

Production of biodegradable packages from whey surplus

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Ainia	03
Current situation	06
Project Idea	09
Project Objectives	10
Project Overview	11

Who **we** are

We are a technology center whose **MISSION** is to bring value to the company by leading innovation and technological development in a responsible and committed way.

Priority lines

- Food & Health
- Food quality & Safety
- Design and Industrial Production
- Sustainability, environment
- Consumer

Know how

- Food technology
- Biotechnology
- Nanotechnology
- Electronics and communications
- Chemical Technologies
- Environmental and energetic technologies
- Packaging technologies

Sectors



More than **13.000** m2 of facilities for the development of our research activity, with a value above **30 M €**

- 8 laboratories
- 12 pilot plants
- Classrooms
- Research area
- Industrial supercritical plant
- Consumolab Madrid and Valencia

> Current situation

Environmental problem of plastics

Europe >70 Mill Tn plastic waste (>203 billions Tn CO₂ eq)
60% food packaging.

Global **trend** towards the development of **sustainable packaging**

Need to **reduce dependence on petrol** in the production of polymers.

Environmental problem of whey surplus

Cheese production: 9 kg whey / 1 kg cheese.

Europe > 50 Mill Tn whey (>20% considered as waste)

High BOD (difficult treatment)

Alternative of **revalorization**: Raw material for **PHB bioproduction**

Water 85%, proteins, lactose, vitamins y minerals



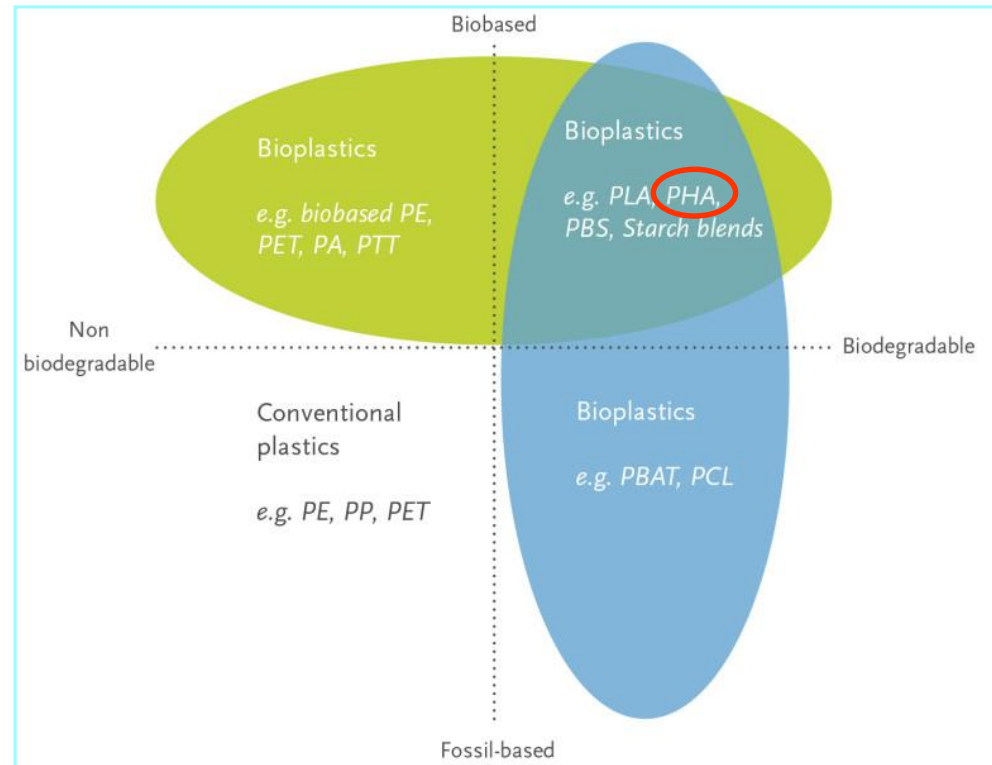
> Bioplastics

- **Biobased**
- **Biodegradable**
- **Biobased & Biodegradable**

Market is still dominated for over 99% by petrol-based plastic.

