

Session: Novel polymers
Presentation by: Frans Kappen,
Wageningen Food & Biobased Research

Title: **Natural rubber from dandelions**

Author: **Frans Kappen**

Contact details:

Frans H.J. Kappen (MSc)
Wageningen Food & Biobased Research
P.O. Box 17, 6700 AA Wageningen, The Netherlands
Wageningen Campus, Building 118,
Bornse Weilanden 9, 6708 WG Wageningen,
The Netherlands
T +31 317 481162
E frans.kappen@wur.nl



Curriculum:

Frans Kappen studied Chemical Engineering at the University of Groningen, the Netherlands. After his traineeship at Shell/Exxon Mobil (drilling fluids), he went to work at the Food & Biobased Research institute, part of Wageningen University and Research Centre (WUR).

His working fields include in particular refining and processing of agricultural materials (carbohydrates (starch, chitin), natural rubber, polyhydroxy alkanooates) and biobased polymer product development (bioplastics, packaging, adhesives, coatings). Scaling up and implementation of new biobased materials into several industrial production processes are part of his work. Frans Kappen is work package leader in the DRIVE4EU project in which dandelions as a new source for alternative natural rubber is demonstrated. Extraction, refinery and analysis of natural rubber from rubber dandelion are part of this work package. Scaling up this refinery from small laboratory scale to pilot scale is the main task.

In the last 22 years, Frans Kappen performed and managed projects for raw product and end product producers, small enterprises and multinationals. These projects (over 80) were feasibility studies for 1 month to application research of 2-4 years.

Abstract:

Wageningen University and Research is the coordinator of the DRIVE4EU demonstration project. DRIVE4EU stands for Dandelion Rubber and Inulin Valorization and Exploitation for Europe. The consortium is a collaborative network of European research organisations and industrial participants, which consists of 13 partners located in 6 countries.

DRIVE4EU aims to demonstrate the technical and economic feasibility and potential of an European production chain for natural rubber and inulin as building block for green chemicals, using the rubber dandelion as a production platform. The value chains cover all elements from plant breeding and agronomy to ultimately the production of rubber based consumer end products (e.g. tyres). Scaling-up of each individual step in the production chain has to be demonstrated.

This presentation will give an overview of the background, the progress obtained in the DRIVE4EU project and impact and perspectives of this rubber dandelion. Aspects of breeding, agronomy, ecological interactions, extraction and analysis of natural rubber, and properties of rubber products will be covered.

