This project has received funding from the Bio Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 720726.
Biobased Industries Joint Undertaking

The Bio-Based Industries Joint Undertaking is a new €3.7 billion Public-Private Partnership between the EU and the Bio-based Industries Consortium. Operating under Horizon 2020, it is driven by the Vision and Strategic Innovation and Research Agenda (SIRA) developed by the industry.

A major public and private effort
- €3.7 billion investments in bio-based innovation from 2014-2020;
- €975 million of EU funds (Horizon 2020) and €2.7 billion of private investments
- Leveraging capital markets and additional private and public funds (e.g. synergies with EU Structural Funds).

Focus
- **Feedstock**: foster a sustainable biomass supply with increased productivity and building new supply chains
- **Biorefineries**: optimise efficient processing through R&D and demonstrate their efficiency and economic viability at large-scale demo/flagship biorefineries
- **Markets, products and policies**: develop markets for bio-based products and optimise policy frameworks

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LIBBIO

The LIBBIO project is about researching the potential of Andes Lupin for breeding cropping and biorefinery. 14 partners from 8 different EU countries cooperate together. The project is from 2016 to 2020 and has a budget of 5mio€
LIBBIO partners
- 14 partners from 8 countries
- SME’s and research institutes

Iceland
Netherlands
Germany
Portugal
Spain
Greece
Romania
Austria
The LIBBIO project is organised according to the potential value chain.
Andean lupin advantages

- Andean lupin grows on marginal lands
- Andean lupin for
  - Bean production (4 ton/ha)
  - Green biomass production (16 ton dm/ha)
- Soil conservation
- Soil nitrogen fixation and phosphate mobilisation
LIBBIO

- Pre-industrial processing is developed and optimized for the lupin. New product development will create new opportunities. Techno-economical evaluation of the supply chain will assess agricultural viability, sustainability and effect on farm and biorefinery income.
Andean Lupin: farmer economic benefits

- Scenario analysis for virtual Andean bean cropped in EU
- Comparison with winter wheat in NL, DE, F, RO, PL
- Compared with world market prices for soy bean oil and soy bean meal
- Years 2011-2013
Advantages Andean Lupin

- Rich in proteins and lipids
- Comparable with soy bean
## Andean lupin composition

composition lupin seeds and other major protein-oil crop material

<table>
<thead>
<tr>
<th>material</th>
<th>unit</th>
<th>L.albus</th>
<th>L.christianii</th>
<th>L.christianii</th>
<th>L.christianii</th>
<th>L.christianii</th>
<th>G.max</th>
</tr>
</thead>
<tbody>
<tr>
<td>moisture</td>
<td>g /100 g fw</td>
<td>8.6</td>
<td>9.0</td>
<td>9.4</td>
<td>8.1</td>
<td>8.54</td>
<td>4.73</td>
</tr>
<tr>
<td>metabolic energy</td>
<td>kJ/ 100 g dw</td>
<td>2078</td>
<td>2032</td>
<td>2164</td>
<td>2307</td>
<td>2040</td>
<td>2565</td>
</tr>
<tr>
<td>crude protein</td>
<td>g/100 g dw</td>
<td>38.2</td>
<td>33.9</td>
<td>42.2</td>
<td>43.3</td>
<td>39.9</td>
<td>21.8</td>
</tr>
<tr>
<td>crude lipids</td>
<td>g/100 g dw</td>
<td>11.2</td>
<td>6.3</td>
<td>5.5</td>
<td>18.9</td>
<td>21.8</td>
<td>54.0</td>
</tr>
<tr>
<td>fiber</td>
<td>g/100 g dw</td>
<td>8.9</td>
<td>16.0</td>
<td>15.8</td>
<td>8.2</td>
<td>10.2</td>
<td>9.0</td>
</tr>
<tr>
<td>ash</td>
<td>g/100 g dw</td>
<td>3.4</td>
<td>3.0</td>
<td>3.8</td>
<td>3.9</td>
<td>5.3</td>
<td>2.8</td>
</tr>
<tr>
<td>carbohydrates</td>
<td>g/100 g dw</td>
<td>39.3</td>
<td>41.0</td>
<td>38.8</td>
<td>32.9</td>
<td>33.0</td>
<td>21.0</td>
</tr>
</tbody>
</table>
# Andean lupin: oil & protein production

