Guayule & R.Dandelion sebagai bahan bakou alternatif dari karet alami
Status, Tantangan, Peluang

S.Palu / D.Pioch / T.Chapuset / D.Snoeck / E.Tardan / F.Bonfils¹, A.Amor², M.Dorget², S.Suchat³, N.Sfeir⁴

¹=CIRAD, ²=CTTM, ³=PSU-Thailand
⁴=IAMM-CIHEAM

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Guayule & R. Dandelion as alternative feedstock of natural rubber
Status, challenges, opportunities

S. Palu / D. Pioch / T. Chapuset / D. Snoeck / E. Tardan / F. Bonfils¹, A. Amor², M. Dorget², S. Suchat³, N. Sfeir⁴

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2. GUAYULE & R. DANDELION DEVELOPMENT AND HISTORY

3. AGRONOMY OF GUAYULE

4. COMPARISON LATEX TISSUS & CELLS HEVEA / GUAYULE / DANDELION

5. PRODUCTION

6. RUBBER PROPERTIES & APPLICATIONS

7. CONCLUSION & PERSPECTIVES
Hevea plantation, **Tropical climate** (>0°C >1500mm)

Guayule field, **Mediterranean/semi-arid climate** (>10°C 250-800 mm)

Dandelion field, **Temperate/cold climate** (-30°C, 800-1000 mm)

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NR from Hevea, Guayule and Dandelion SUSTAINABLE polymers

BIOREFINERY models

SYNTHETIC RUBBER

NATURAL RUBBER

Excellent Hysteresis

Low heat build-up

3.7-5.0 Toe per ton SR

0.4 Toe per ton NR

1 Toe/Tep = 42 GJ

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**WHY NR ALTERNATIVES SOURCES ?**

- **HEVEA**, only commercial source of NR (93% world prod. in Asia)
  
  Growing demand from emerging countries (China, India,..).
  
  5.0 M. Tons in 1990 → 17.0 M.T. in 2025 ?
  
  *Indonesia 2nd World Produced*

- Price NR & SR linked with volatile price of oil (80-150 $/ barrel)
  
  NR prices will rocket upward again (4.800€/T. in Feb. 2011).

- Replacement of rubber plantations by palm oil plantations ?

- Threat *Microcyclus ulei* (SALB) to spray in Asia/Africa. Climatic changes ?

- Increasing demand for sustainable materials, biopolymers.

- Hevea proteins and IgE-latex allergy. Cross allergy with fruits
  
  Guayule hypoallergenic.
New plantations & more replanting
8.3 M. ha in production, 11.4 M. ha with young planting.

Improve SALB Hevea clonal resistance (*IRRDB research*)

Develop new alternatives sources
- GUAYULE (*Parthenium argentatum* Gray)
- Russian DANDELION (*Taraxakum kok saghyz*)

Implement European or International projects
- **EU-PEARLS (2008-2012)**

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A bush, native from Mexico/Chihuahua semi-arid desert
(from the Aztec : quahu + ule ou olli / hayolli – hayule)

*Asteraceae / Compositae* (Parthenium argentatum Gray)
in the wild, life up to 40 years; commercial up to 10 -12 years

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WHAT IS RUSSIAN-KAZAKHSTAN DANDELION?

Native from Kazakhstan,
*Asteraceae* (*Taraxacum kok saghyz*),
an annual plant, wild & commercial (?), cold (-30°C) & heat (+40°C)

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Photos U.Munster(GER) & J.Kirshner
HISTORY, DEVELOPMENT OF GUAYULE

- **1906-1912:** 55,000 T. of GR, < 1000 T. *hevea* plantations at same period.

- Emergency Rubber Project (WWII): 8,000 ha in the US, stopped with end of war with access to *hevea* plantations in Asia and synthetic rubber development.


- **2000s**, **YULEX:** Guayule hypoallergenic latex (*K. Cornish*)

- **2008, EU-PEARLS:** Guayule, France (Montpellier), Spain (Carthagena). TKS in Germany, The Netherlands, Spain.

- **2012-2013:** Bridgestone project. *Yulex* new factory in USA. Cooper Tire project with *Yulex*. Bridgestone interest for GR bioproducts. *Yulex* with VERSALIS & PIRELLI in Italy. *PANARIDUS* in India. Europe, follow up of EU-PEARLS?
HISTORY, DEVELOPMENT OF R. DANDELION

- **WWII:** 100,000 ha in the ex-URSS, 540,000 ha in Germany

- **2008:** Ohio (USA), PENRA project. EU-PEARLS project


- **2013:** Bridgestone & Ohio State University, claim TKS commercially viable, renewable source of tire-grade rubber. Project TAKOWIND in Germany for commercial development in 2016.

