

Using *Jatropha Curcas* for Generating Energy – A Study of the Properties During Processing

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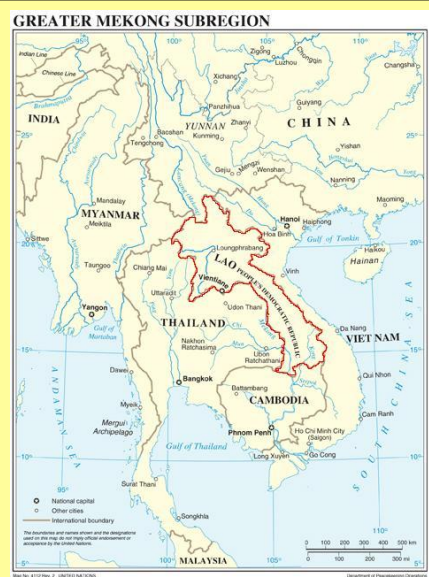
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Outline

- Introduction of LIRE and PPM Magdeburg
- LIRE's biofuel involvement in Lao PDR
- Processing of different *Jatropha* seeds into biofuel
 - Cold- and hot extraction
 - Refining
 - Transesterification
 - Comparison of the results
- Conclusions



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The Lao Institute for Renewable Energy (LIRE)

- LIRE is a public non-profit organisation founded in 2006 by Laotian companies and organisations
- LIRE is attached to National Science Council (NSC), Prime minister's office (PMO)
- Applied research on agronomic, technical and socio-economic aspects of renewable energy in the Lao PDR
- Working areas:
 - Biofuels (energy crops, biodiesel)
 - Biobased (Gasification, Biogas)
 - Small- and Pico-hydro
 - Solar operated water purification
 - PV solar
- Major funders are NGOs and Laotian companies



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LIRE's involvement in Biofuels

- Partners:
 - National University
 - Lao Extension Agriculture Products (LEAP)
 - Lao State Fuel Company (LSF)
 - Sunlabob Ltd.
 - FONDEM
 - Pilot Plantoiltechnology Magdeburg (PPM)



Activities related to biofuels

- Jatropha agronomical research program
- Agricultural extension services
- Assessing the feasibility of biofuel production on village level
- Biofuel policy development
- Capacity building



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Pilot Pflanzenöltechnologie Magdeburg e.V. (PPM)



- **Public supported research and development**
- **Contract research**
- **Test trials and sample manufacturing**



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PPM Vegetable Oil and Protein Processing Facilities

- **Laboratory and/or pilot scale**
 - Seed pretreatment
 - Crushing
 - Solvent extraction
 - Refining
- **Protein processing**
 - Extraction
 - Purification
 - Modification
 - Conservation
- **Pilot-scale processing simulation**
 - Interesterification
 - Transesterification
 - Epoxidation
 - Steam distillation



Unique plant in Germany for the simulation of the oil mill process in pilot scale



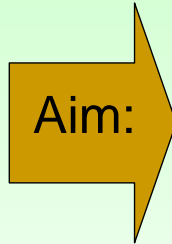
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Introduction of the Study

- Jatropha seeds with different origin / quality
 - Cold- and hot pressing
 - Refining
 - Transesterification
 - Analyses



Opportunities for:

- Decentralized production, pressing, simple cleaning and transesterification in Laos



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Process Chain of the Study



Jatropha Seeds from Laos, India and Vietnam



Seed Crushing



Cold- and Hot Pressing



Chemical analysis and comparison to DIN standard



Refining and Transesterification



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Fuels For Plant Oil Suitable Engines – Canola Oil Fuel and Biodiesel

	unit	DIN V 51605 Canola oil fuel	DIN EN 14214 Biodiesel
Acid value (Corrosion problems)	mg KOH/g	max. 2	max. 0,5
Phosphorus content (Problematic deposits)	mg/kg	max. 12	max. 10

- The phosphorus content and the acid value are important biofuel characteristics!
- Breaking the limit value, can cause serious engine problems
- Oils with a high acid value and phosphorus content can cause difficulties in the processing



