2^{nd} VegOil

Demonstration of 2^{nd} Generation Vegetable Oil Fuels in Advanced Engines

Work Package 3

Fuel Development

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Survey on Oil Quality

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1 Prolog

With the beginning of using pure plant oil (ppo) in diesel engines, the issue of fuel quality became more and more important. Highest standards for vegetable oil fuel quality have been always combined with the increasing knowledge on vegetable oil engine technology.

The first engine fuelled by vegetable oil can be traced back to the origins of the diesel engine which was exhibited by Rudolf Diesel with peanut oil as fuel at the World Exposition in Paris in 1900. At this time fuel quality was not yet discussed. The important fact was, that different vegetable oils have been easier to get than diesel or petroleum which, at that time, have mainly been offered by pharmacies.

As a reaction to oil shortages due to two oil crisis (1973, 1979) and wars in the gulf region, the interest in vegetable oil as an alternative fuel for diesel engines grew from year to year. Thus, it became more and more important to understand and find out parameters which have influence on oil quality.

For the purpose of 2nd VegOil, the variable properties for phosphor (P), calcium (Ca) and magnesium (Mg) of plant oils and the influence of different oil press parameters on these properties have been of special interest. Also just data from or for decentralized oil mills have been examined.

In a literature review, first the progress of different oil quality standards over time was elaborated. Then, the parameters which can change the oil quality have been described.

For the most important oil influencing parameters and their impact on the content of phosphor laboratory tests have been made.

Due to the German pioneer position almost all experience refers to rape seed oil. Also all preliminary oil quality standards and the DIN V 51605 refer just to rape seed oil. In 2nd VegOil also some other plant oils than rape seed oil will be demonstrated. Therefore experiences with different plant oils and its impact on the oil press technology will be reported.

2 Literature Review on Existing Know-how on Oil Quality Influencing Parameters

With the beginning of Rudolf Diesel's first test runs with vegetable oil, it took some time to establish oil quality standards which have been continuously tailored to meet current requirements of plant oil engine technology. Based on these quality standards, the parameters especially influencing the elements P, Ca/Mg of the DIN V 51605 could be discussed in literature.

2.1 Variations of Oil Quality Standards till Today's DIN V 51605

Till the German DIN V 51605 for rapeseed oil as fuel different preliminary quality and fuel standards for pure plant oil have been developed.

2.1.1 First Plant Oil Quality Standards

One of the first studies on plant oil properties was done by Kurt Gaupp in 1937.[1] For different plant oils (sesame, soy, peanut, palm, sunflower, sheabutter), Gaupp described the characteristic differences in their physical/chemical properties like viscosity, iodine number, cloud point etc. and their impact on a regular diesel engine. Variable properties like water, ash, phosphor content, have been of no interest at this time and haven't been examined.

In 1982, the research chemist E.H. Pryde developed and proposed a first fuel specification standard which also included variable properties. Table 1 shows the vegetable oil together with a ester fuel and a diesel fuel specification.[2]

Property	Test method[a]		Suggested standards		ASTM specifications for no. 2 diesel oil (D975)
	AOCS	ASTM	Oil	Ester	
Physical					
Cetane number (min.)	-	D613	(30-40)	(30-40)	40
Cloud point (max.)	Cc6	D2500	20°C	20°C	6°C above 1/10 percentile minimum ambient temperature[b]
Distillation temperatures, 90% point	-	D86			
min.			(>300°C)	(>300°C)	282°C
max.					338°C
Flash point (min.)	Cc9a	D93	(~300°C)	(~300°C)	52°C
Pour point (max.)	-	D97	-5°C	-5°C	-
Specific gravity, 15/15°C	Cc10a	D1217	0.910-0.930	(0.8-0.9)	-
Turbidity	-	-	-	-	-
Viscosity, cSt @ 100°F	-	D445	30-50	(3-6)	1.9-4.1
Compositional					
Ash (max.)	Ca11	D482	0.05%	0.05%	0.01%
Carbon residue on 10% residuum (max.)	-	D524	-	-	0.35%
Copper strip corrosion (max.)	-	D130	-	-	No. 3
Free fatty acid (max.)	Ca5a	-	0.2%	0.2%	-
Insolubles (max.)	Ca3	D128	0.001%	0.001%	-
Iodine value	Cd1	-	80-145	80-145	-
Moisture (Karl Fischer) (max.)	Ca2e	D1744	0.2%	0.2%	-
Phosphorus (max.)	Ca12	D1091	0.02%	0.02%	-
Sulfur (max.)	-	D129	-	-	0.50%
Volatile matter (max.)	Ca 2b, c, or d	-	0.3%	0.3%	-
Water and sediment (max.)	-	D1796	-	-	0.05%
Wax (max.)	-	D3117	0.02%	0.02%	-

[a] AOCS = American Oil Chemists' Society; ASTM = American Society for Testing and Materials. Values in parentheses are actual values or ranges and not necessarily a suggested specification.

