

Innovative fully biodegradable mulching films & fruit protection bags for sustainable agricultural practices LIFE14 ENV/ES/000486

LIFE MULTIBIOSOL



Legume waste valorization from food industry for the production of green materials

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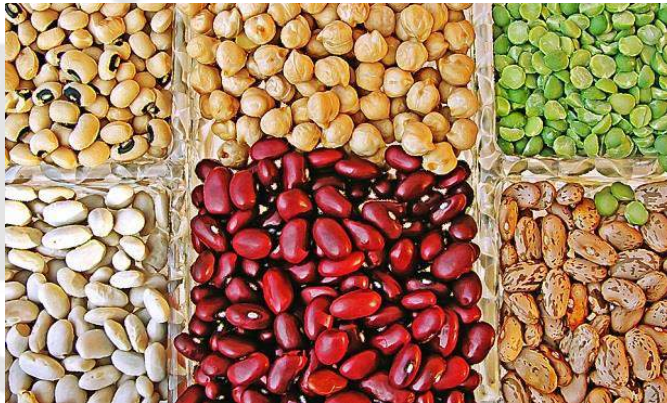


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2016
INTERNATIONAL
YEAR OF PULSES

PULSES are a type of leguminous crop that are harvested solely for the dry seed. Dried beans, lentils and peas are the most commonly known and consumed types of pulses.



- **Pulses are highly nutritious**
They are a critical source of plant-based proteins, amino acids and other essential nutrients.
- **Pulses are economically accessible and contribute to food security at all levels**
They are produced and consumed widely in developing countries.
- **Pulses have important health benefits**
They are recommended for preventing chronic diseases and obesity
- **Pulses foster sustainable agriculture and contribute to climate change mitigation and adaptation**
Their nitrogen-fixing qualities can improve soil fertility and produce a smaller carbon footprint.
- **Pulses promote biodiversity**

The needs



Tons of **legumes by-product** produced annually in Europe are **discarded** with **costly** disposal for the food industry and generating a significant **environment impact**

Vegetable residues contain considerable amounts of potentially interesting compounds.

- Need for a **bio-based alternatives** to reduce the dependence on conventional (petrochemical) plastics, to **enhance recyclability** (EU Directive on packaging and packaging waste 94/62/CE and 2004/12/CE) while offering similar performance, especially barrier properties for food packaging.
 - Organic food manufacturers look for packaging materials consistent with the packed product
- Need for new **alternative energy sources** to reduce the dependency on fossil fuel.

Average chemical composition of by-product legumes

dry residue	21%
protein	6%
starch	3,5%
fibres	8%
sugars	2%

European regulations are more and more restrictive with the wastes disposal, the management of wastes for the legume processors is a very important problem to be solved, according with the **DIRECTIVE 2008/98/CE**.

The **DIRECTIVE 2008/98/CE**.

- introduces the "polluter pays principle" and the "extended producer responsibility";
- incorporates provisions on hazardous waste and waste oils (old Directives on hazardous waste and waste oils being repealed with the effect from 12 December 2010);
- includes two new recycling and recovery targets to be achieved by 2020:
 - 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households,
 - 70% preparing for re-use, recycling and other recovery of construction and demolition waste;
- requires that Member States adopt waste management plans and waste prevention programs.

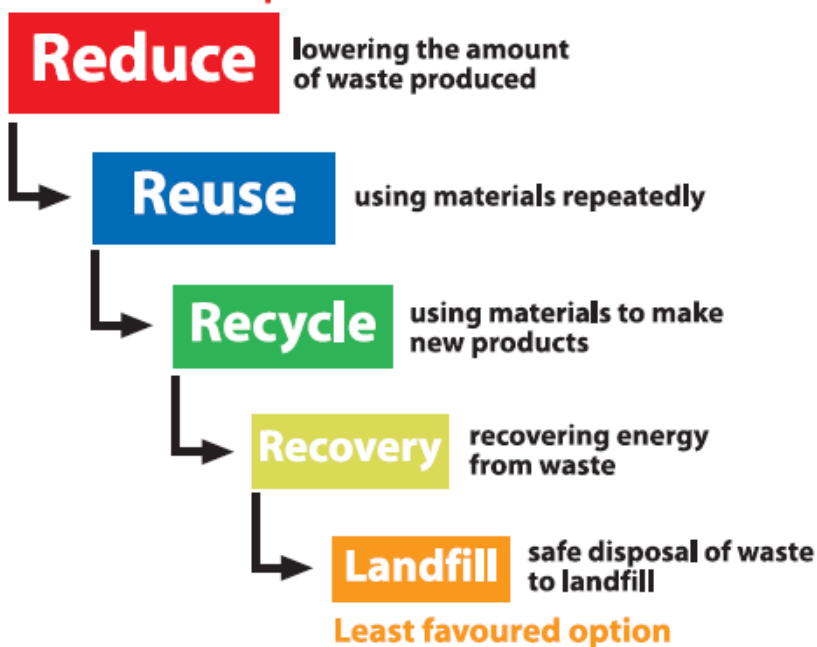
Waste management hierarchy



Bio-waste:

The Member States shall take measures, as appropriate, and in accordance with **waste hierarchy** and **Protection of human health and the environment**, to encourage: (a) the separate collection of bio-waste with a view to the composting and digestion of bio-waste; (b) the treatment of bio-waste in a way that fulfils a high level of environmental protection; (c) the use of environmentally safe materials produced from bio-waste.