Natural Rubber from dandelions

Biobased Performance Materials symposium 2018

Wageningen, 14th June 2018, Frans Kappen



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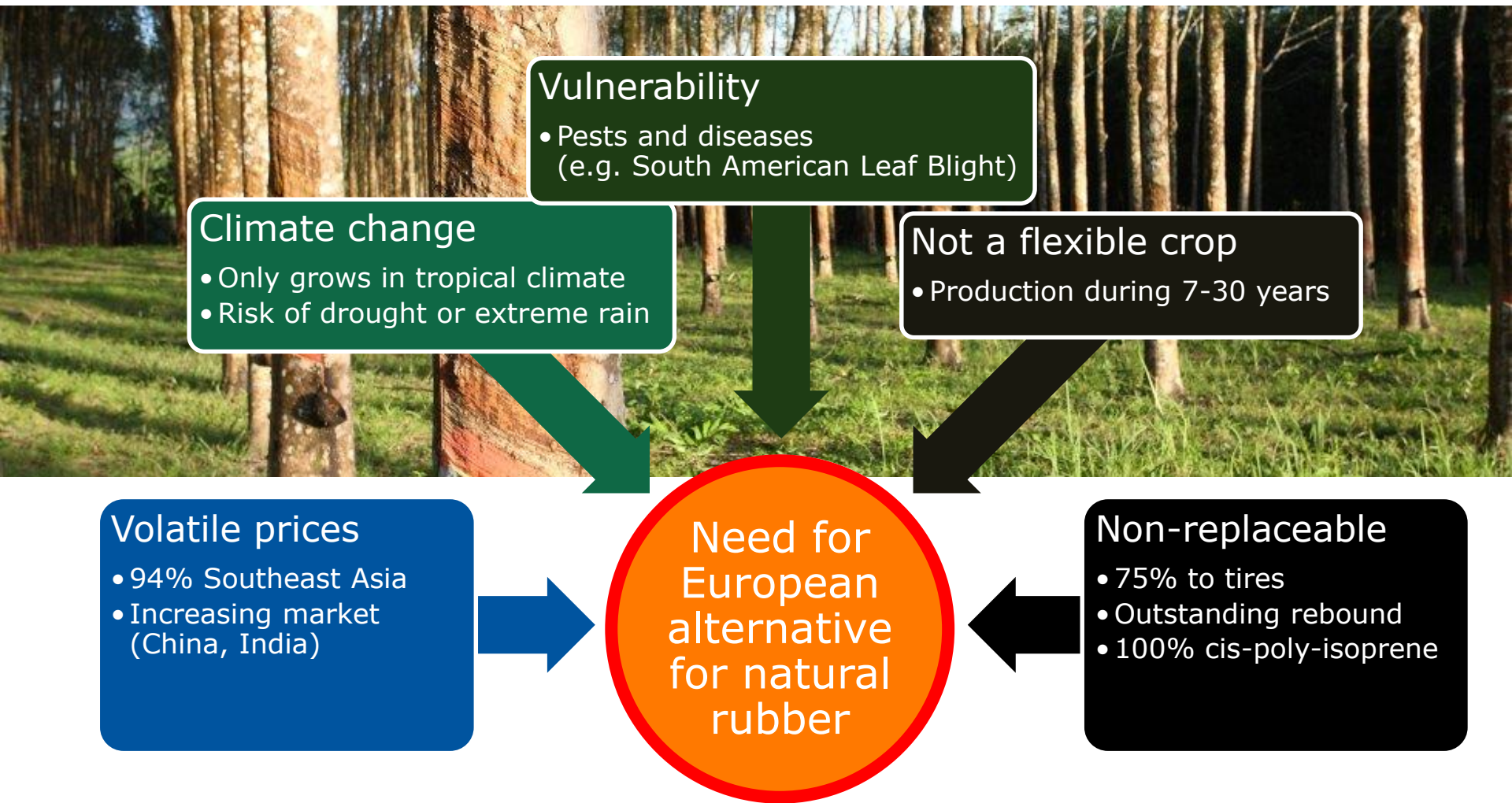
- Why alternatives to *Hevea* Natural Rubber?
- Rubber dandelion
 - DRIVE4EU
 - The production chain of Dandelion Rubber
 - Results, challenges
- Expectations of the future

Why alternatives to *Hevea* Natural Rubber?

- List of “critical raw materials” for the EU
 - High risk of supply disruption
 - High economic importance

2017 CRMs (27)			
Antimony	Fluorspar	LREEs	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs	PGMs	Vanadium
Coking coal	Indium	Phosphate rock	

Natural rubber from *Hevea brasiliensis* tree



Alternatives to *Hevea* Natural rubber?

- Natural rubber sources
 - 2000 plant species that contain rubber
 - Quality, amount, economics, development
 - *Hevea*: high Mw, 2000 kg/ha/yr, almost 200 yrs

- Also a shortage during World War II
 - USA: Guayule in warm, dry climate
 - USSR: Dandelion in cold to moderate climate
 - Development stopped

Russian/Kazakh rubber dandelion *Taraxacum koksaghyz* (TKS)



- Annual mechanical whole crop harvest
- Latex in threads, coagulates very fast to dry rubber
- High molecular weight rubber
- High inulin content

Dandelion Rubber and Inulin Valorisation and Exploitation for Europe



Breeding



Cultivation



Refinery



Products



Ecology & Economy

- Demonstration project (2014-2018)
- Optimisation and upscaling

Breeding of Rubber dandelion



Breeding

- Wild type
- Variations
- Size
- Quantity
- Root shape

- Wild type *T. koksaghyz* (rubber dandelion)
 - Small, fragile, but high rubber content

↓
- Breeding tools, knowledge of metabolic pathways

↓

- Hybrids TKS and bigger dandelions
 - Large, strong, and high rubber content
 - Increasing inulin content

The cultivation of Rubber dandelion



Cultivation

- Yield / ha
- Sowing
- Harvest
- Storage

- Mechanical sowing
- Protocol for use of fertilizers, water, etc.
- Mechanical harvest
- ± 5 hectares planted and harvested



The production of Dandelion Rubber



Production

- Efficiency
 - Dry rubber
 - Volume
 - Energy
- Patent pending biorefinery process to obtain both rubber and inulin
 - From laboratory to pilot scale
 - Up-scalable equipment specified for this process
 - Dry rubber
 - High rubber recovery and high purity
 - High molecular weight