[b] For example, the 10th percentile minimum temperature for Northern Illinois is 16°F for November and 12°F for March, bracketing the winter period when there would be minimum tractor activity in the field.

Table 1: Fuel Specification for Vegetable Oil

It is interesting that with maybe the first vegetable oil specification already phosphor was on the list. Astonishing is also the suggested limit of less than 20 ppm. But it has to be emphasized that all variable properties in this study including phosphor are not engine related but are discussed to prevent problems in fuel tanks, lines and filters.

At the same time, Ryan et al. used gas chromatography for its plant oil analysis and integrated phosphor in their table of elemental composition of vegetable oil.[3] The conclusion on engine test runs did not refer to phosphor or suggested limits. Phosphor still was not considered an engine problem at this time.

2.1.2 Plant Oil Quality Standard till the Pre-Weihenstephan Standard 1996

After the oil crisis 1979, Germany became a centre of worldwide plant oil activities. A first proposal for a quality standard of rapeseed oil as fuel was presented in 1994 (table 2).[4]

Specification	Entity	Requirement	Inspection Method
Density at 15 °C	g/ml	0.90 – 0.93	DIN 51757
Kinematic Viscosity at 20	mm^2/s	max. 80	DIN 51562
°C	MJ/kg	min. 35	
Heat value at 20 °C	°C	min. 55	DIN 51755
Flashpoint		~ 39	DIN 51773
Cetane number	°C	+ 15	EN 116
CFPP	mg KOH/g	max. 1,5	DIN 51558
Neutralisation number	mg KOH/g	max. 190	DGF CV 3 (77)
Saponification value	g Io-	max. 115	DIN V 51 606
Iodine figure	dine/100g	max. 1	DGF CIII 4 (53)
Free fatty acids	w.-%	30	DGF CVI 4
Sum of phosphorus	mg/kg	max. 0.03	DIN EN 41
Sulphur content	w.-%	max. 0.5	DIN 51551
Coke residue	w.-%	max. 0.02	DIN EN 7
Ash content	w.-%	max. 1000	DIN 51777
Water content	mg/kg	~ 210	DIN 51751
Boiling point	°C	~ 340	
50 vol.-% vaporised	°C	max. 5	
Filter fineness	µm		

Table 2: Proposal for Fuel Quality Standard

Table 2 at the first time shows a limit of 30 ppm for phosphor which is not just referring to tank, fuel filter and fuel line problems, but also to technical problems in engine technology especially for smaller high-speed engines.

In a preliminary quality standard for rapeseed oil in 1996 the phosphor content was then fixed to 25 ppm.[5] To achieve a complete combustion and long-term functionality for catalysts has been the reason for this low phosphor content. This proposal was fixed and continuously developed in work sessions of the Technical University of Munich, Landtechnik Weihenstephan, in cooperation with the University of Stuttgart-Hohenheim and the private analysis company ASG together with engine and plant oil technology companies, oil mill owners and plant oil interested groups.

2.1.3 The Weihenstephan Quality Standard for Rapeseed Oil 5/2000

The final quality standard for rapeseed oil as a fuel of this work session was set up in Mai 2000 and is shown in the following table 3.[6] This quality standard 5/2000, often called Weihenstephan standard, was widely accepted and gave a clear orientation for farmers and decentralized oil mills to control and meet the fixed limits.

Features / Ingredients	Entity	Limit values max.	Limit values min.	Inspection Method
for rape seed oil characteristic features				
Density (15°C)	kg/m³	900	930	DIN EN ISO 3675 DIN EN ISO 12185
Flash point by P.-M.	°C	220		DIN EN 22719
Heat value	kJ/kg	35000		DIN 51900-3
Kinematic viscosity (40 °C)	mm²/s		38	DIN EN ISO 3104
Cold behaviour				Rotary viscosimetry (Test conditions will be elaborated)
Combustibility (Cetan figure)				Test procedure will be evalueted
Coke residue	Mass-%		0.40	DIN EN ISO 10370
Iodine figure	g/100 g	100	120	DIN 53241-1
Sulphur figure	mg/kg		20	ASTM D5453-93
variable features				
Total contamination	mg/kg		25	DIN EN 12662
Neutralisation number	mg KOH/g		2.0	DIN EN ISO 660
Oxidation stability (110 °C)	h	5.0		ISO 6886
Phosphorus content	mg/kg		15	ASTM D3231-99
Ash content	Mass-%		0.01	DIN EN ISO 6245
Water content	Mass-%		0.075	Pr EN ISO 12937

