Hanzehogeschool Groningen
University of Applied Sciences

Lupin Bioeconomy Development

LIBBIO
Lupin beauty from marginal soils

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LIBBIO: Lupinus mutabilis for Increased Biomass from marginal lands and value for BIOrefineries

BIO-BASED INDUSTRIES Public-Private Partnership

Horizon 2020
European Union Funding
for Research & Innovation

Bio-based Industries Consortium

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€

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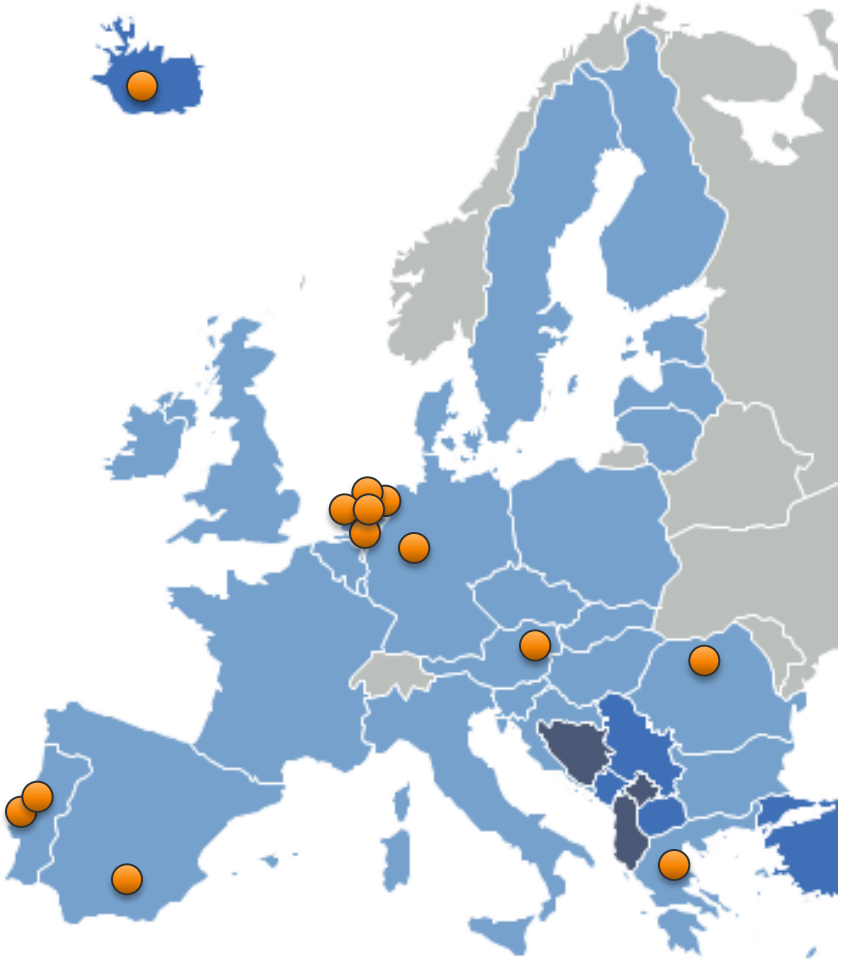
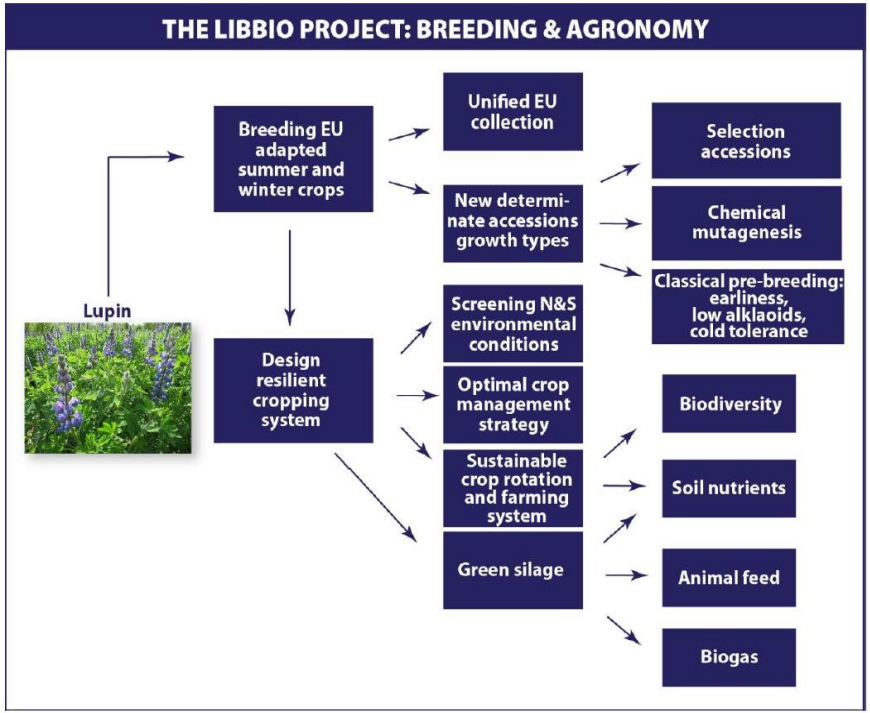
LIBBIO partners

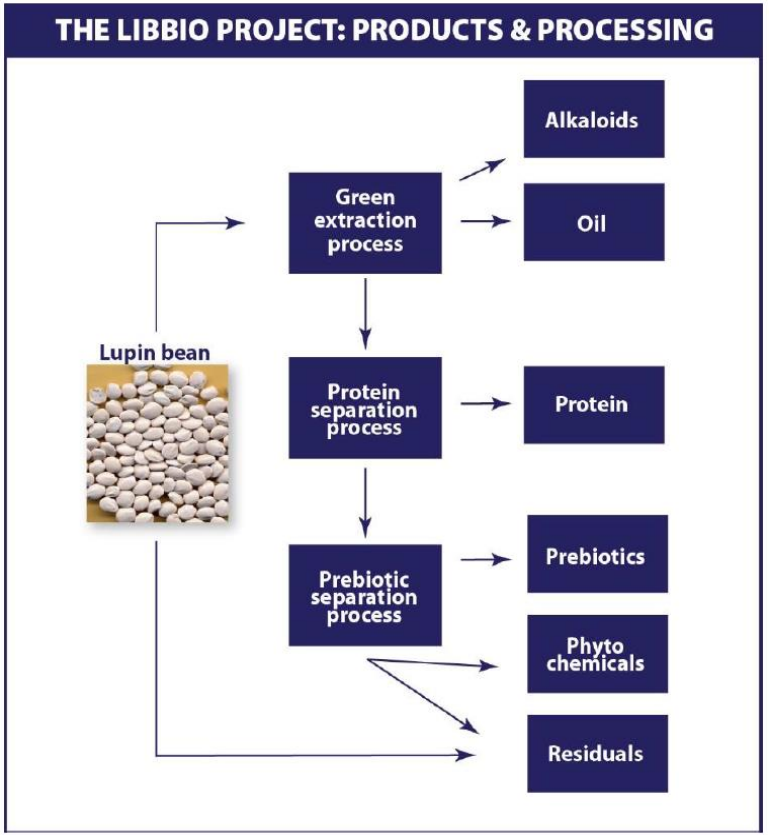
- 14 partners from 8 countries
- SME’s and research institutes