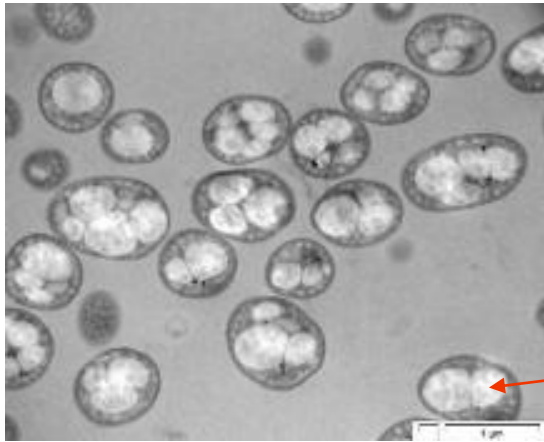
Redesign of bioplastics has the potential to reduce the use of fossil fuels, decrease CO2 emissions and decrease plastic waste.

Main disadvantage: Cost (2-4 times higher)



Source: European Bioplastics

> PHB

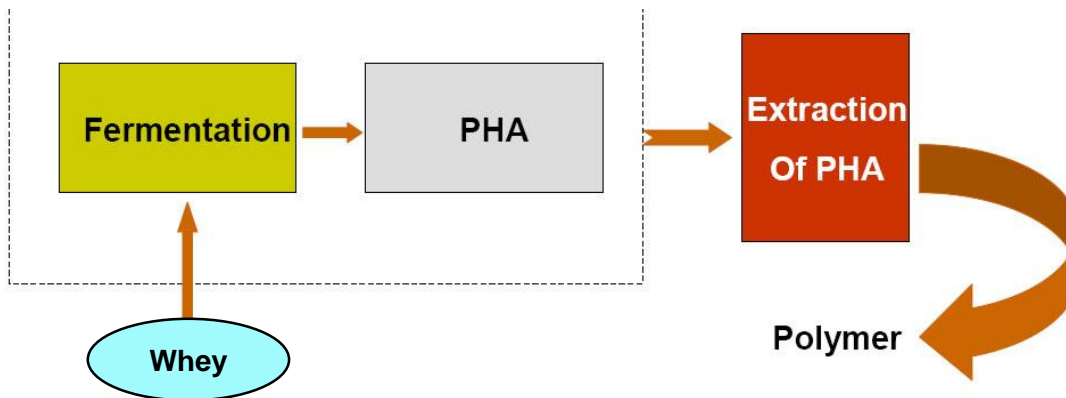


PHB (polyhydroxybutyrate) is a biodegradable polyester that can be synthesized and intracellularly accumulated by microorganisms as energy and carbon storage source. Could be obtained from different by-products of the food sector (whey, sugars, substrates rich in carbohydrates and nitrogen, etc.)

PHB Granules

Advantages:

- > Biobased
- > Biodegradable
- > Compostable



> Project Idea

To demonstrate **environmental and socio-economic benefits** of a **biodegradable packaging material** with a **lower environmental impact** in comparison with current petrol-based packaging materials (PP).

The biodegradable packaging material selected is **PHB** (Poly-hydroxybutyrate) that will be **obtained from a by-product (whey)** that comes from the cheese industries; PHB will be **produced** using a process of microbial **fermentation**.



PARTNERS:



- **AINIA – RTD (COORDINATOR)**
- **AIMPLAS – RTD**
- **CENTRAL QUESERA MONTESINOS**
Dairy products industry
- **EMBALNOR**
Packaging industry
- **NUTRIPACK** (Packaging industry)