Table 3: Weihenstephan Quality Standard for Rapeseed Oil as Fuel

Similar to Pryde in 1982, also this standard is now divided in characteristic and variable properties for rapeseed oil. In difference to the preliminary standard from 1996, the content for phosphor was reduced to 15 mg/kg. The property oxidation stability which has a chemical correlation to the amount of phosphor was newly installed into the quality standard 5/2000. The elements calcium and magnesium were still missing.

2.1.4 The Quality Standard DIN V 51605 for Rapeseed Oil as Fuel

In 7/2006, the Weihenstephan standard 5/2000 was improved in many work sessions to the DIN V 51605. With the first world-wide quality pre-norm for plant oil in 2000, the German DIN V 51605 set up a stronger limit for phosphor (12 mg/kg). Also, for the first time, calcium and magnesium have been added to the variable property list (20 mg/kg).[7]

The DIN V 51605 replaced the Weihenstephan standard and was the new benchmark for rapeseed oil quality. It is important to mention that the DIN V 51605 also has a crucial fiscal impact in putting a mineral oil tax on rapeseed oil.[8] Rapeseed fuels according to the

DIN V 51605 has no mineral oil tax for fuel used in agriculture and a reduced mineral oil tax for cars and trucks. Rapeseed oils which do not reach all quality parameters of the new DIN V 51605 are not considered as rapeseed oil and cause the whole mineral tax for agriculture, cars and trucks.

Parameter	Entity	Limit values max.	Limit values min.	Inspection Method
Density at 15°C	kg/m^3	900.0	930.0	DIN EN ISO 3675 or. DIN EN ISO 12185
Flash point by Pensky-Martins	°C	220	-	DIN EN 2719
Kinematic viscosity at 40 °C	mm^2/s	-	36.0	DIN EN ISO 3104
Heat value	kJ/kg	36000	-	DIN 51900-1, -2, -3
Combustibility	-	39	-	
Coke residue	% (m/m)	-	0.40	DIN EN ISO 10370
Iodine figure	g Iod/ 100g	95	125	DIN EN 14111
Sulphur figure	mg/kg	-	10	DIN EN ISO 20884 DIN EN ISO 20846
Total contamination	mg/kg		24	DIN EN 12662
Acid value	mg KOH / g		2.0	DIN EN 14104
Oxidation stability at 110 °C	h	6.0		DIN EN 14112
Phosphorus content	mg/kg		12	DIN EN 14107
Sum content of calcium and magnesium	mg/kg		20	DIN EN 14538
Ash content (oxid ash)	% (m/m)		0.01	DIN EN ISO 6245
Water content	% (m/m)		0.075	Pr EN ISO 12937

Table 4: DIN V 51605[9]

Since 2006 the DIN V 51605 commission is working to transfer the pre-norm DIN V 51605 into a final norm DIN 51605. Subject of an intense discussion is the content of P, CA/Mg which has to be reduced due to modern diesel engines with phosphor and earth alkali sensitive emission treading systems like catalysts, selection catalytic reduction (SCR) and soot filters.

2.2 Parameters Influencing Oil Quality

The variations of oil quality standard mentioned in 3.1 showed a continuously decreasing content of phosphor. The DIN V 51605 as a fiscal, governmental leverage to impose or not impose mineral oil tax on rapeseed oil maybe had the strongest impact on decentralized oil mills to understand all parameters to control the variable properties, especially the elements P, Ca/Mg of rapeseed oil.

Parallel to the mineral oil tax leverage, plant oil engine technicians have a common sense about the danger of phosphor and earth alkali for new modern engines. For P and also for Ca/Mg, which has been just implemented to the DIN V 51605 engine experts are asking for a limit of almost zero.[10] In 2nd VegOil the final stage of oil development is defined by < 1 mg/kg P, Ca/Mg. Therefore, the rapeseed oil quality and the knowledge of all parameters to achieve this quality is of major importance for decentralized oil mills.