Iceland
Netherlands
Germany
Portugal
Spain
Greece
Romania
Austria



LIBBIO workpackages





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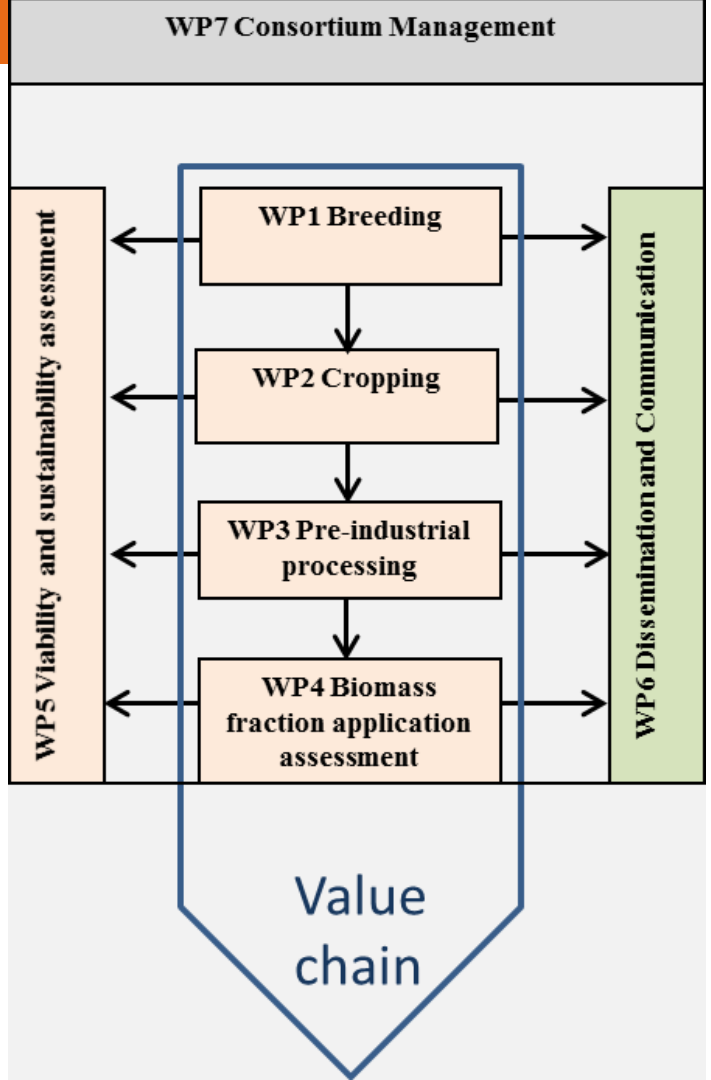
LIBBIO workpackages

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.

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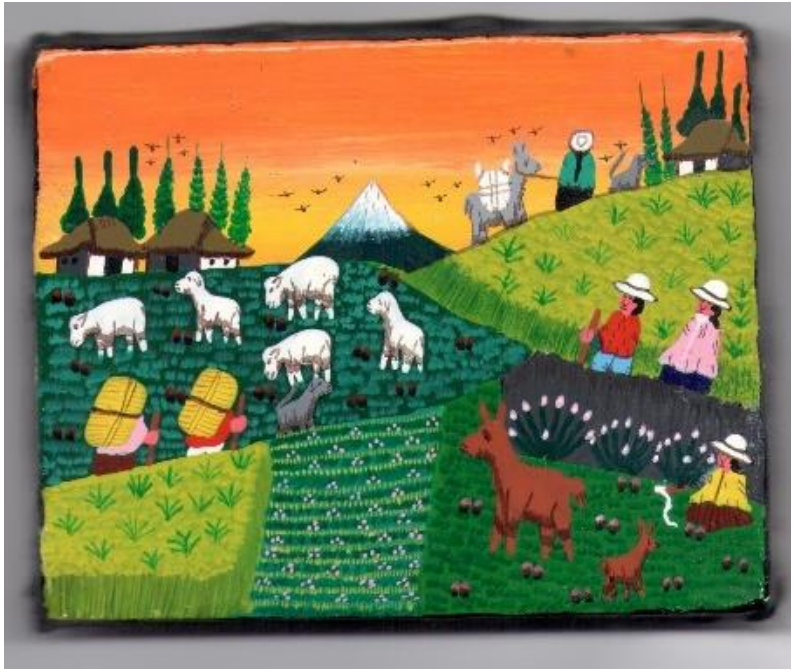
Andean Lupin: farmer economic benefits

- 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



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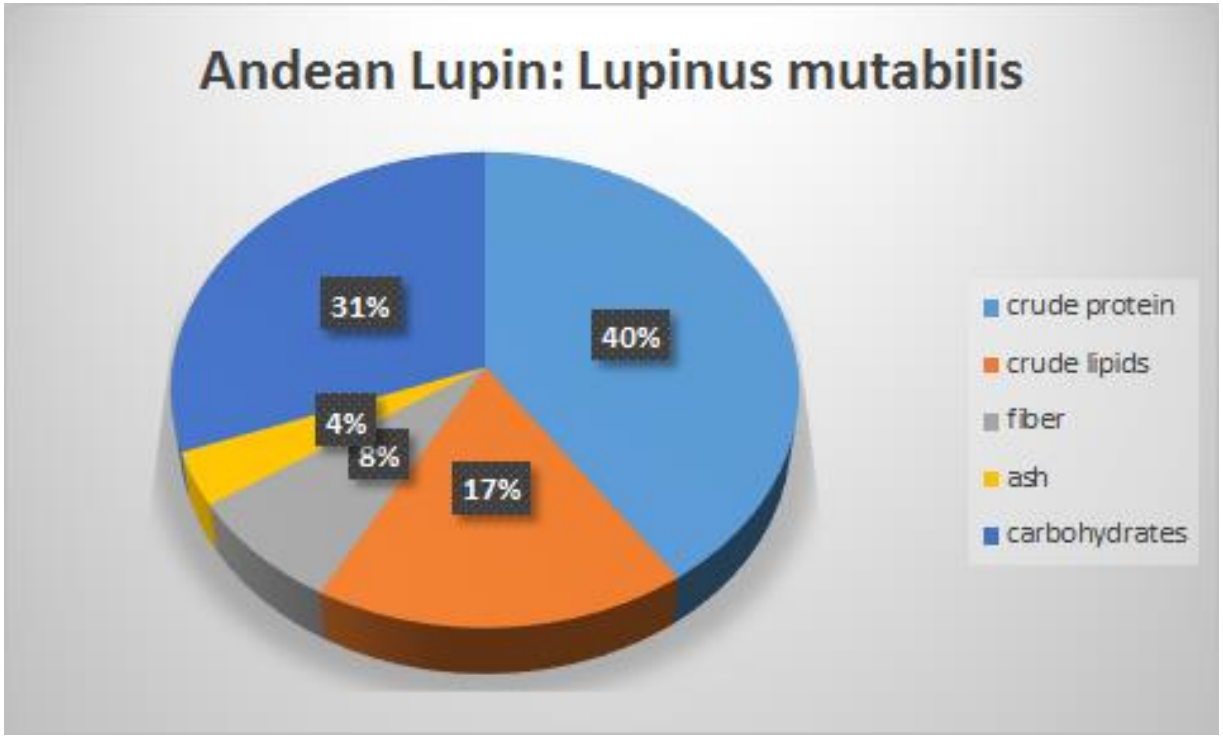
Adavantages Andean Lupin