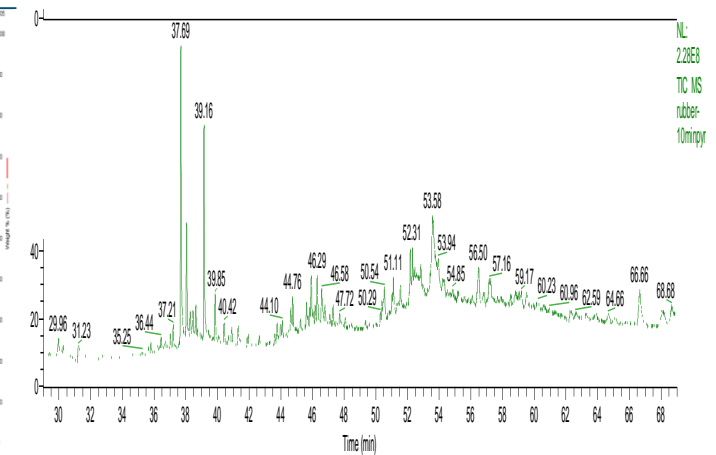
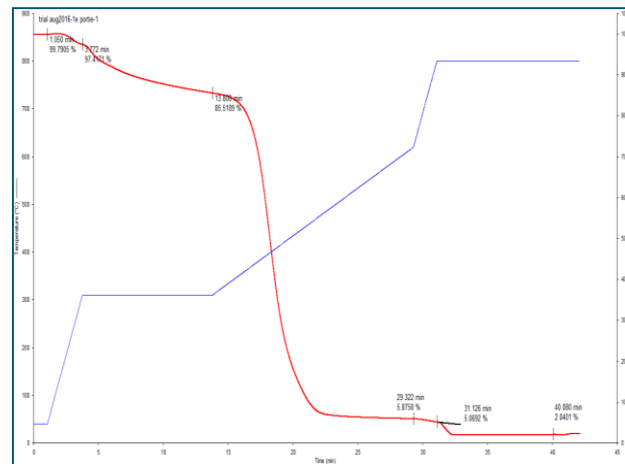
Analysis of Dandelion Rubber



Analysis

- Properties
- Rubber
- Compound
- Product

- Quantitative and Qualitative analysis
 - ASE, soxhlet, HTSE, FTIR, GPC, TGA, GC-MS



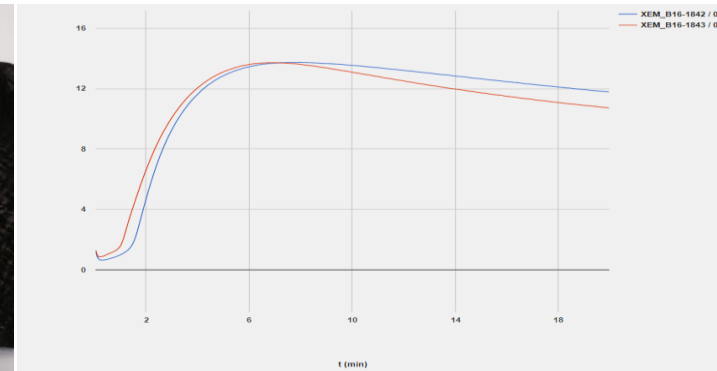
Compounding of Dandelion Rubber



Compounding

- Properties
- Rubber
- Compound
- Product

- Standard ASTM methods
 - Improved milling behaviour, higher stickiness



Sheets of rubber compounds and their curing curve (Apollo Tyres Global R&D)

Compounding of Dandelion Rubber



Compounding

- Properties
- Rubber
- Compound
- Product

- Tyres are made and at the moment on their way to New Zealand for winter testing



Winter tyres by Apollo Tyres Global R&D

Ecology of Rubber Dandelion



Ecology

- Natural crossings
- Invasion

- Dandelions are a “weed”...
- Will the Rubber Dandelion (TKS) take over?
 - No natural crossings between TKS and other dandelion species in Kazakhstan and in the laboratory
 - No TKS any more at “old farms” in Sweden



Economy of Dandelion Rubber chain



Economy

- Yield
- Costs

- Current status → near future → long term
 - Maintaining quality
 - Low yield → high yield
 - Optimise processes
 - Scale up processes

- Future looks promising!
- Final report is being prepared

After DRIVE4EU

- Research → demonstration → flagship?
- Using 2nd generation rubber dandelions
- Further automate sowing and harvesting
- Building pilot refinery plant
 - Quality of dandelion roots
 - Pilot production of dandelion rubber
 - Pilot production of inulin
- Formulation, compounding and testing of tires and rubber goods

Expectations for Natural Rubber from alternative feedstock

- There is a need, so something will happen...
 - Not only several synthetic rubbers and additives
 - But also several natural rubbers and additives



Questions?

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Dandelion Rubber and Inulin Valorisation and
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