Characteristic properties for plant oils are specifically and genetically fixed and show just small variations in analysis.
Variable properties, instead, are heavily depending on different sorts of seed, agricultural method, harvest and processing and storing of rapeseed. Especially P, Ca/Mg contents have a wide range in fuel analysis and need a strong control to meet the required fuel quality standards. So, it is important to know and understand all factors which can contribute to regulate the content of P, Ca/Mg in rapeseed oil.

The following table 5 shows a matrix of all factors influencing the oil properties of rapeseed oil.

parameters	rape seed								oil pressing	oil filtration	oil storage	oil delivery
	sort	dust	corn break	maturity	out growth	soiling	drying	storage				
density	rape oil specific – no influence											
flash point	rape oil specific – no influence											
kin. viscosity	rape oil specific – no influence											
heating value	rape oil specific – no influence											
combustibility	rape oil specific – no influence											
carbon residue	(✓)[1]											
iodine number	(✓)[1]											
sulphur content	rape oil specific – no influence											
purity									✓	✓	✓	✓
acid value	(✓)		✓	✓	✓	✓	✓	✓			✓	
oxidation stability	(✓)[1]		✓	✓	✓	✓	✓	✓			✓	
phosphorus content			✓						✓			
calcium content			✓						✓			
magnesium content			✓						✓			
ash content		✓										
water content							✓				✓	✓

1 HighOleic-rape sort in comparison to conventional 00-rape sort

Table 5: Factors Influencing Rapeseed Oil Quality[11]

In this table 5, at that time the P, Ca/Mg relevant factors are just corn break and oil pressing.

Due to intense agricultural and scientific studies how to control the oil quality of decentralized oil mills, more influencing factors have been found.

The following scheme is a summary of all P, Mg/Ca relevant parameters which have influence on oil quality. The scheme is used from the FNR handbook to produce rapeseed oil in decentralized oil mills.[12] At the moment, this FNR handbook gives presumably the best overview about quality rapeseed oil fuel production in decentralized oil mills.

parameters	rape seed											
	sort	dust	corn break	maturity	out growth	soiling	drying	storage	oil pressing	oil filtration	oil storage	oil delivery
density	rape oil specific - no influence											
flash point	rape oil specific - no influence											
kin. viscosity	rape oil specific - no influence											
heating value	rape oil specific - no influence											
cetane number	rape oil specific - no influence											
carbon residue	x											
iodine number	x											
sulphur content				x			x	x				
purity									x	x	x	x
acid value	x		x	x	x	x	x	x				
oxidation stability	x		x	x	x	x	x	x			x	
phosphorus content			x	x	x	x			x			
calcium content			x	x	x	x			x			
magnesium content			x	x	x	x			x			
ash content		x										
water content							x				x	x

Table 6: Survey of Parameters with Influence on Quality of Rapeseed Oil

For the purpose of 2nd VegOil just the parameters have been examined which have influence on the P, Ca/Mg content in rapeseed oil.

2.2.1 The Influence of Corn Break on P, Ca/Mg Content in Rapeseed Oil

There is a direct correlation between percentage of corn break in the oil seed and content of P, Ca/Mg in the plant oil fuel.[13] The higher the percentage of corn break in the seed material, the higher is the content of P, Ca/Mg in the fuel.

So, it is important that through all phases of harvest, transportation and storage, rapeseed has to be prevented from breaking or squeezing by harvestors, transportation vehicles or front loaders.