- Rich in proteins and lipids
- Comparable with soy bean



Andean lupin composition

composition lupin seeds and other major protein-oil crop								
material	unit	L.albus	L.angustifolius	L.luteus	L.mutabilis	G.max		
		white lupin	bleu lupin	yellow lupin	Andean lupin	Soy bean	Sunflower seed	Rapeseed
moisture	g /100 g fw	8.6	9.0	9.4	8.1	8.54	4.73	9.4
metabolic energy	kJ/ 100 g dw	2078	2032	2164	2307	2040	2565	1920
crude protein	g/100 g dw	38.2	33.9	42.2	43.3	39.9	21.8	35.8
crude lipids	g/100 g dw	11.2	6.3	5.5	18.9	21.8	54.0	1.4
fiber	g/100 g dw	8.9	16.0	15.8	8.2	10.2	9.0	16.0
ash	g/100 g dw	3.4	3.0	3.8	3.9	5.3	2.8	7.1
carbohydrates	g/100 g dw	39.3	41.0	38.8	32.9	33.0	21.0	48.0

Andean lupin: oil & protein production

	Oil seed rape (UK)	Sun-flower	Soybean	Andean lupin L.mutabilis (JKI pre-breeding field study years 2010-2014)
Oil production ton/ha/year	1,3-1,6	0,8	0,3-0,6	1,0-1,4
Protein production ton/ha/year	0,6-0,8	0,6-0,9	0,6-1,2	1,7-2,8

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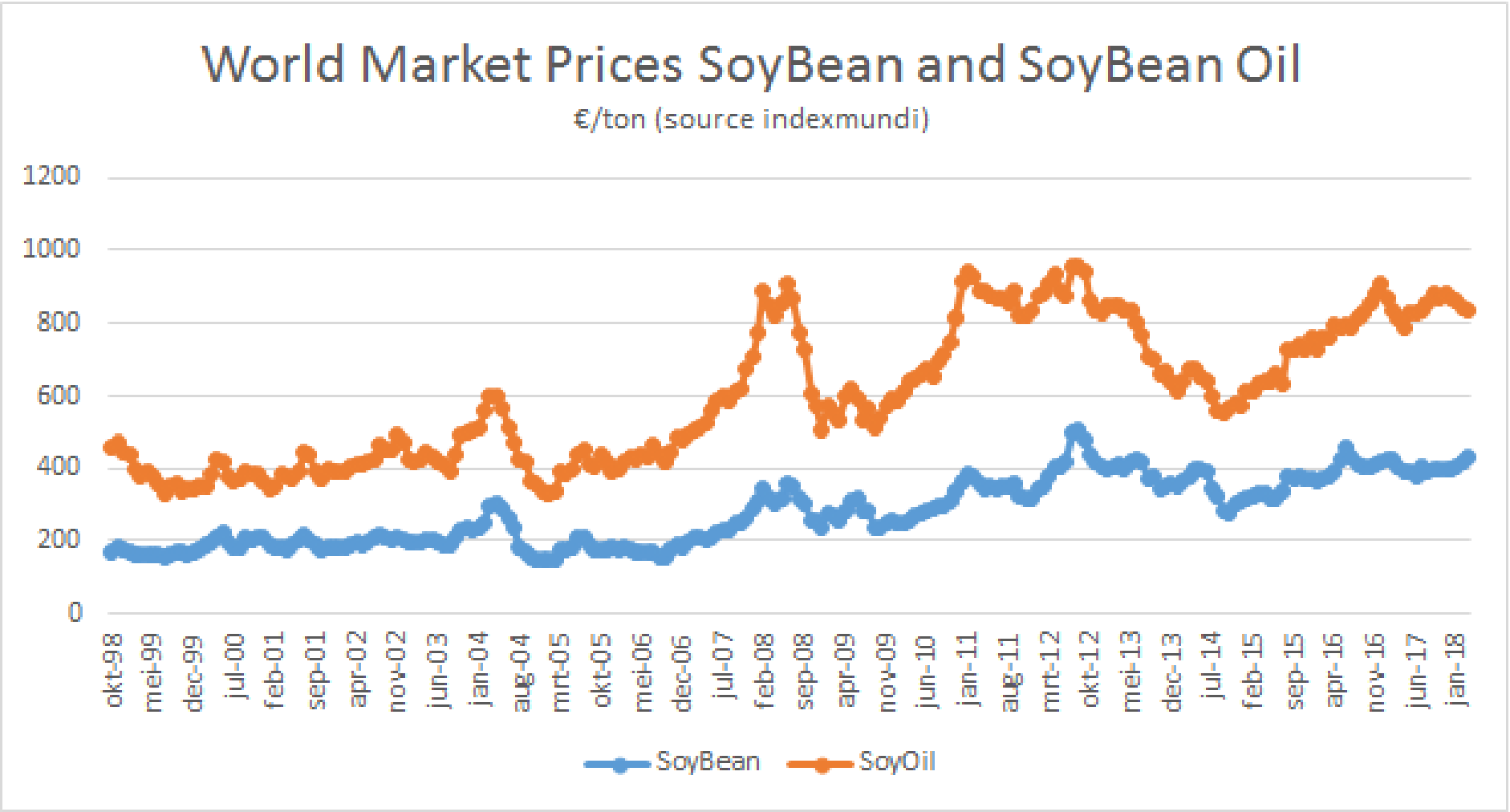
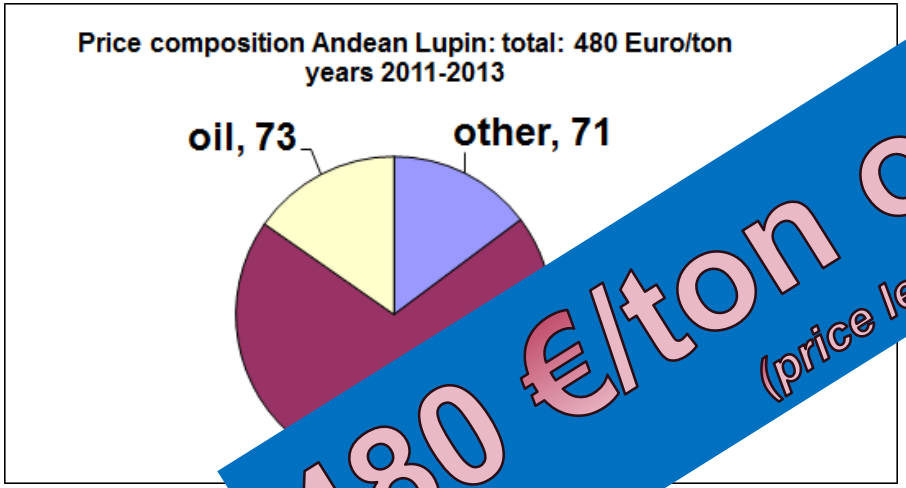
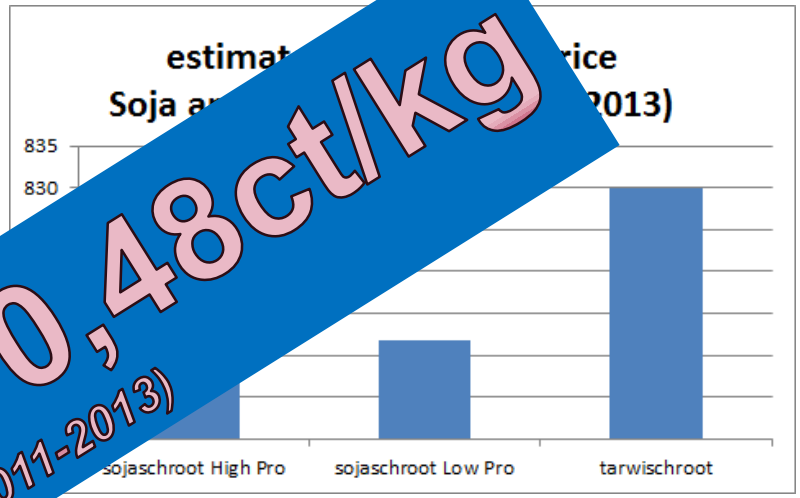