<table>
<thead>
<tr>
<th></th>
<th>Oil seed rape (UK)</th>
<th>Sunflower</th>
<th>Soybean</th>
<th>Andean lupin L. mutabilis (JKI pre-breeding field study years 2010-2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil production</strong></td>
<td>1.3-1.6</td>
<td>0.8</td>
<td>0.3-0.6</td>
<td>1.0-1.4</td>
</tr>
<tr>
<td><strong>Protein production</strong></td>
<td>0.6-0.8</td>
<td>0.6-0.9</td>
<td>0.6-1.2</td>
<td>1.7-2.8</td>
</tr>
</tbody>
</table>
Calculation product price

Price composition Andean Lupin: total 480 Euro/ton years 2011-2013

- oil, 73
- other, 71

480 €/ton or 0,48ct/kg (price level 2011-2013)
Expected Andean Lupin Crop yields

field experiments in Poland: 1.5 – 2.7 ton/ha
Seed densities 60-120/m² in 2011 and 2012


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Agronomical perspective
study WUR-LEI 2014 & JKI 2014, LIBBIO 201

• LIBBIO yield: possible 3-4 ton/ha
• JKI: possible yield: 4-7 ton/ha (top 5 accessions, 3 years)
• Break-even yields with winter wheat
  – NL: 3.7 ton/ha
  – D: 3.3 ton/ha
  – F: 2.3 ton/ha
  – Pl: 1.1 ton/ha
  – Ro: 1.9 ton/ha

share your talent. move the world.
Activities performed: Breeding

- Tool development with new genetic technologies (non-GMO) such as GWAS for assessing and using existing genetic variability and creating tools (genetic markers) for breeding.
Activities performed

- Selection funnel JKI prebreeding collection, activities started in 2009
Activities performed
high yielding accessions for improved harvesting and processing

- Development of protocols for phenotyping accessions for GWAS, including protocols for chemical characterization biomass composition
- Seed propagation for GWAS

Field trial in ISA, Lisbon Portugal in February/March 2018. Field with 25 accessions in randomized 3 block design with 20 plants/plot with 30cm spacing between lines.
Land reclamation

Reclaiming barren volcanic soil (Iceland)

share your talent. move the world.
Activities performed:
Task 5.1 Assessment of lupin beneficial effect on soil

- Main activities: protocol development for inclusion in activities of WP2
  - Protocols for root sampling
  - Harmonizing protocols for soil nutrient analysis
  - Protocol for fast bioassay for soil biodiversity activity for decomposition

[Map of soil organic matter]
Activities performed:
Task 5.1 Assessment of lupin beneficial effect on soil

- Main activities especially in Iceland due to its unique soil conditions
- Soil measurements are included of protocols in WP2.
- Litterbag Tea Bag Index
- Root augering
Benefits for people and planet

• High added value products for consumers:
  – Healthy foods
  – Natural anti-aging cosmetics
  – New biomaterials
• Alternative for GMO soy
• Contribution to biodiversity
• Nitrogen fixation in soils
• Prevention soil-erosion
• Increased soil carbon sequestration
LIBBIO applications

Biomass fraction properties and applications assessment (food, feed and non-food)

- Oil composition, properties and applications
- Protein composition properties and applications
- Oligosaccharides, alkaloids and lecithins
- Other applications
- Green silage
LIBBIO: multipurpose biorefinery
LIBBIO: healthy and delicious food

- Oil based
  - Mayonnaise, Margarine
- Protein based
  - Milk, Yoghurt, Ice cream
- Prebiotic carbohydrates
  - Stachyose & Raffinose
- Functional ingredients
  - Foaming, gelling, emulsification, stabilisation, color
LIBBIO: cosmetics with lupin bioactives

- Caring decorative cosmetics lips and eyes
- Anti-aging skin care cosmetics
LIBBIO oils

- Andean lupin has excellent fatty acid profile
- More than 80% unsaturated fatty acids
- Fatty acid profile is comparable with soy bean oil
- Andean oil can replace soy bean oil in many food applications
- Andean lupin oil high in γ-tocopherol which prevents lipid oxidation
### Fatty acid composition

- Andean lupin oil is high in unsaturated fatty acids.