Most favoured option



According with the Directive:

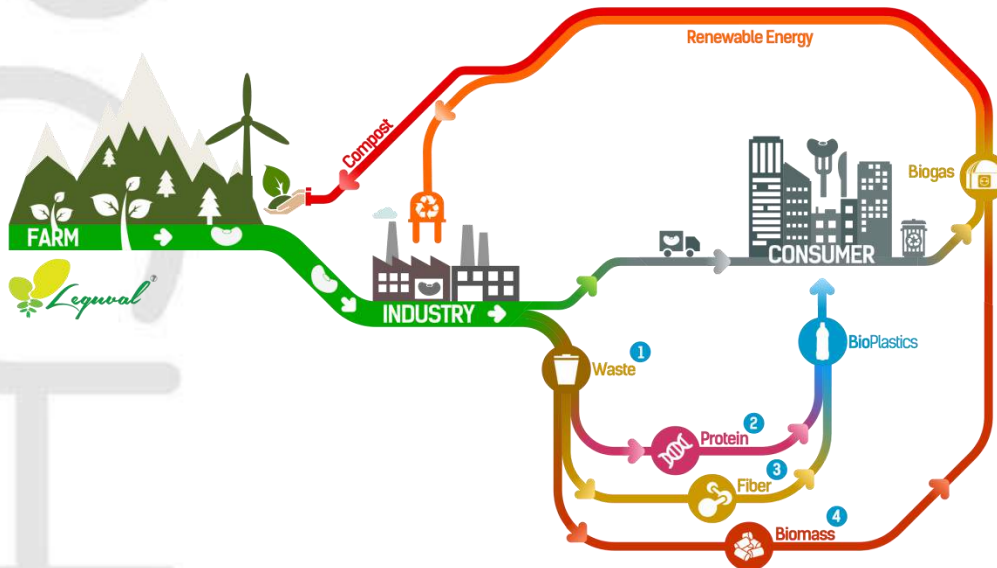
- by considering composition and possibilities of valorization of wastes obtained from companies of legume transformation products, these products *can be considered as by-products* with high possibilities for their use as raw materials for ingredients, polymers, feed or energy production;
- their *valorization* has to be considered *previous to the waste consideration*. On the other hand, the final produced wastes have to be treated in an adequate way to guarantee the protection of human health and environment.

By-products:

1. A substance or object, resulting from a production process, the primary aim of which is not the production of that item, but if the following conditions are met:
 - (a) further use of the substance or object is certain;
 - (b) the substance or object can be used directly without any further processing other than normal industrial practice;
 - (c) the substance or object is produced as an integral part of a production process;
 - (d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.
2. Measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by- product and not as waste.

The project

- Based on circular bioeconomy paradigms, **LEGUVAL** deals with the valorization of legume by-products and co-products as a raw materials in packaging.
- Biogas, automotive and agricultural applications are considered for maximising the use of resources in cascade.



- 12 partners from 4 countries (Italy, Slovenia, Spain and Romania)
- FP7- Research for SME associations
- 3 years (December 2013- November 2016)

Project outcomes

Integral valorization:

Legume proteins for the production of **coatings** for applications on **barrier packaging films**, **plastics compounds** for **injected packaging** and **biodegradable agriculture pots**

Biomass leftover from protein extraction for application as a filler in **bio-composites** for **packaging, agricultural** but also **light weight automotive applications**

Final **leftover biomass** for **biogas production**

Impacts:

- Reduction of environmental pollution
- Reduction the fossil fuel dependence for long term supply
- New bio-plastics with improved properties for packaging, agriculture and automotive sectors
- Increased competitiveness of the agricultural sectors and the users of the new materials

- other
- vetches
- lupins
- cow pea
- pigeon pea
- lentils
- chickpea
- faba bean
- pea
- dry beans

Phaseolus & Vigna



Country	Product	Fresh	Dehydrated
SPAIN	Soya	34%	66%
	Chickpea	89%	11%
	Common vean	64%	36%
	Faba vean	93%	7%
	Lentils	9%	91%
	Green bean	100	
	Pea	96%	4%
	Garrofon	100%	
ITALY	Soya	95%	5%
	Chickpea	15%	85%
	Common bean	21%	79%
	Faba bean	100%	
	Lentils		100%
	Green bean	100%	
	Pea	53%	47%
ROMANIA	Common bean	100%	
	Peas	100%	