World Market Prices SoyBean and SoyBean Oil
€/ton (source indexmundi)
1200
1000
800
600
400
200
0
okt-98
mei-99
dec-99
jul-00
feb-01
sep-01
apr-02
nov-02
jun-03
jan-04
aug-04
mrt-05
okt-05
mei-06
dec-06
jul-07
feb-08
sep-08
apr-09
nov-09
jun-10
jan-11
aug-11
mrt-12
okt-12
mei-13
dec-13
jul-14
feb-15
sep-15
apr-16
nov-16
jun-17
jan-18
SoyBean
SoyOil

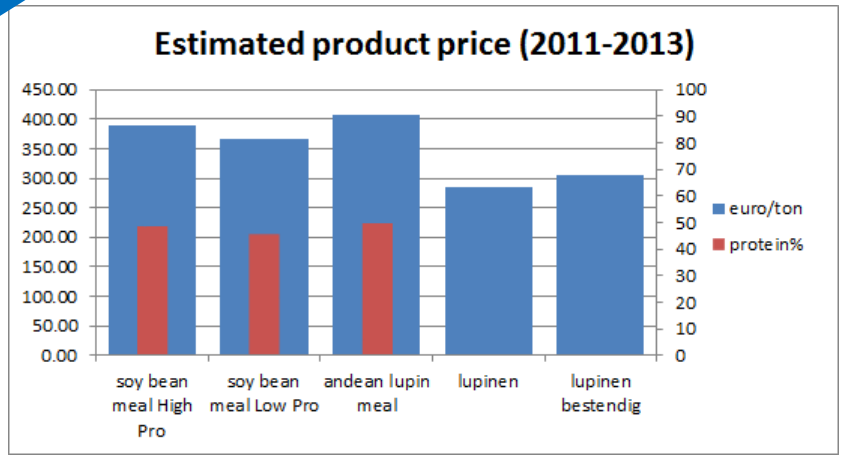
Calculation product price





480 €/ton or 0,48ct/kg

(price level 2011-2013)



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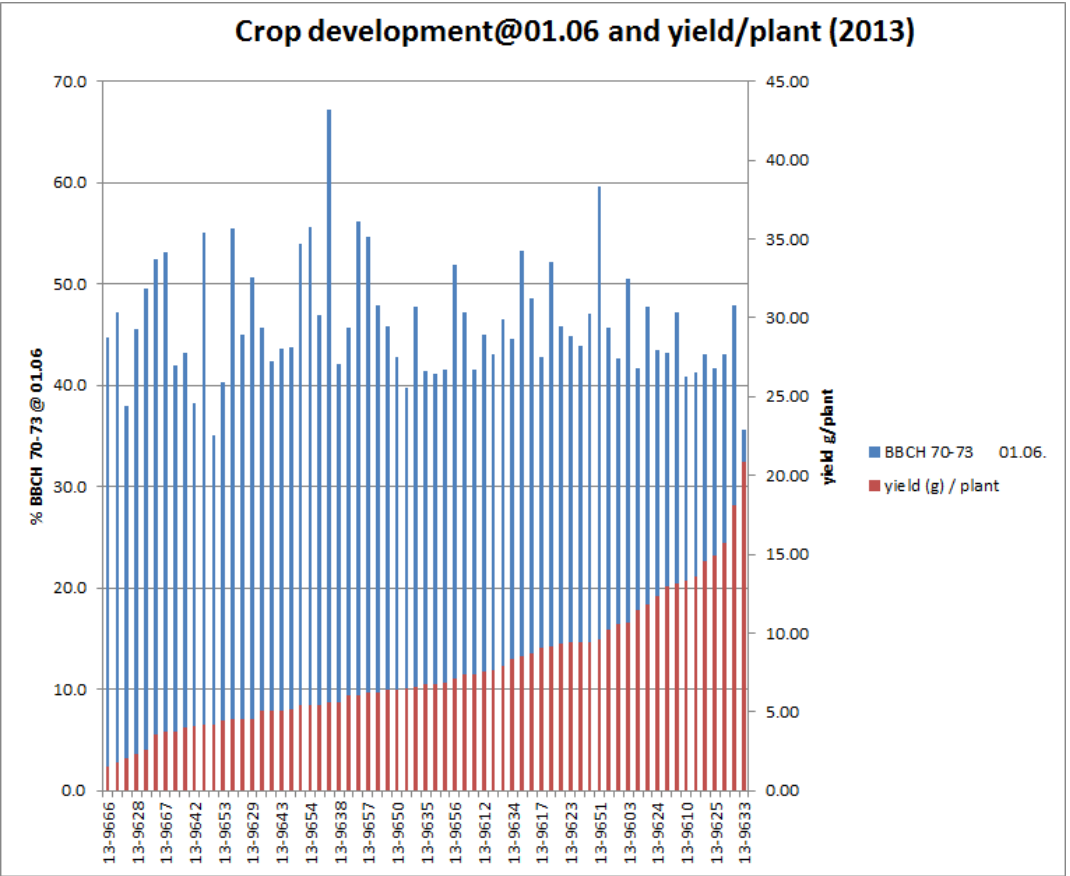
Expected Andean Lupin Crop yields