<table>
<thead>
<tr>
<th></th>
<th>Saturated fatty acids</th>
<th>Unsaturated fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C12:0</td>
<td>C14:0</td>
</tr>
<tr>
<td></td>
<td>C14:0</td>
<td>C16:0</td>
</tr>
<tr>
<td></td>
<td>C18:0</td>
<td>C20:0</td>
</tr>
<tr>
<td>%SF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olive oil</td>
<td>na</td>
<td>0.7%</td>
</tr>
<tr>
<td>Palm kernel</td>
<td>41.0%</td>
<td>16.0%</td>
</tr>
<tr>
<td>Soy bean oil</td>
<td>na</td>
<td>0.5%</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>White lupin oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleu lupin oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andean lupin oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C16:0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C18:0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C18:2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C18:3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%UF</td>
<td></td>
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<tr>
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<td>78.40%</td>
<td>7% na</td>
</tr>
<tr>
<td>Palm kernel</td>
<td>22%</td>
<td>1.25% na</td>
</tr>
<tr>
<td>Soy bean oil</td>
<td>28.50%</td>
<td>49.50%</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>31.50%</td>
<td>59.50% na</td>
</tr>
<tr>
<td>White lupin oil</td>
<td>na</td>
<td>54%</td>
</tr>
<tr>
<td>Bleu lupin oil</td>
<td>na</td>
<td>33.90%</td>
</tr>
<tr>
<td>Andean lupin oil</td>
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<td>13.90%</td>
</tr>
<tr>
<td>U/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olive oil</td>
<td>85%</td>
<td>5.9</td>
</tr>
<tr>
<td>Palm kernel</td>
<td>23%</td>
<td>0.3</td>
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<tr>
<td>Soy bean oil</td>
<td>86%</td>
<td>6.4</td>
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<tr>
<td>Sunflower oil</td>
<td>91%</td>
<td>11.4</td>
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<tr>
<td>White lupin oil</td>
<td>81%</td>
<td>7.7</td>
</tr>
<tr>
<td>Bleu lupin oil</td>
<td>80%</td>
<td>4.9</td>
</tr>
<tr>
<td>Andean lupin oil</td>
<td></td>
<td>96%</td>
</tr>
</tbody>
</table>

---

- Andean lupin oil is high in unsaturated fatty acids.
LIBBIO proteins

- Andean lupin has most of the relevant amino acids for healthy products
- Drinks: milk, smoothies
- Yoghurts
- Ice cream
Andean lupin has an amino acid profile which is comparable with soy bean.
LIBBIO: feed for animal nutrition

- Feed for
  - Pigs
  - Poultry
  - Cattle

- Andean lupin can replace soy bean!
Andean lupin for pig feed NO soy

Andean lupin has an amino acid profile which is comparable with soy bean.

Recipe for pig starter feed without soy bean

<table>
<thead>
<tr>
<th>Ingrediënt</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerst</td>
<td>27.2</td>
</tr>
<tr>
<td>Tarwe</td>
<td>28.0</td>
</tr>
<tr>
<td>Maïs</td>
<td>4.8</td>
</tr>
<tr>
<td>Tarwegries 2</td>
<td>1.3</td>
</tr>
<tr>
<td>Profit P1</td>
<td>5.3</td>
</tr>
<tr>
<td>Lupinen</td>
<td>10.9</td>
</tr>
<tr>
<td>Raapschroot</td>
<td>9.9</td>
</tr>
<tr>
<td>Zonnepitschroot 28 P</td>
<td>7.4</td>
</tr>
<tr>
<td>Palmolie</td>
<td>0.5</td>
</tr>
<tr>
<td>Melasse riet</td>
<td>1</td>
</tr>
<tr>
<td>Overig</td>
<td>3.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>nutrienten</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>ruw eiwit</td>
<td>167.8</td>
</tr>
<tr>
<td>ruw vet</td>
<td>33.2</td>
</tr>
<tr>
<td>ruwe celstof</td>
<td>72</td>
</tr>
<tr>
<td>EW*100</td>
<td>108</td>
</tr>
<tr>
<td>iv Lysine</td>
<td>9.07</td>
</tr>
<tr>
<td>FK</td>
<td>143.9</td>
</tr>
</tbody>
</table>
LIBBIO lupin flour & functional ingredients

• Applications
  – Bread (10-15%)
  – Pasta/Noodle
  – Pastry

• Andean lupin has low glycemic index
  The glycemic index or glycaemic index (GI) is a number associated with a particular type of food that indicates the food's effect on a person's blood glucose.
LIBBIO prebiotics

- Andean lupin has no starch as carbohydrates
- Andean lupin has oligosaccharides as carbohydrates
- Stachyose and raffinose
- Andean lupin has low glycemic index

The glycemic index or glycaemic index (GI) is a number associated with a particular type of food that indicates the food's effect on a person's blood glucose.

THE COLON
Where do the prebiotics act?
Prototypes made of lupin
LIBBIO

A H2020 project with great potential for unlocking added value from marginal soils in Europe with a new crop and new value chain

Benefits for farmer, consumer and EU society