2.2.2 The Influence of Maturity of Rapeseed on P, Ca/Mg Content in Rapeseed Oil

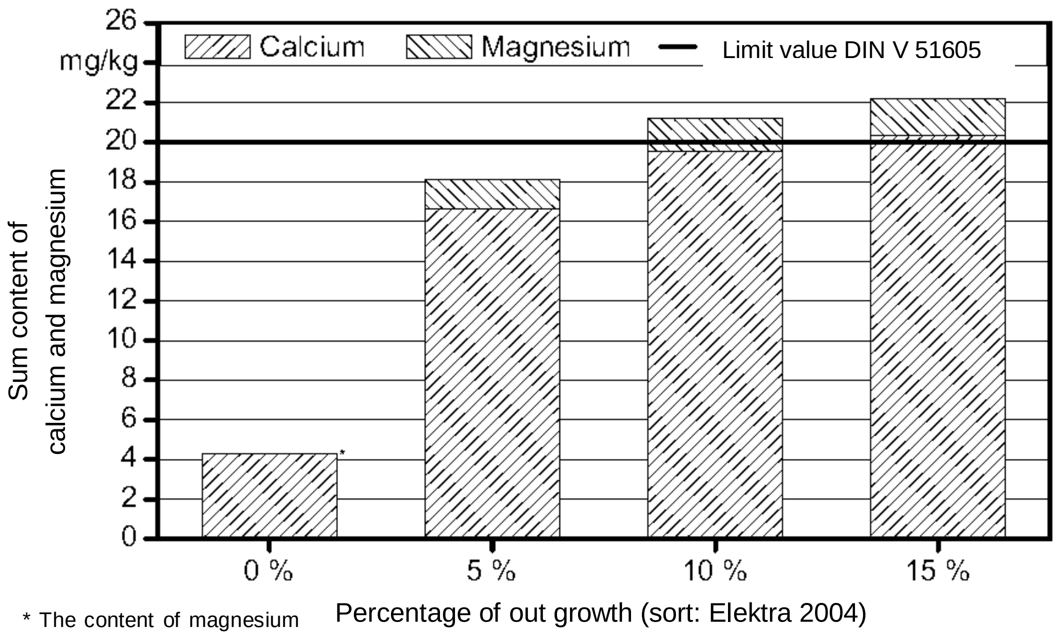
The Technologie- und Förderzentrum Bayern (TFZ), the Thüringer Landesanstalt für Landwirtschaft, the Landesanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern and the University of Rostock did a study how to produce quality rapeseed oil in decentralized oil mills.[14]

An important result of the study showed that the degree of maturity of rapeseed has impact on the fuel quality. With a higher percentage of unmature seed material the content of P, Ca/Mg in the oil becomes higher. Early harvested rapeseed with a high content of green or brown corn material produces plant oil with a high content of P, Ca/Mg.[15] To meet the DIN V 51605 standard, the percentage of unripe, green or brown oil seed should not exceed 2 %.[16]

2.2.3 The Influence of Outgrowth on P, Ca/Mg Content in Rapeseed Oil

If it is not possible to harvest mature rapeseed because of a longer raining period, for example, the seed starts to regerminate. Next to an increasing acid value of the oil also P, Ca/Mg increases.

Table 7 shows how the content of Ca/Mg grows with the percentage of outgrown rapeseed material.



* The content of magnesium lies below the detective limit of 0.5 mg/kg.

Table 7: Influence of % Outgrowth on Ca/Mg Content of Rapeseed Oil[17]

Already 5 % of outgrowth leads to a Ca/Mg content of 18 mg/kg which is close to the limit in the DIN V 51605.

2.2.4 The Influence of Soiling on P, Ca/Mg Content in Rapeseed Oil

Soiling means all different biomass which is harvested together with the rapeseed. Soiling with a higher water content than rapeseed leads to fungi and enzymatic processes during storage which have a negative impact on the content of P, Ca/Mg in the rapeseed oil. This negative impact was not very strong but remarkable.

2.2.5 The Influence of Different Oil Seed Sorts on the Content of P, Ca/Mg in Rapeseed Oil

Although it is not mentioned on the oil quality matrix (table 8), the sort of rapeseed obviously also has influence on the content of P, Ca/Mg in rapeseed oil.