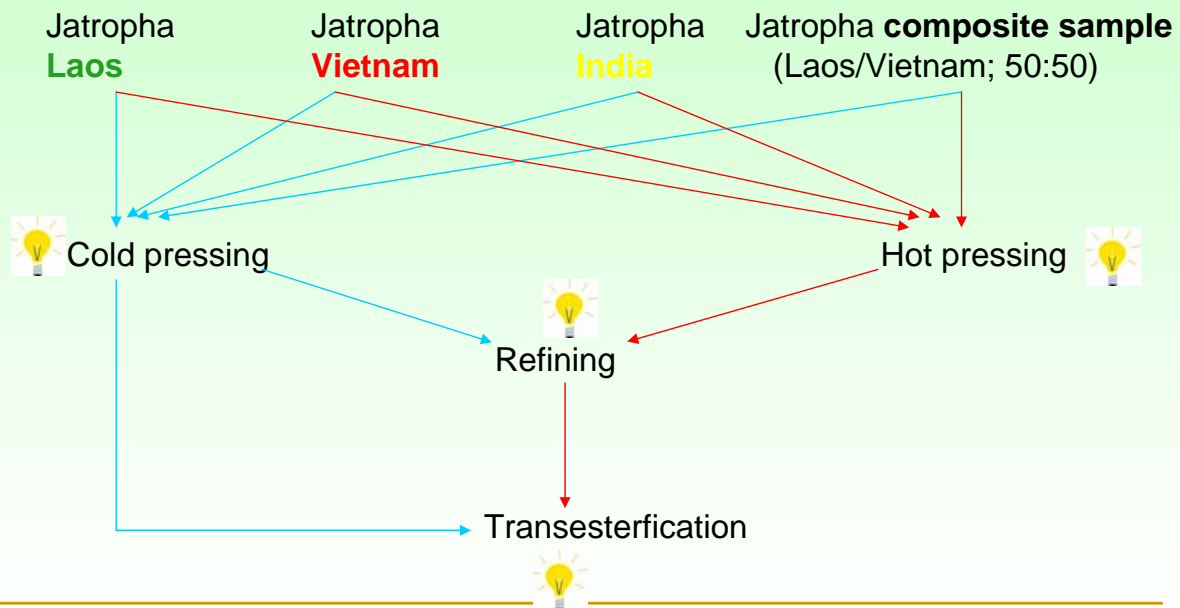
Source Material

Origin		Laos	Vietnam	India	Composite Sample (CS)
Seed humidity	[M - %]	8.8	6.6	6.3	6.5
Oil content seed	[% i. dm]	40.1	35.0	35.0	37.8
TCW	[g]	685.6	552.0	623.0	612.0

- **Laos:** Seeds were plucked from the bush and sundried. The seeds were not treated in any way
- **Vietnam:** Seeds were picked up from the ground and treated with pesticides because of transportation regulations
- **India:** Unknown collection of the seeds, but treated with pesticides because of transport regulations



Process Chain At the Trials



Press Trials – General Cold Pressing

- + Smooth pressing results in a high quality oil
- + Low degree of phosphorus load
- + High flow rate
- Low oil yield



Press Trials – Results Cold Pressing

Seed species		Jatropha Laos	Jatropha Vietnam	Jatropha India	Jatropha CS	Limit DIN
Oil flow temperature	[°C]	44.5	55.0	56.0	49.8	
Press cake - Oil content	[% i. dm]	16.6	17.6	14.2	18.4	
Press cake - Humidity	[M.-%]	11.8	6.4	6.1	7.3	
Oil yield	[%]	76.3	65.4	72.6	67.5	
Crude oil yield after filtration	[%]	64.1	44.6	55.4	47.6	
Phosphorous load	[ppm]	4.8	164.0	13.6	56.0	< 12

- Large differences regarding phosphorous load.
- High sediment amount → Low oil yield.



Press Trial – General Hot Pressing

- + High oil yield
- + Less particles in the oil
- Increased phosphorous load
- low mass flow



Press Trials – Results Hot Pressing

Seed species		Jatropha Laos	Jatropha Vietnam	Jatropha Indien	Jatropha CS	Limit DIN
Oil flow temperature	[°C]	95.0	97.0	99.0	93.0	
Press cake - Oil content	[% i. dm]	8.8	10.1	7.9	8.1	
Press cake - Humidity	[M.-%]	5.5	3.9	4.0	3.8	
Oil yield	[%]	87.0	80.9	85.7	86.8	
Crude oil yield after filtration	[%]	75.1	66.2	74.0	75.4	
Phosphorous load	[ppm]	15.9	180.0	91.0	150.0	< 12

- + High oil yield
- - Increased phosphorous load



Press Trials – Comparison Between the Cold and Hot Pressing Operation

		Cold pressing				Average
		Jatropha Laos	Jatropha Vietnam	Jatropha India	Jatropha CS	
Oil yield after pressing	[%]	76.3	65.4	72.6	67.5	70.4
		87.0	80.9	85.7	86.8	85.1
Solid material amount	[%]	16.0	31.8	23.7	29.4	25.2
		13.7	18.1	13.7	13.1	14.7
Oil yield after filtration	[%]	64.1	44.6	55.4	47.6	52.9
		75.1	66.2	74.0	75.4	72.7
Phosphorous load	[ppm]	4.8	164.0	13.6	56.0	
		15.9	180.0	91.0	150.0	



Cold pressed



Hot pressed

- Oil yield differs between cold and hot pressing
- With cold pressing operation, more particles are in the oil
- The phosphorous load depends on the press operation **and** the seed material.



Press Trials – Fatty Acid Spectrum

	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	
Laos	15.0	0.9	7.2	42.1	34.4	0.2	0.2	Cold pressing
	15.6	1.1	7.1	41.1	34.7	0.2	0.2	Hot pressing
Vietnam	15.3	1.1	6.3	38.8	38.1	0.2	0.2	
	15.0	1.1	6.3	38.8	38.2	0.3	0.2	
India	15.1	1.0	7.1	42.2	34.1	0.2	0.2	
	15.6	1.1	7.0	41.7	34.2	0.2	0.2	
Composite sample	15.2	1.0	6.9	40.3	36.1	0.2	0.2	
	16.0	1.1	6.9	39.8	35.9	0.2	0.2	
Canola oil	3.0	<3	4.0	60.0	20.0	10.0	3.0	

- The fatty acid spectrum does not change among the cold and hot pressing operation.
- Proportion between saturated and unsaturated fatty acids is in the ratio of 20 : 80 percent (canola oil 10 : 90).