- **2015:** Novabiorubber & Universities Canada, industrial plant of TKS rubber

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Commercial conditions: soils well-drained, 12 years, -9°C minimum, 380-800 mm. Needs irrigation, nursery plants, high density planting (30,000 to 55,000 plants/ha).

More biomass ≈ more rubber

Guayule lines: apomitic, tetraploids most common form, bigger plants, more productive. USDA lines: AZ1, AZ2, AZ3, CAL 6, 11591, N565, old 593 (IRC/ERP)

Rubber content 6–12% (dry weight biomass)

81% of rubber in branches, 18% in roots, 1% in leaves,

Expected yield ≈ 0.5-1.0 kg/ha/an

Harvest after 2 years versus 6-8 y. for hevea,
Every 1-2 years for 12 years before replanting, instead of every 2 days S/2,D2.
GUAYULE CULTIVATION

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Photos EU-PEARLS project France & Spain
CONTROL OF RUBBER & RESINS CONTENT BY NIRS METHOD

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Simple & rapid method for rubber and resin contents by NIRS

Guayule sample
0.5mm Ground

2. Reference Lab data

Extraction

Quantified by Gravimetry

1. NIRS analysis
XDS: FOSS

Calibration Model

NIR spectrum of an unknown sample

Calibration equation and validation

% Moisture, rubber and resin contents

Triplicate NIR spectra

Sunisa SUCHAT
PhD student from PSU-Thailand
POSSIBILITY TO GROW GUAYULE IN INDONESIA?

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HEVEA
Latex ducts with connections

GUAYULE
Latex in individual cells

R.DANDELION
Latex vessels similar to Hevea, no connection between latex vessels.
EXTRACTION PROCESS
NR GUAYULE

HARVEST

LATEX
YULEX
USDA
CIRAD

SOLVENT
DRY RUBBER & RESINS

SALTILLO (Mexico)
TEXAS A&M
FIRESTONE/SACATON
(1980s)
YULEX&PANARIDUS (2012)

SC FLUID
RESINS & Low Mw

USDA,YULEX
CIRAD
Laboratory

COMMERCIAL (500 T./Y)

COMMERCIAL PILOT

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MODEL GUAYULE LATEX EXTRACTION

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EXTRACTION PROCESS

TKS

HARVEST (annual)

WET PROCESS LATEX

Soviet Tech (1936).
ESKEW (1940)
PENRA process (2012)
Primary, Secondary
Milling Screening,
Centrifuging Flotation

DRY PROCESS RUBBER

NovaBioRubber
25°C, mechanical, green additive (US Patent 
#7,540,438)
200 T./Y.

PILOT LEVEL

Source OHIO State U.OARDC

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NR cannot be replaced by SR in some applications

**TSR/RSS:**

- Heavy duty tyres (e.g. airplanes, agricultural)
- low heat build up
- high resiliency
- resistance to break
- high tear and tensile strength
- green strength

**Latex applications:**

- Gloves, condoms
  
  Guayule latex no allergy
**LATEX PROPERTIES**

<table>
<thead>
<tr>
<th></th>
<th>HEVEA LATEX</th>
<th>COMMERCIAL GUAYULE LATEX*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid content (%)</td>
<td>61.4</td>
<td>55.6</td>
</tr>
<tr>
<td>Viscosity (Cp)</td>
<td>48</td>
<td>53</td>
</tr>
<tr>
<td>pH</td>
<td>9.6</td>
<td>10.9</td>
</tr>
<tr>
<td>Average size (µm)</td>
<td>1.0</td>
<td>1.2</td>
</tr>
</tbody>
</table>

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GUAYULE and HEVEA gloves mechanical properties are similar after slight formulation and process adaptations.