		yield t/ha		
		plant density/m2		
year	yield g/plant	***20***	***30***	***50***
2013	***15***	3	4.5	7.5
	20	4	6	10
2014	***24***	4.8	7.2	12
	29	5.8	8.7	14.5

field experiments in Poland:
1,5 – 2,7 ton/ha

Seed densities 60-120/m2 in 2011 and 2012

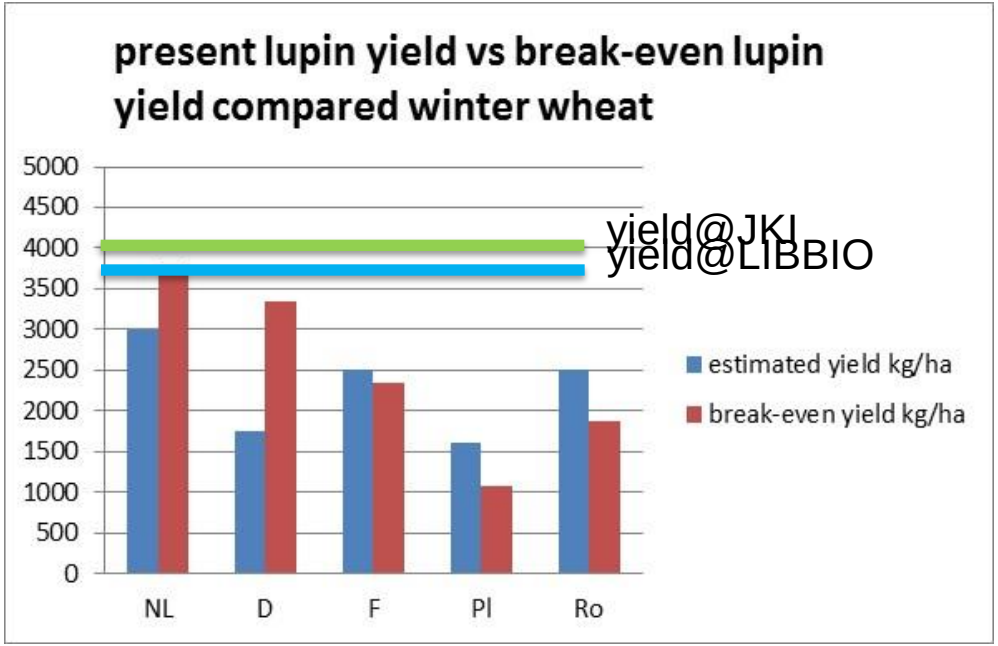
Pszczółkowska A., etal A. 2016. *Incidence of seed-borne fungi on Lupinus mutabilis depending on a plant morphotype, sowing date and plant density*. J. Elem., 21(2): 501-512. DOI: 10.5601/ jelem.2015.20.3.888

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)

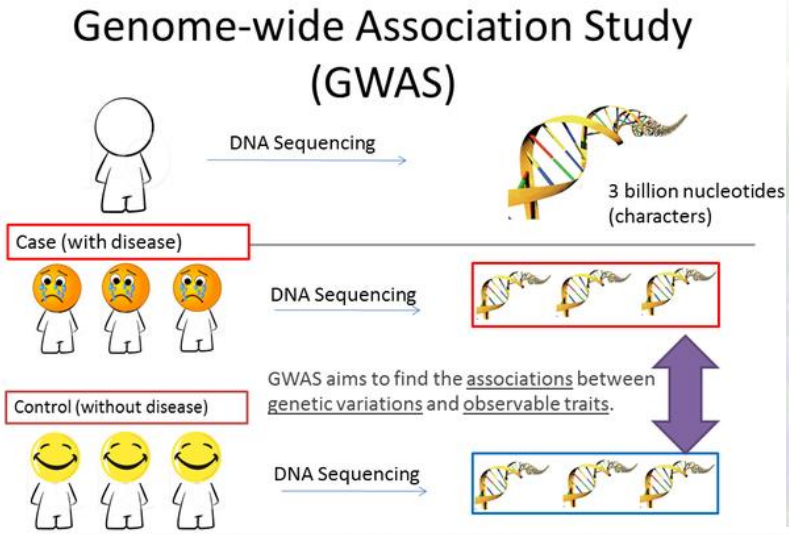
- Break-even yields with winter wheat
  - NL: 3.7 ton/ha
  - D: 3.3 ton/ha
  - F: 2.3 ton/ha
  - Pl: 1.1 ton/ha
  - Ro: 1.9 ton/ha