> Project Objectives

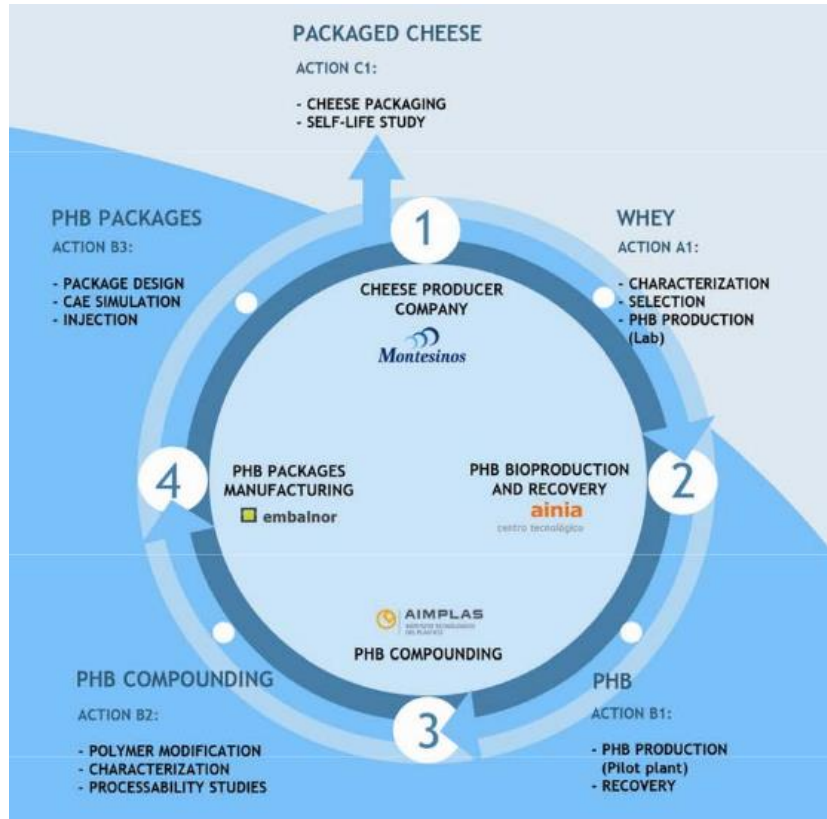
- 01 Demonstration** of the **environmental, technical and economical feasibility** of performing **PHB based packaging manufacturing processes from whey**, considering all the chain steps involved:
 - 1) PHB bioproduction from whey,
 - 2) polymer compounding,
 - 3) PHB-based package manufacturing and
 - 4) use by the cheese maker.

- 03 Definition** of the **PHB bioproduction and recovery processes** from whey at pilot plant scale. Study of the scale up conditions from pilot plant to industrial scale

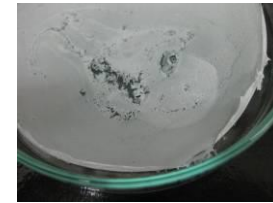
- 04 Formulation, compounding and adjustment of the PHB polymer** in order to improve its processability properties for injection moulding process

- 05 Development of 100% biodegradable PHB-based packages (trays)** and demonstration of their **application to dairy products**: cheese packaging.

> Project Overview



Circular Economy Project: The industry that generates whey becomes the beneficiary of the new packages tailored to the needs of their products



> Characterization and selection of whey streams

	WHEY TYPE	pH	ACIDITY (°D)	FAT (%)	PROTEIN (%)	LACTOSE (%)	DRY MATTER (%)	COD (mg O ₂ /l)	BOD (mg O ₂ /l)	TOTAL ORGANIC CARBON (g/100g)	TOTAL ORGANIC NITROGEN (g/100g)
1	ACID (NO CONCENTRATED)	4,39	49,18	0,07	0,99	4,43	6,56	71880,00	15525,00	3,20	0,18
2	ACID (RO CONCENTRATED)	4,37	92,98	0,18	2,63	7,58	14,66	185250,00	41900,00	8,63	0,40
3	LACTOSE (NO CONCENTRATED)	6,49	8,62	0,06	0,21	4,79	5,35	52666,67	15666,67	2,40	0,02
4	LACTOSE (RO CONCENTRATED)	5,95	20,82	0,07	0,84	8,81	14,08	160500,00	35000,00	7,40	0,08
5	SWEET (NO CONCENTRATED)	6,52	9,51	0,54	0,84	4,45	6,48	67625,00	20750,00	3,08	0,08
6	SWEET (UF CONCENTRATED)	6,49	14,90	2,84	3,41	2,64	10,78	147225,00	24600,00	5,87	0,52
7	EXHAUSTED	5,35	27,94	0,28	0,71	3,79	4,31	80533,33	19800,00	3,00	0,11
8	ACID + LACTOSE (NO CONCENTRATED)	5,41	20,79	0,03	0,51	4,80	5,67	63666,67	35333,33	2,57	0,06
9	ACID + LACTOSE (RO CONCENTRATED)	4,94	56,69	0,04	1,39	8,82	15,24	165666,67	38100,00	8,40	0,20
10	FRESH	6,5	9,52	0,39	0,96	4,65	6,64	116800,00	26500,00	3,70	0,23
11	MATURED	6,5	9,54	0,37	0,77	4,65	6,64	86275,00	21125,00	4,67	0,18

> Bioproduction of PHB:

Integrated Bioproduction System up to 300 L that includes all stages of the process



> Polymer modification

Selection of **optimal additives** (in accordance with current European and American food contact materials legislation) to **protect polymer degradation** and to **improve** their **processability** such as antioxidants, plasticizers, release agents, lubricants, nucleating agents.