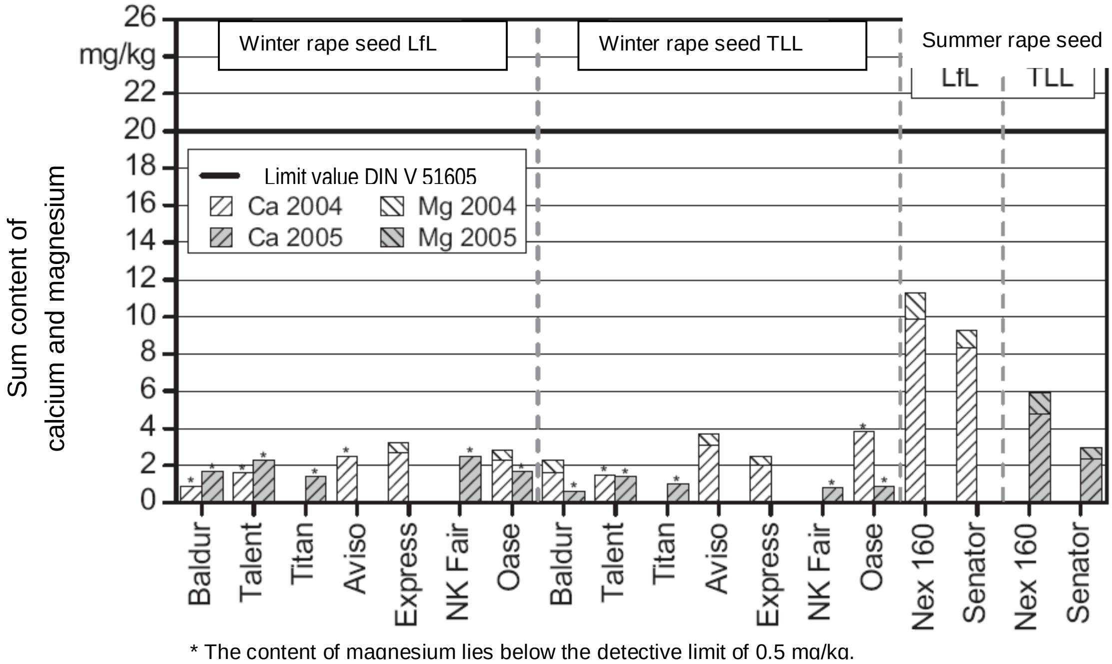


Table 8: The Content of Ca/Mg of Different Sorts of Rapeseed[18]

Table 8 shows that rapeseed oil from summer rape tends to contain more Ca/Mg than rapeseed oil from winter rape. Results for phosphor are not noted but should have the same tendency. Therefore, decentralized oil mills which press summer rape instead of winter rape have a higher risk not to reach the limits of all mineral elements in the DIN V 51605.

2.2.6 Oil Pressing and its Influence on Low Content of P, Ca/Mg in Rapeseed Oil

The oil pressing process has a strong impact on the quality of the oil. Especially with the temperature of the cold pressing process also the content of P, Ca and Mg varies.

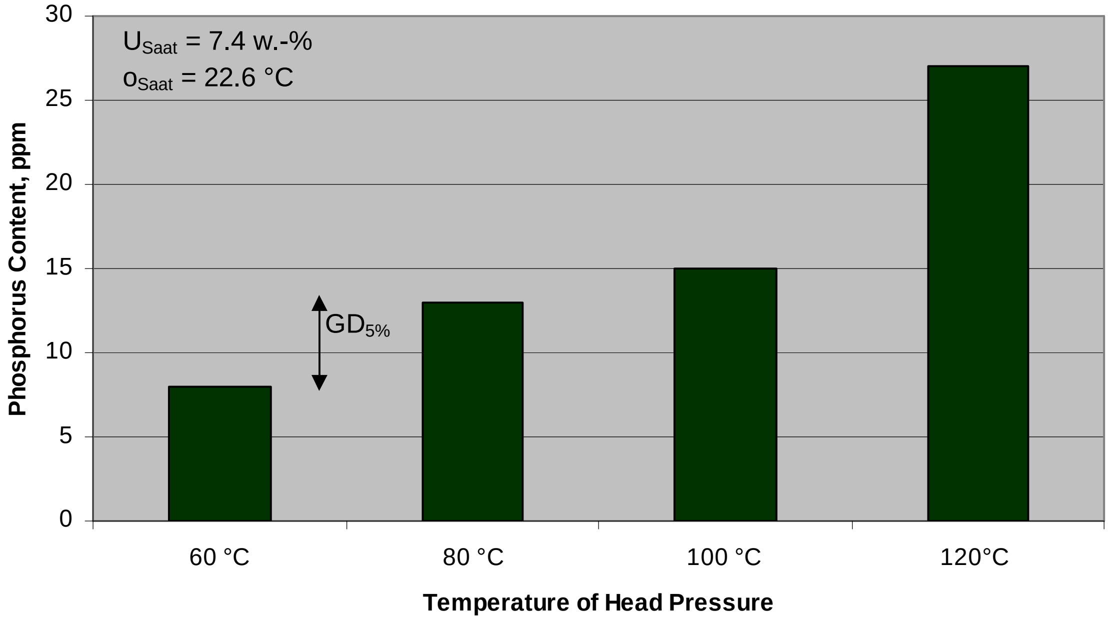


Table 9: P Content of Rapeseed Oil Depending on Temperature of the Head of the Oil Press[19]

In table 9 it can be seen that by doubling the temperature of the oil press head from 60 °C to 120 °C the phosphor content increases from 9 mg/kg to 28 mg/kg. The P limit of 12 mg/kg in the DIN V 51605 is reached at a temperature of the oil press head of more than 80 °C.