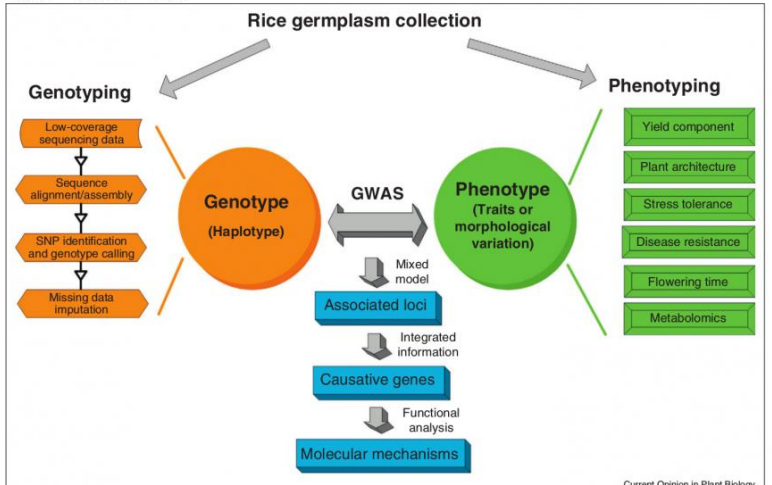


Lupin Bioeconomy Development

Activities performed: Breeding

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

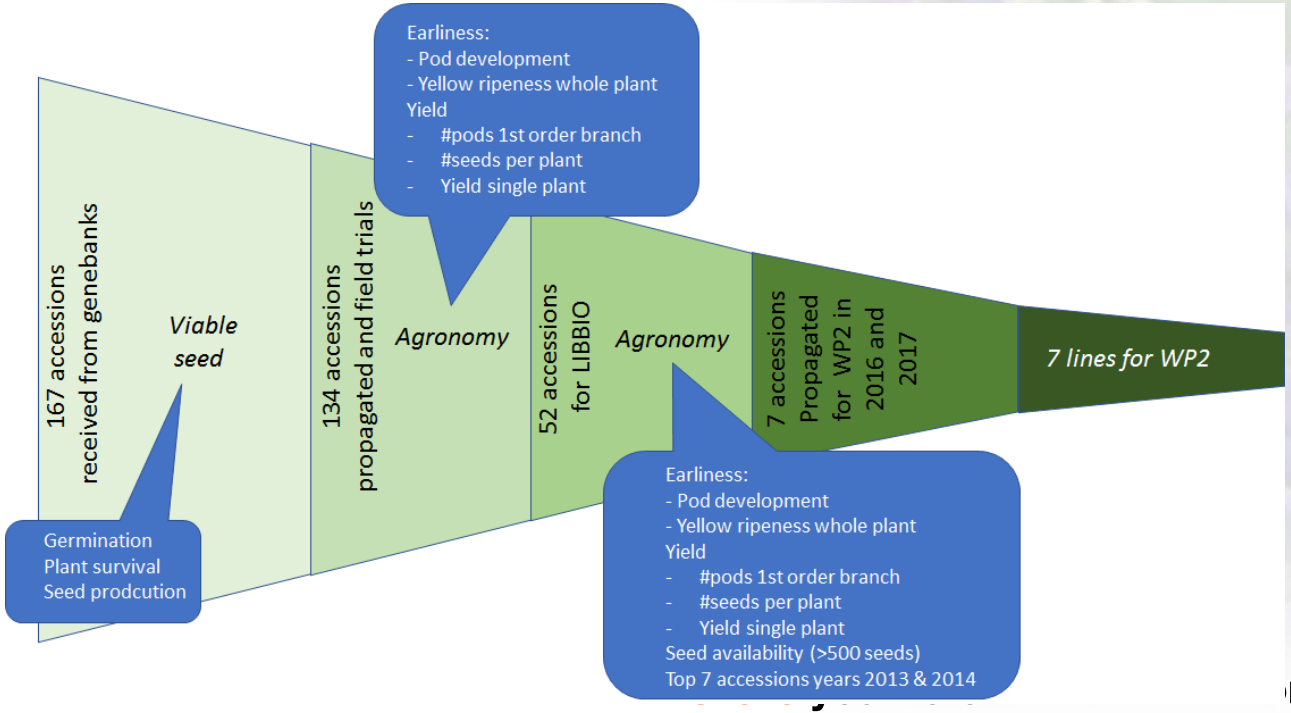




Lupin Bioeconomy Development

Activities performed

- Selection funnel JKI prebreeding collection, activities started in 2009



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Lupin Bioeconomy Development

Activities performed

high yielding accessions for improved harvesting and processing

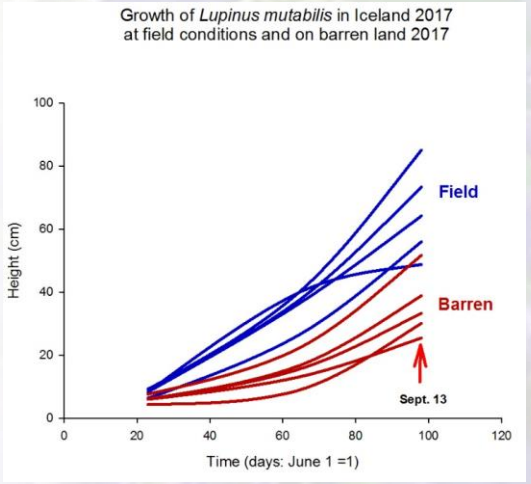
- Development of protocols for phenotyping accessions for GWAS, including protocols for chemical characterization biomass composition
- Seed propagation for GWAS

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.

Lupin Bioeconomy Development

Land reclamation

Reclaiming barren volcanic soil (Iceland)



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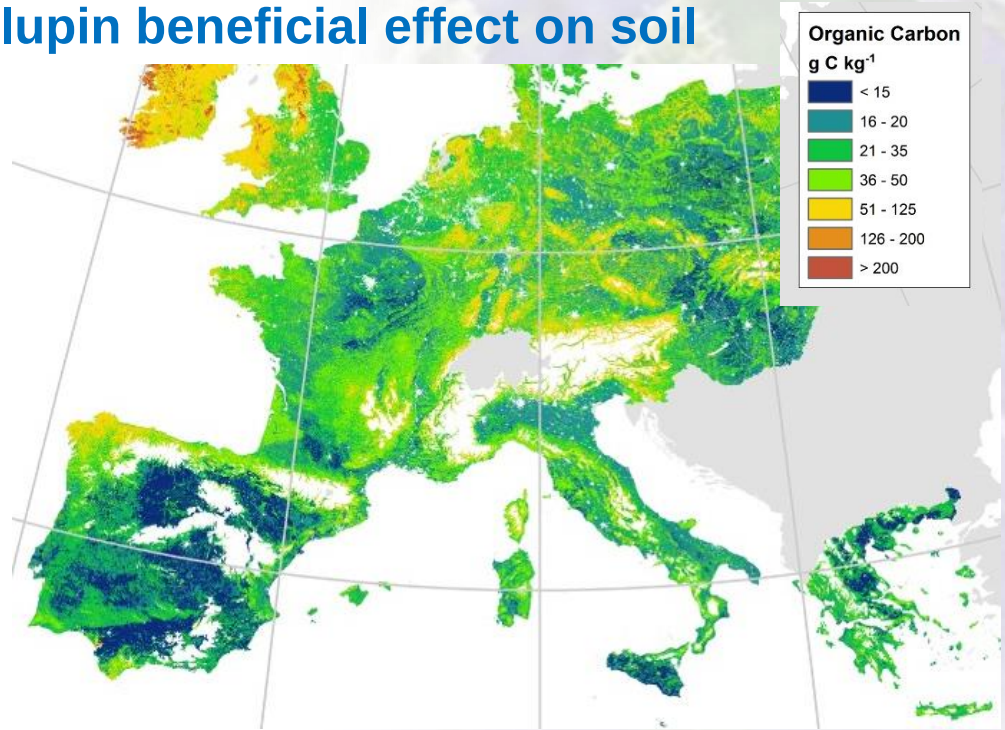
Activities performed:

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 Soil Organic Matter



de Brogniez, D. , Ballabio, C. , Stevens, A. , Jones, R. J., Montanarella, L. and van Wesemael, B. (2015), A map of the topsoil organic carbon content of Europe generated by a generalized additive model. Eur J Soil Sci, 66: 121-134. doi:10.1111/ejss.12193