Refining - General

- Function: Cleaning, deacidification, conservation and elimination of undesired minor components.
- Refining consist following procedures:

1. Hydratisation
2. Degumming
3. Neutralisation
4. Bleaching
5. Deodorisation



Refining – Source Material and Proceeding Steps

- Cold and hot pressed Jatropha oils from Laos, Vietnam and the composite sample
- All oils have been processed with the first three refining steps

Hydratisation: with H₂O

Degumming: with citric acid

Neutralisation: with NaOH / KOH

- Analyses: Acid value and phosphate load



Refining – Comparison of the Hot Pressed Jatropha Oils During the Refining Process

Stage 1:

Hydratisation

Water soluble substances.



Oil from Vietnam

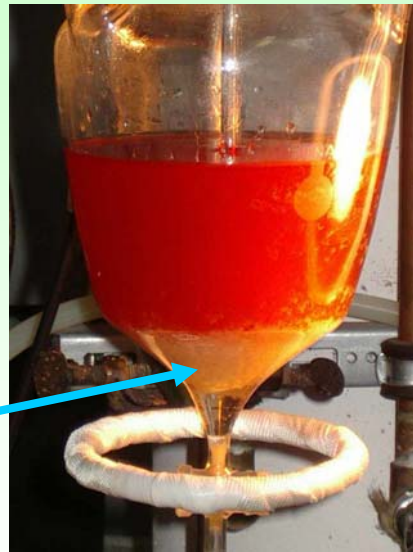


Oil from Laos

Refining – Comparison Of the Hot Pressed Jatropha Oils During the Refining Process.

Stage 2: Degumming

Deposited slime substances



Vietnam



Laos



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Refining – Comparison Of the Hot Pressed Jatropha Oils During the Refining Process.

Stage 3: Neutralisation

Massive Soap formation and solving of several substances



Vietnam



Laos



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Refining – Comparison With the Crude Oil and Raffinate

Crude Oil



Laos / Vietnam / India / CS

Raffinate



Laos / Vietnam / India / CS



Refining – Summarization of the Results

Source Material (hot pressed)		Laos	Vietnam	India	CS	Limit DIN	
Acid rate		2.7	19.1	5.7	7.7		Crude oil
		0.2	2.9	0.1	1.5	< 2	Raffinate
Phosphorous load	[ppm]	15.9	180.0	91.0	150.0		
		3.8	45.3	--	27.8	< 12	
Oil losses during refining	[%]	2.0	29.0	--	19.0		

- Significant reduction of the acid value
- Decreasing of the phosphorus load
- Different mass losses during refining



Transesterification - General

- Ester compounds from triglycerides of the plant oil will be separated and the accruing fatty acids will be transesterified with methanol
- + decreasing viscosity
- + decreasing phosphorous load



Transesterification – Source Material

- Cold pressed crude oil
(Laos, Vietnam, composite sample)
- Hot pressed refined oil
(Laos, Vietnam, composite sample)
- Catalyst: KOH (1,24 Ma. %)
- Alcohol: Methanol (20 Ma. %)

Transesterification – The Process

Reaction with KOH and methanol:



Vietnam



Laos



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Transesterification – The Process

Deposition of the glycerine Phase:

Clear separation of the glycerine and biodiesel phase



Vietnam



Laos



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Transesterfication – Comparison Between the Jatropha Transesterifications

		Crude Oil			Raffinate				
		Laos	Vietnam	Composite Sample	Laos	Vietnam	Composite Sample		
Acid ratio		4.2	18.2	8.3	0.7	8.6	1.5	Crude Oil / Raffinate	Biodiesel
		0.1	k.A.	0.2	0.1	0.2	0.1		
Phosphorous load	[ppm]	4.9	164.0	56.0	3.8	45.3	27.8		
		7.6	k.A.	12.5	7.7	32.6	4.8		
Losses at the transesterfication	[%]	6.0	> 85	14.9	5.5	14.8	9.3		

- Significant reduction of the acid value.
- Decreasing of the phosphorus load.
- Different losses during transesterfication.



Summarization:

- The raw seed material has to be properly harvested and stored – otherwise problems can occur during processing
- Cold pressing operation can provide a suitable fuel for direct combustion in modified engines **IF** the raw seed material has sufficient quality
- Phosphorous load depends on the press method and quality of the source material
- Refining is connected with mass losses depending on the scale of quality
- The production of biodiesel with crude Jatropha oil can meet the DIN standard
- Technical problems are less compared to the agricultural challenges – **Sufficient Jatropha feedstock production seems to be more challenging**



Thank you for your attention!



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