fat methyl ester (AFME) regarding chemical or physical properties and combustion behavior.

## Introduction

In Europe, biodiesel seems to be synonymous for RME. Only a small, well-informed public realizes that this alternative fuel can also be produced from other feedstocks, such as non-edible oils (or seed oils), used cooking oils, and animal fats. This aspect will become more and more important when seen in context with the latest developments on food- and feeding-stuff safety.

The fact is, that the usage of biodiesel produced from used cooking oils is well-known to the public and its advantageous emission behavior compared to fossil diesel or even RME could be pointed out sufficiently.<sup>1,2,3</sup>

What is less known is the fact that biodiesel can also be produced from 100 percent animal fats and fulfills the current EN 14214 for fatty acid methyl esters, as long as state-of-the-art process technology is applied.

## Properties of Different Feedstock Materials

When chemical properties of various feedstock materials for biodiesel production are compared, the main difference between vegetable oils like rapeseed oil and animal fats can be found in the diverse fatty acid composition as shown in Table 1.

While rapeseed oil and soybean oil have a high content of unsaturated fatty acids, mainly oleic acid and linoleic acid, animal fats like tallow or lard have a major content of saturated fatty acids (e.g., palmitic and stearic acid).

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**Table 1. Comparison of Fatty Acid Composition of Rapeseed Oil, Soybean Oil, and Tallow<sup>5</sup>**

		Rapeseed Oil (low erucic)			Soybean Oil			Beef Tallow		
		Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
<b>Saturated Fatty Acids</b>										
Lauric	C12:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myristic	C14:0	0.0	0.0	0.0	0.0	0.3	0.5	2.0	3.0	4.0
Palmitic	C16:0	3.0	4.5	6.0	8.0	10.0	12.0	23.0	26.0	29.0
Stearic	C18:0	1.0	1.8	2.5	3.0	4.0	5.0	20.0	27.5	35.0
Arachidic	C20:0	0.0	0.5	1.0	0.0	0.3	0.5	0.0	0.3	0.5
Behenic	C22:0	0.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
<b>TOTAL</b>		<b>4.0</b>	<b>7.0</b>	<b>10.0</b>	<b>11.0</b>	<b>14.5</b>	<b>18.0</b>	<b>45.0</b>	<b>56.8</b>	<b>68.5</b>
<b>Unsaturated Fatty Acids</b>										
Myristoleic	C14:1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5
Palmitoleic	C16:1	0.1	0.3	0.5	0.0	0.0	0.0	2.0	3.0	4.0
Oleic	C18:1	52.0	59.0	66.0	18.0	21.5	25.0	26.0	35.5	45.0
Linoleic	C18:2	17.0	21.0	25.0	49.0	53.0	57.0	2.0	4.0	6.0
Linolenic	C18:3	8.0	9.5	11.0	6.0	8.5	11.0	1.0	1.0	1.0
Gadoleic	C20:1	1.5	2.5	3.5	0.0	0.3	0.5	0.0	0.3	0.5
Erucic	C22:1	0.0	1.3	2.5	0.0	0.0	0.0	0.0	0.0	0.0
<b>TOTAL</b>		<b>78.6</b>	<b>93.6</b>	<b>108.6</b>	<b>73.0</b>	<b>83.3</b>	<b>93.5</b>	<b>32.0</b>	<b>44.7</b>	<b>57.5</b>
Iodine Number [-]		96	115	134	116	133	149	30	43	56

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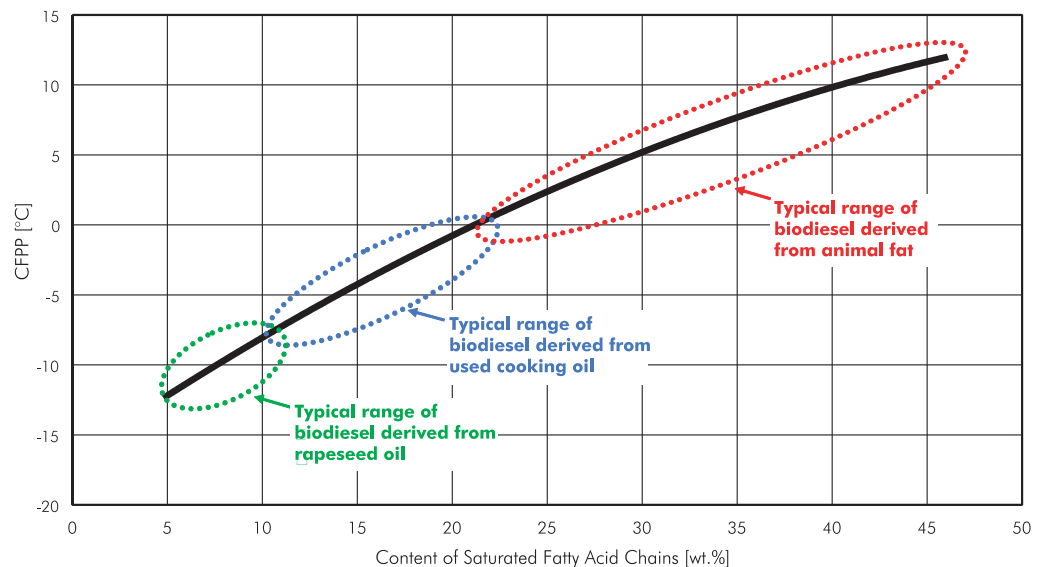
saturated fatty acids shows a reversed trend for two main fuel properties. While the oxidation stability of biodiesel derived from animal fats increases, the cold temperature performance decreases with a rising content of saturated fatty acids. Figure 1 shows the dependence of the content of saturated fatty acids in biodiesel – without additives – on its cold filter plugging point (CFPP).