LIBBIO Lupin Bioeconomy Development

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

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fertilized
no fertilizer

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

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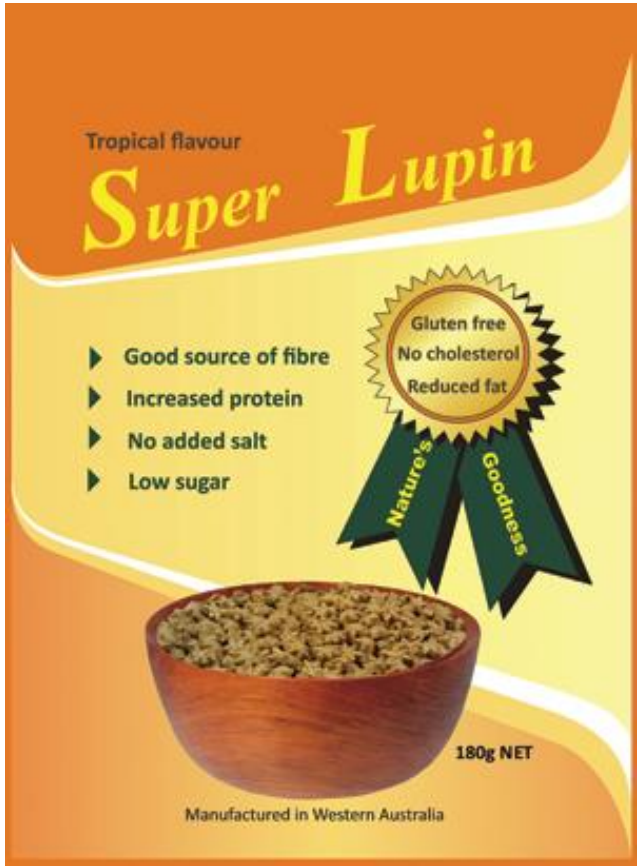
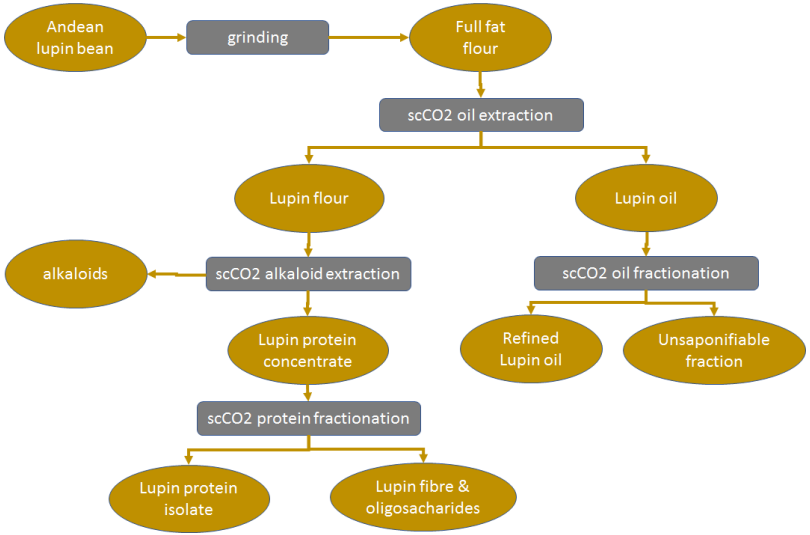
LIBBIO applications

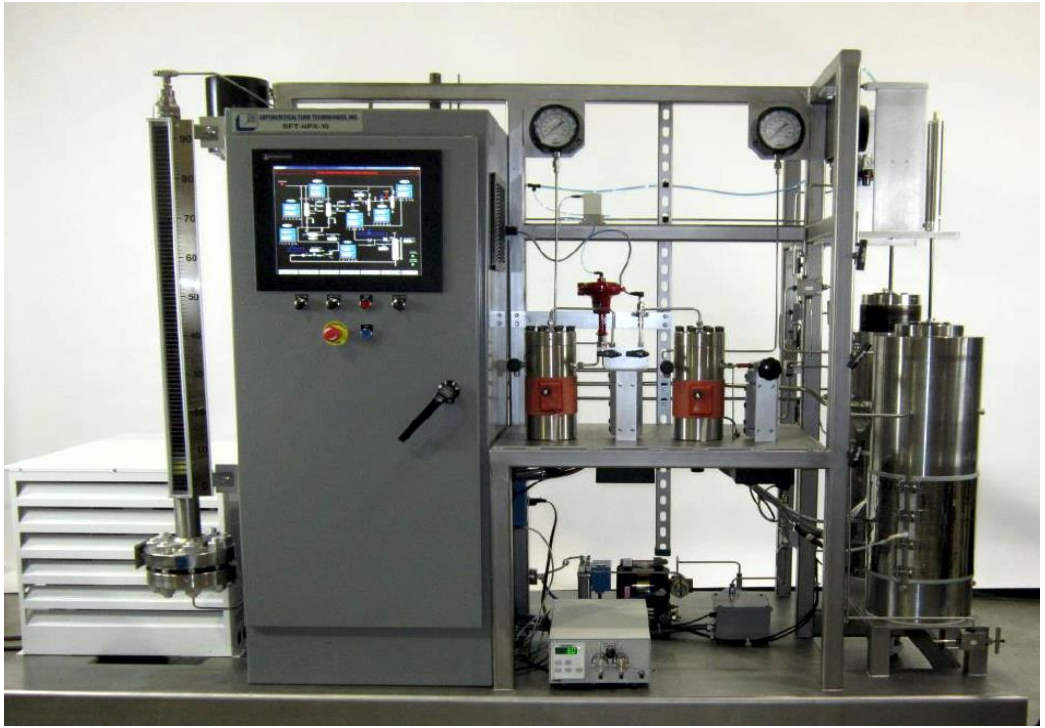
Biomass fraction properties and applications assessment (food, feed and non-food)

- 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

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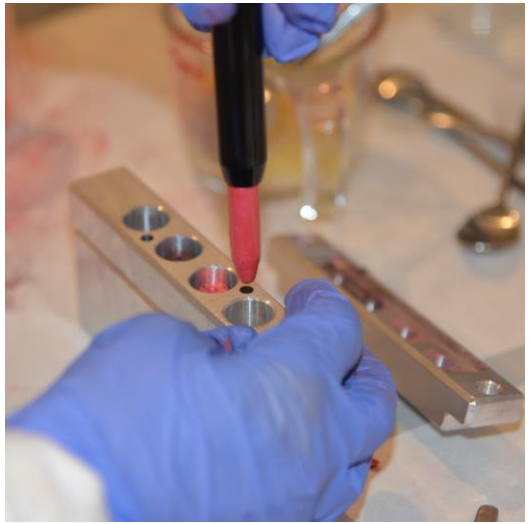
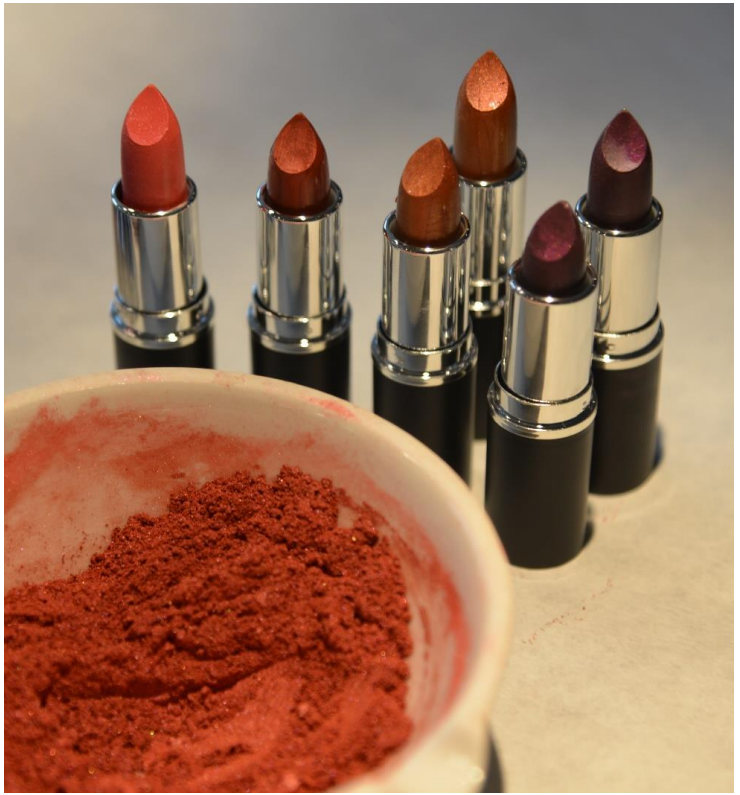
LIBBIO: cosmetics with lupin bioactives