Further influences the distances of sieve-bars at the screw press the phosphorus content.
Waldland remarked these effects in regularly vegetable oil production in June of 2007, by optimising murk-rate in oil. By conversions on the screw press, to reach lower murk-rate in vegetable oil production the distances of sieve-bars were lowered. Because of the reduction of the sieve-bar size the pressure density increases, on the other hand the oil profit become lower. Ongoing the pressing process the produced vegetable oil were analysed for quality management.
As it can be seen at the analysis of vegetable oil (see Table 10) because of the changes on sieve-bars the element content of phosphorus, calcium and magnesium decreased. Before the changes of sieve-bars the element content of calcium was 47 mg/kg, magnesium 7.22 mg/kg and the phosphorus content was 47.3 mg/kg (see Table 10, Trial: QK2007-313). Through the distance changes of sieve-bars the element content of calcium decreased to 18.9 mg/kg, the magnesium content down to 1.7 mg/kg as well as the phosphorus content decreased to 12.9 mg/kg (see Table 10, Trial: QK2007-314).

Trial	Calcium	Magnesium	Phosphorus	Ash	Neutralisation number
	mg/kg	mg/kg	mg/kg	mass-%	mg KOH/g
QK2007-313	47.0	7.22	47.3	0.025	2.72
QK2007-314	18.9	1.70	12.9	< 0.0075	2.96

Table 10: Comparison of vegetable oil quality before and after changes on sieve-bars[20]

To avoid a high P content it is also necessary to use relatively dry rapeseed. A moisture content of 7 % reduces P and increases the oil pressing efficiency.[21]

Beside the oil press temperature and settlements of the screw press the performance of the oil mill is also an influencing factor of P, Ca and Mg content in vegetable oil. If the screw press performance will raised, more pressure density influences on the seed and increases the temperature of the screw press. The amount of the temperature is of particular importance, because the higher the temperature of the screw press more oil profit of seed is accessible. As side effect more minerals, like P, Ca and Mg be squeezed out of seed by higher temperatures of the screw press.[22]

2.2.7 Seed Conditioning, Preheating and Peeling and its Influence on P, Ca/Mg Content of Rapeseed Oil

Preheating the seed material in a so-called heating pan leaves, a lower oil content in the oil cake but also increases the content of P, Ca/Mg in the oil.[23] So, just little preheating, maybe through a heat exchanger to cool the oil cake, is recommended for decentralized oil mills.

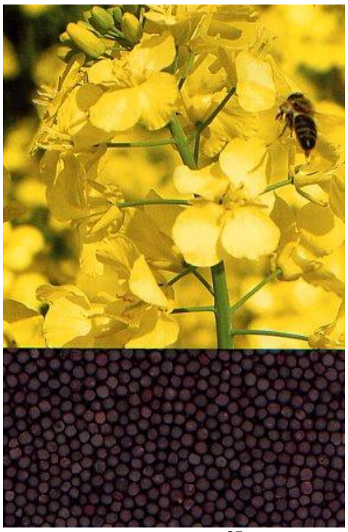
A remarkable reduction of phosphor in the rapeseed oil is possible by peeling the seed. In pressing experiments, a P content of down to 2 ppm has been achieved.[24] Since high cost of the peeling process and reported problems of oil millers to build up pressure for pressing, this very interesting process is almost not used in decentralized oil mills.

2.2.8 Parameters influencing Oil Quality of Jatropha, Camelina, Sunflower and Corn germ

The influence above discussed parameters of rape seed (corn break, maturity of seed, outgrowth, soling, different oil seed sorts, seed conditioning, preheating and peeling of seed) are apportionable on all oil fruits, excepted the oil pressing of seed.

Each oil fruit requires oil mill processing adjustments adapted on its seed properties. The most important processing parameters for oil production are the gain size, the shell share and the shell thickness. On these seed properties oil mills has to be adapted for oil production.

If camelina seed and sunflower seed should be processed nearly the same oil mill settlements like for rape seed processing is usable. As it is demonstrated at picture 1 and picture 2 the gain size of rape seed and camelina seed is nearly identical. Hence, by oil production of camelina is the same oil profit reachable with the machine settlements as for rape seed oil production.
Because of sunflower seeds properties, larger gain size and a higher shell share as rape seed, if same oil mill settlements for rape seed were used, the oil profit is 40% – 50% kg/h lesser than by rape seed oil production.