State of the raw materials used in companies involved in the project

Legumes and their residues current uses

Human consumption	Direct/primary	Food grain eaten raw, sprouted, cooked, boiled, roasted, fried
	Processed/industrial use	Natural sources of amino acids, vitamin E, complex carbohydrates, potassium, calcium, fiber, antioxidants, amino acids, fatty acids and other nutrients
		Processed into high-protein snacks, ground into (cotyledon) fortified flour, juiced into milk, canned
Animal feed	Ingredient in animal feed (E.g., common beans for poultry feed, chickpea feed for horses, high quality cowpea feed/hay, groundnut cakes/hay, soybean meal)	
	Crop residue post harvest also used as forage for livestock; particularly in the case of cowpeas	
Seed	Used in the generation of seed	
Other	Nitrogen-fixation: Intercropped to leverage nitrogen-fixing properties	
	Health: E.g., Cowpeas treat boils, groundnut-based solvents used in medicine, soybeans aid kidney functioning	

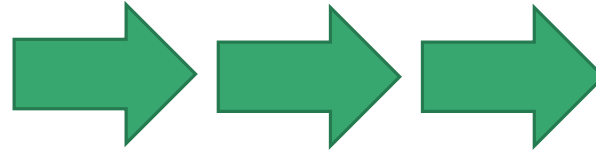
The principal final use in *Spain and Romania* is for animal feed. In *Italy*, ***anaerobic digestion and composting are the most important uses***. Low number of companies sends the wastes to municipal dumping site or uses them in land spreading.

Leguval objectives



Legumes by-products

Fractionation



Biomass

Biogas

Proteins



Fibers



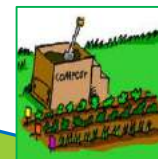
PLA was selected as matrix because of the lower price with respect to others commercial biodegradable polymers

Additives were selected to allow fibre dispersion and improve the material toughness

Biocomposite production



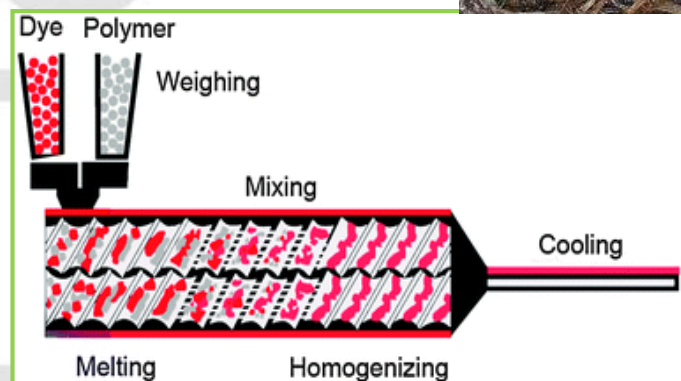
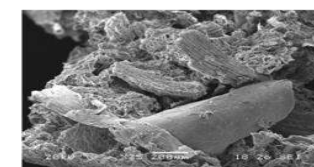
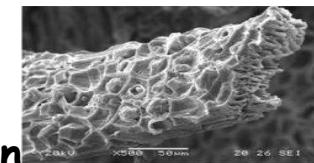
**Biodegradability
e/o
compostability**



PEAS
P1



Characterization



Blending



PEA's fibres

Toluene/Ethanol

- Waxes (4 %)

Ammonium
oxalate

- Pectine (69 %)

Sodium chlorite - Lignin

Lignin (n.d.)

Cellulose + hemicellulose

Potassium hydroxide

- Hemicellulose (12 %)

Cellulose (15 %)

Lab scale (Brabender and Mini Lab equipments)

Drying set-up (general procedure):

- $T = 60\text{ }^{\circ}\text{C}$, $P = 0.1\text{ mmHg}$, min 4 hours

Brabender Plastograph® EC plus

Processing set-up:

- $T = 180\text{ }^{\circ}\text{C}$
- Screw speed = 50 rpm, 10 min
- Time = 10 min
- Fibre addition: 1.5-2 min from the beginning
- Plasticizer addition: with the fibres (masterbatch)



MiniLab II HAAKE Rheomex CTW 5

Processing set-up:

- $T = 180\text{--}190\text{ }^{\circ}\text{C}$,
- Screw speed = 90 rpm
- Recirculating time of 1 min.



Production of fibre-rich fraction biocomposites at semi-industrial scale (Comac equipment)



Injection moulding of items (plant pots, spoons,)

Foils



Tubular Films



Pots and spoons



Pots



Technical products



Fiber-rich composite

Pots



Spoons



Proteine-based blends

LEGUVAL blend coloured wires for additive manufacturing



Thank you to the consortium....



....and to you for your attention





- <http://it.euronews.com/2017/04/17/i-legumi-salveranno-il-pianeta-dal-petrolio-in-italia-bio-plastiche-prodotte>
- <https://www.youtube.com/watch?v=8JtX16n1S7I>