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





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LIBBIO oils

- Andean lupin has excellent fatty acid profile
- More then 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

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Fatty acid composition

- Andean lupin oil is high in unsaturated fatty acids

	saturated fatty acids						
	C12:0	C14:0	C16:0	C18:0	C20:0	%SF	
	lauric acid	myristic acid	palmitic acid	stearic acid	araquidic acid		
olive oil	na	0.7%	11.5%	2.0%	0.2%	14%	
palm kernel	41.0%	16.0%	8.0%	2.0%	na	67%	
soy bean oil	na	0.5%	9.0%	4.0%	na	14%	
sunflower oil	na	na	3.7%	2.0%	2.3%	8%	
white lupin oil			7.9%	1.6%	1.0%	11%	
bleu lupin oil			10.3%	5.2%	0.7%	16%	
andean lupin oil			10.4%	4.7%	0.9%	16%	
	unsaturated fatty acids						
	C16:1	C18:1	C18:2	C18:3		%UF	U/S
	palmitoic acid	Oleic acid	Linoleic acid (w6)	Linolenic acid (w3)			
olive oil		78.40%	7%	na		85%	5.9
palm kernel		22%	1.25%	na		23%	0.3
soy bean oil		28.50%	49.50%	8.00%		86%	6.4
sunflower oil		31.50%	59.50%	na		91%	11.4
white lupin oil	na	54%	18.70%	8.60%		81%	7.7
bleu lupin oil	na	33.90%	40.30%	5.60%		80%	4.9
andean lupin oil	13.90%	46.40%	33.10%	2.50%		96%	6.0

LIBBIO proteins

- Andean lupin has most of the relevant amino acids for healthy products
- Drinks: milk, smoothies
- Yoghurts
- Ice cream

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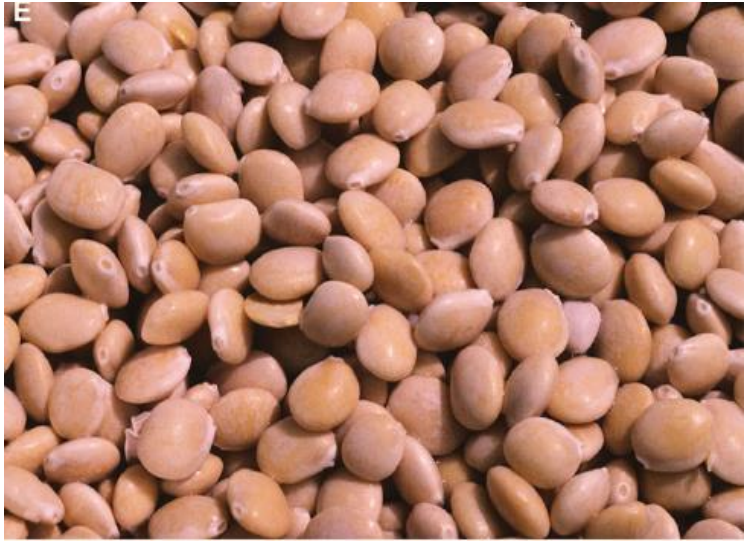
Amino acid composition

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



amino acids		L.albus	L.angustifolius	L.mutabilis	G.max
g/100 g protein		white lupin	bleu lupin	andean lupin	soy bean
alanine	ala	na	na	3.3	5.2
arginine	arg	12.4	12.0	10.2	8.6
asparagine	asn				
aspartic acid	asp	na	na	9.6	14.0
cysteine	cys	1.5	1.6	1.6	1.8
glutamine	gln	na	na		
glutamic acid	glu	na	na	24.3	21.6
glycine	gly	na	na	3.8	5.2
histidine	his	2.0	2.6	3.5	3.0
isoleucine	ile	4.1	4.0	4.2	5.4
leucine	leu	6.8	6.9	7.0	9.1
lysine	lys	4.5	4.6	5.8	7.4
methionine	met	0.7	0.7	0.8	1.5
methionine+cysteine		2.2	2.3	2.4	
phenylalanine	phe	3.4	3.7	3.5	5.8
proline	pro	na	na	3.8	6.5
serine	ser	na	na	4.9	6.5
threonine	thr	3.4	3.4	3.5	4.8
tryptophan	trp	0.9	0.9	0.8	1.6
tyrosine	tyr	4.8	3.4	4.0	4.2
valine	val	3.8	3.7	3.9	5.6

LIBBIO: feed for animal nutrition

- Feed for
  - Pigs
  - Poultry
  - Cattle

- Andean lupin can replace soy bean !

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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 wihout soy bean		
Ingrediënt		%
Gerst	rye	27.2
Tarwe	wheat	28.0
Maïs	corn	4.8
Tarwegries 2	wheat	1.3
Profit P1	Profit P1	5.3
Lupinen	Bleu lupin	10.9
Raapschroot	rapeseed meal	9.9
Zonnepitschroot 28 P	sunflower meal	7.4
Palmolie	palm oil	0.5
Melasse riet	melasse	1
Overig	rest	3.7
nutrienten		
ruw eiwit	total protein	167.8
ruw vet	total fat	33.2
ruwe celstof	fibre	72
EW*100		108
iv Lysine		9.07
FK		143.9

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

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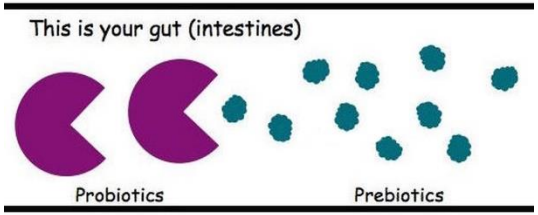
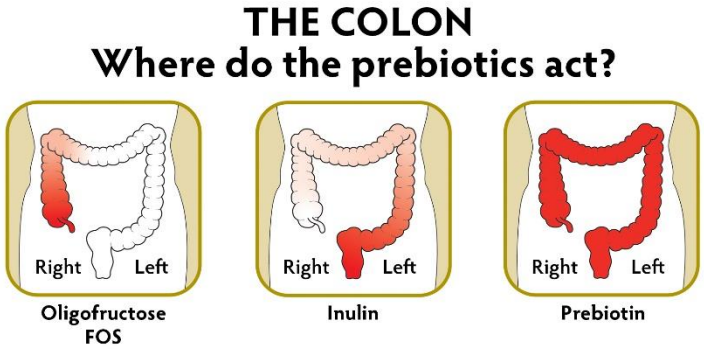
LIBBIO prebiotics

- 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





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Prototypes made of lupin

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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

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