<table>
<thead>
<tr>
<th></th>
<th>HEVEA latex</th>
<th>COMMERCIAL GUAYULE latex</th>
<th>EU-PEARLS GUAYULE light phase latex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulcanising dispersion ratio</td>
<td>27</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Stress at break (Mpa)</td>
<td>17</td>
<td>7.0</td>
<td>13.3</td>
</tr>
<tr>
<td>Strain at break (%)</td>
<td>810</td>
<td>860</td>
<td>808</td>
</tr>
</tbody>
</table>
# GR TSR SPECIFICATIONS

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>GR 1</th>
<th>GR 2</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Plasticity P0, ISO 2007</strong></td>
<td></td>
<td>13</td>
<td>31-33</td>
</tr>
<tr>
<td><strong>Plasticity retention indice PRI (ISO 2930)</strong></td>
<td>15.4</td>
<td>6.5-15.2</td>
<td>&gt;40</td>
</tr>
<tr>
<td><strong>Mooney Viscosity ML (1+4) 100° C ISO 289-1</strong></td>
<td>25</td>
<td>52-53</td>
<td>60-80</td>
</tr>
<tr>
<td><strong>Dirt content % ISO 249</strong></td>
<td>-</td>
<td>0.016-0.038</td>
<td>&lt;0.20</td>
</tr>
<tr>
<td><strong>Acetone extract ISO 1407</strong></td>
<td>12.4</td>
<td>12-14</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td><strong>Ash content % ISO 247</strong></td>
<td>-</td>
<td>0.19-1.25</td>
<td>&lt;1.00</td>
</tr>
<tr>
<td><strong>Total nitrogen ISO 13878</strong></td>
<td>-</td>
<td>0.21</td>
<td>&lt;0.60</td>
</tr>
</tbody>
</table>
1 ha farm of guayule for 10 years
Dry biomass branches = 10 T./ha/year
Dry rubber C. 8% (800 kg/ha/Y)
Planting density 50,000 plants/ha

Field Prod. Costs = 1.500-2.000€/ha
Sale dry biomass = 3.000€/ha/year

Source: Nisrin SFEI IAMM/CIRAD 2011-2012 with « Olympe » software (for publication)
VALORISATION OF BIOCHEMICALS FOR GUAYULE

R.DANDELION ➔ INULINE ➔ BIOETHANOL

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THRESHOLD SELLING PRICE OF GUAYULE RUBBER

Option 1: only Latex (centrifugation)
- With current technology, it is possible to extract 25% of the total rubber as latex.
  - The valorisation of sole guayule latex would be possible only through a niche market with very high added value.

Option 2: only crude rubber + resin (solvent extraction)
- With current technology, it is possible to extract 90% of rubber + 95% of the resin.
  - (Prices recorded in 2011).

Option 3: Latex as step 1, followed by crude rubber + resin as step 2.
- It is possible to extract 25% of latex + 65% of crude rubber + 95% of resin.

<table>
<thead>
<tr>
<th>Option</th>
<th>Latex</th>
<th>Crude rubber</th>
<th>Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Latex only</td>
<td>8.0-9.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2. Solvent only</td>
<td>5.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>3. Latex, then solvent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSION

➢ GUAYULE OR TKS RUBBER NOT A THREAT FOR HEVEA

HEVEA NR NOT AVAILABLE, ALTERNATIVE SOURCES WILL DEVELOP. (5000 TONS OF GR & TKS GRADES IN 2025 ?)

➢ COMMERCIAL CONDITIONS FOR PRODUCTION OF GR & TKS NR

- PRICE OF NR (> 3.0 $US /kg),
- HIGHER RUBBER YIELD (≈1 TON/HA),
- LOWER COSTS OF PRODUCTION, EFFICIENCY OF PROCESS EXTRACTION
- NEW CULTIVARS, GENETIC IMPROVEMENT,
- VALORISATION OF BIOPRODUCTS, BIOREFINING
COMMERCIAL PRODUCTION OF NR ALTERNATIVES SOURCES DEPENDS ON:

- RUBBER PRODUCTION & DEMAND (CHINA, INDIA), economy recovery EU
- MORE COMMERCIAL PLANTS OF GR & TKS PLANT WITH HIGHER CAPACITY & NEW AREAS OF PRODUCTION
- TYRES & RUBBER INDUSTRY, NATIONAL & INTERNATIONAL ORGANIZATIONS INVOLVED
- MORE ECONOMIC & FEASABILITY STUDIES (CIRAD paper in progress)
- INTEREST FOR GUAYULE AND TKS IS LIKE RUBBER PRICE

CIRAD (BIOWWOOEB) OPENED TO PARTNERSHIP FOR DEVELOPMENT OF GUAYULE IN INDONESIA, OTHER COUNTRIES
“Catch the alternative Natural Rubber ball”
"Memanfaatkan cadangan gumpalan karet alam”

TERIMA KASIH

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