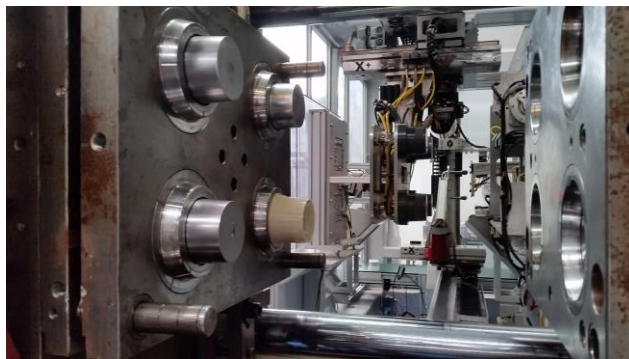
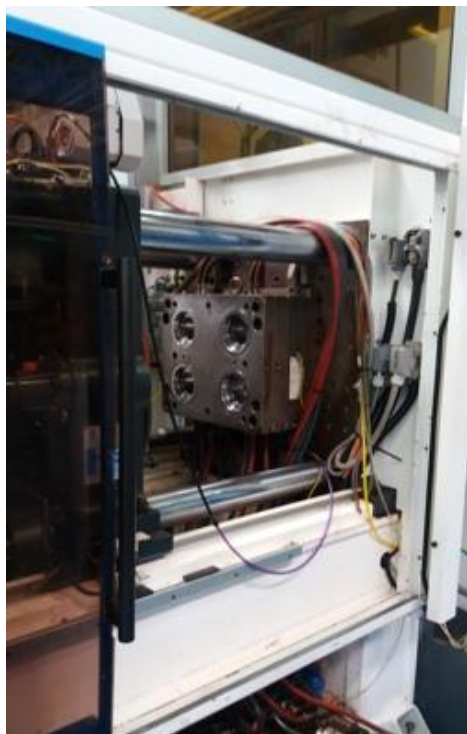
	Reference PP	Synthesis PHB	Modified PHB
Flexural modulus (MPa)	1750	3750	1050
Elongation at break (%)	10	5,9	12
Tensile strength (MPa)	30	38,8	23,4
Impact resistance at 23°C (kJ/m ²)	70	10	67
Impact resistance at 0°C (kJ/m ²)	50	2	36
HDT (°C)	100	129	113



Rigidity of the material has been reduced and the impact resistance has been significantly improved, especially at low temperatures.

> Package manufacturing

Standard injection moulding process was optimized for the PHB compound.



Packages were manufactured with current industrial injection equipment

> Package validation

Packages are being characterized (thermal, chemical and mechanical properties) in order to validate the end properties of developed PHB cups and comparing with PP cups.

- Oxygen and Water vapour transmission rate.
- Thermoresistance
- Compression
- Drop resistance
- Thickness distribution
- Migration test: Overall migration with different simulants and storage conditions



> Cheese packaging validation

Requirements of selected cheese product (cottage cheese) have been established.

Goat cottage cheese	
-	Package dimensions: - Base: D: 7,5 - 8,5 cm. L: 5,7 cm - Cover: D: 9 cm. L: 1 cm
-	Weight: 200 g
-	MAP (Modified Atmosphere Packaging) is required. Requirement of gases and water barrier
-	Hot filling.
-	Need of light protection (opaque material)
-	Storage: 2-4°C, 80% RH
-	30 days shelf-life



Industrial packaging process validation. Shelf-life studies

- **Physical analyses:** Texture.
- **Sensory analyses:** smell, taste, colour and consistency.
- **Chemical analyses:** pH, acidity, dry matter and fat.
- **Microbiological analyses:** *Escherichia coli*, *Salmonella*, *Listeria*, *Staphylococcus aureus*.





Thank you for your attention

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