As indicated in Table 2, the cetane number of biodiesel is also positively affected by an increased amount of saturated fatty acids. Tallow-derived biodiesel can reach cetane numbers of up to 74, which leads to a much better performance in diesel engines regarding engine efficiency and subsequently reduced exhaust emissions.<sup>4,5</sup> Compared to conventional fossil diesel, the noise level of diesel engines – an often underestimated environmental pollution concern – is also reduced when AFME is used.

The lubricity behavior of biodiesel was also investigated.<sup>7,8</sup> Compared to soybean oil- and rapeseed oil-derived biodiesel, a superior performance of tallow-derived biodiesel could be found. Table 3 shows the lubricity enhancement of biodiesel when added to low-sulfur diesel. For High Frequency Reciprocating Rig (HFRR) 60C test, the limit for lubricity according to European diesel fuel standard EN 590 is below 460  $\mu\text{m}$  (micrometer). Biodiesel derived from tallow showed best performance as a lubricity enhancer for low-sulfur diesel and fulfills the prescribed limit already at a percentage of 0.5 percent added to diesel fuel.<sup>8</sup>

Certainly, due to the differences in composition and quality of the raw material (e.g., content of free fatty acids, content of impurities, etc.), the production of high-quality biodiesel from used animal material needs a more sophisticated production technology and specific know-how concerning the pre-treatment of the feedstock. BDI, in close cooperation with research institutes of Graz Universities, developed an appropriate technology. In 1998, BDI built a multi-feedstock biodiesel production plant in Butler, KY, where animal fat has been used for six years now.

**Figure 1. Relation Between Content of Saturated Fatty Acids in Biodiesel (without additives) and its CFPP Value<sup>5</sup>**



### Ecological Study of Animal Fat-based Biodiesel

In a life cycle analysis study, ecological effects of the production of biodiesel (“from well to wheel”) derived from rapeseed oil or animal fat (with and without synergy effects of a rendering plant for animal by-products) were investigated and compared with the production of fossil diesel fuel.<sup>9</sup>

Seven criteria for assessment of fuel production were pointed out:

1. Carcinogenic risk due to fuel components like benzene
2. Particulate matter (PM 10, dust particles < 10  $\mu\text{m}$ ) content in exhaust gas
3. Eutrophication rate of environment (soil, ground water, etc.)
4. Photosmog – breakdown rate of ozone layer due to photochemical oxidants
5. Amount of resources consumed for production (fertilizer, catalysts, primary energy, etc.)
6. Greenhouse effect of relevant gases (carbon dioxide, laughing gas, and methane)
7. Potential of acidification due to noxious gases (e.g., sulfur dioxide)

For AFME production, it could be shown that especially primary energy resources can almost completely

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**Table 2. Comparison of Iodine Number and Cetane Number of Different Types of Biodiesel<sup>6</sup>**

	Biodiesel Derived From				
	Rapeseed Oil	Soybean Oil	Palm Oil	Lard	Tallow
Iodine Number [-]	110-115	125-140	44-58	60-70	50-60
Cetane Number [-]	58	53	65	65	75

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be substituted. Also, carbon dioxide balance is neutral for biodiesel from animal fat, thus no major contribution to the greenhouse effect could be stated. Concerning emission behavior, the amount of particulate matter and concentration of carbon dioxide in the exhaust gases is even better for AFME than for RME. For all other evaluated criteria, AFME is at least comparable with RME.<sup>9</sup>

**Experience of Fleet Tests at SARIA**

Since 2001, AFME from SARIA Bio-Industries' biodiesel plant in Malchin has been used in more than 1,000 trucks at Rethmann Entsorgungs and SARIA Bio-Industries. Due to the cold temperature behavior of AFME, it is blended with fossil diesel or other biodiesel at a surrounding temperature below eight degrees Celsius. Engine tests of Daimler-Chrysler AG, where 9.9 out of 10 points were reached, and engine oil checks of Wearcheck GmbH show that AFME is a proper biofuel for engine operation with environmentally friendly emission behavior and without any technical faults.<sup>7</sup>

**Summary**

Summing up, it can be stated that besides its cold temperature performance, biodiesel derived from animal fat (e.g., beef tallow) shows significantly better fuel properties concerning engine performance compared to conventional biodiesel. Although AFME will stay a niche product compared to other biofuels, SARIA Bio-Industries

has demonstrated that with the appropriate applied biodiesel technology, that animal by-products can be refined to fatty acid methyl esters of highest quality. ❖

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**Table 3. Results of HFRR 60C Test: Biodiesel Added to Low-sulfur Diesel at Different Percentages<sup>8</sup>**

Biodiesel Derived From	Rate of Biodiesel added to Low-sulfur Fossil Diesel		
	0.5%	1.0%	2.0%
Tallow	443 $\mu\text{m}$	420 $\mu\text{m}$	321 $\mu\text{m}$
Rapeseed Oil	509 $\mu\text{m}$	359 $\mu\text{m}$	320 $\mu\text{m}$
Soybean Oil	540 $\mu\text{m}$	483 $\mu\text{m}$	487 $\mu\text{m}$