Picture 1: Rape seed[25]

Picture 2: Camelina seed[26]

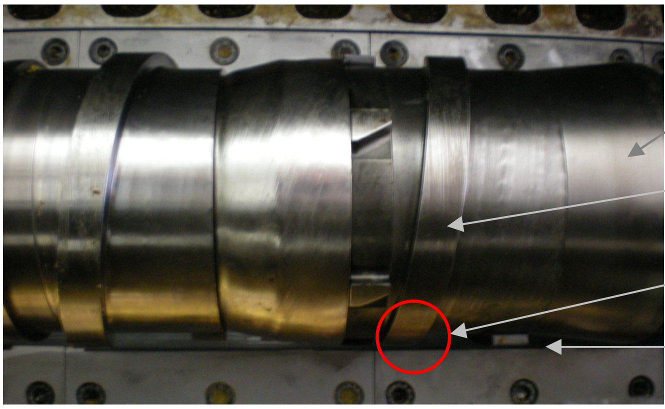
Picture 3: Sunfower seed[27]

Picture 4: Jatropha seed[28]

Picture 5: Corn germ seed[29]

Further interesting oil fruits for vegetable oil production are jatropha and corn germ. In comparison to rape seed is the oil production with jatropha completely different. KEK Egon & Keller GmbH, Germany, requires for jatropha processing a lower pressure and a larger sieve-bar size as it is used for rape seed oil production. For a well oil profit the temperature inside the screw should be between 80 °C – 90 °C by cold press system, for rape seed processing ideal screw temperature lies between 55 °C and 60 °C. Care must be taken, if after jatropha oil production subsequently eatable oil should be produced, that the oil mill has to be adequately cleaned, because of the toxic jatropha.[30]

By production of corn germ oil it is important to generate a higher pressure temperature, between 80 °C and 105 °C as well a lower sieve-bar size as it is used by rape seed. The temperature by seed transfer into the oil press should be between 80 °C and 100 °C.[31]



Picture 6: Screw of oil mill for corn germ processing[32]

Additionally the distance between the screw rings and the sieve bars has to be lowered because of the gain size of the seed. For corn germ production the distance amount 1 mm to 2 mm, compared by rape seed the distance amount 3 mm to 4 mm (see picture 6).[33]

There is no qualified data material about the influence of the oil press technology on the P-, Ca/Mg-content of camelina-, sunflower-,jatropha- and corn germ oil available at this point. This is because the DIN V 51605 and all other preliminary oil quality standards just refer to rape seed oil as fuel. Almost all experience which is available was done for rape seed oil. Already for almost two years the German DIN V 51605 commission runs a sub department to establish a DIN 51605 for other plant oils. But results are still not published. Therefore later for 2nd VegOil full DIN V 51605 analysises of all different plant oils which are demonstrated will be done and reported.

3 Conclusion

The report on variations of different quality standards for plant oil till the DIN 51605 shows that every new standard decreased the limit of phosphor in the plant oil fuel. Due to engine damages, the DIN V 51605 Commission was also forced to add calcium and magnesium as new property to the DIN V 51605.

With every new quality standard the oil mill owners had to increase their effort in quality management to meet the stronger regulations of the new standard. Because of many studies and experimental agricultural tests every oil miller now has access to information how to keep down the content of P, Ca/Mg under the limit of the DIN V 51605. Especially the FNR handbook to produce rapeseed fuel in decentralized oil mills shows the whole variety of P, Ca/Mg influencing parameters. With an optimal combination of these parameters, it is possible to produce a fuel quality which is required in the DIN V 51605.

But it also became evident that with the existing know-how and the existing oil press technology a sum content for P, Ca/Mg of < 1,5 mg/kg, as proposed in 2nd VegOil, cannot be reached. To increase the DIN V 51605 probably new elements like potassium or sodium might furthermore be added. In future also new tools and different and new methods are necessary to purify and decrease P, Ca/Mg during the oil production process to the limits which are required from modern diesel engines in 2nd VegOil.

Since the DIN V 51605 and all other preliminary oil quality standards refer to rape seed oil as fuel there doesn´t exist qualified data material about other plant oils so far. But in 2nd VegOil also other plant oils than rape seed oil are used. The impact of these different plant oils on the existing oil press technology has been reported and requires no major and expensive adaptation of the oil press technology. A full DIN V 51506 analysis of every other used plant oil than rape seed oil will be done later in 2nd VegOil. It also will be examined later weather the P, Ca/Mg purification of the VWP/Waldland system also functions with other plant oils than rape seed oil.

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