Commercialization
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cellana
algae-based products
for a sustainable future™
The Biorefinery concept applied to microalgae

Olivier Lépine, Managing Director, AlgoSource
ABS 01/10/2015
Outline

- AlgoSource: integrated on the whole value chain
- Biorefining: the way to put value into your biomass
- Algorefining technologies that works today
  - Generic methodology
  - Real Examples
- Biorefining for a sustainable microalgae development

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AlgoSource
Saint-Nazaire, France

More than 20 years of experience, with Alpha Biotech producing and transforming microalgae since 1993.

- 26 people (20 employees, 6 partners)
- Turnover ~ 1,6 M € in 2015, profitable
- Key development: Algo-refining
- 4 patents

Key partnership, University of Nantes : GEPEA Lab
Pr. Legrand & Jaouen & Pruvost (CNRS)
www.gepea.fr 50 researchers on microalgae. Since 1985, 300 publications, 10 patents on Process engineering applied to microalgae

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We produce and refine our microalgae biomass.

CERTIFIED
ISO 9001/14001

Antioxydant and immune system booster

AlgoSource Products (Alpha Biotech)

Production of functional ingredients for the cosmetic and nutraceutical industries since 1993

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We provide engineering services: feasibility studies, economic analysis, production systems

CERTIFIED
ISO 9001/14001

Lloyd's Register LRQA

Pure inoculum Production
50 to 200 litres

Screening tool

MultiCells PBR

Experimental throughput

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Automation

Non-fully controlled systems

High-power LEDs

Autoclavable

Control supervisory software

Refining

Airlift flat panel PBR

Industrial production

Flat panel PBRs

Torus
Industrial innovation development methodology

Early Techno-Economic Analysis

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Companies and final consumers are interested in functions, not micro-algae.

Anti-cancer

Skin Protection

Strengthen your Natural Defenses

Algorefining is the way to optimize the production of those products and the value of your biomass.
BIO-BITUMEN

- Replace fossil-based bitumen
- 50% biomass conversion
- Standard visco-elastic properties

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Algorefining: a core activity for AlgoSource

- **2011-2014- ANR AlgoRaffinerie**: formalization of a methodology, and concept development on Porphyridium and Chlorella.

- **2012-2015- FP7 BIOFAT** application of the concept on Nannochloropsis and Tetraselmis in the scope of energy production. Development of wet extraction

- **2013-2016- ADEME AlgoRaff**: development of a Spirulina Algorefinery; optimization of the refining process as a function of physiological induction: impact on the process and economics

- **2013-2016-Private projects** towards industrial production units: products/process optimization, engineering, marketing, upscaling
Step 1 : Identification of the value

Step 2 : Physiological/Topological analyses

Step 3 : Conceptual process design and modelling

Step 4 : Experimental model validation, Upscaling

Step 5 : Techno-Economic optimization, LCA analysis
Demonstration at industrial scale (1 ha) of the feasibility of biofuels and bioproducts’ production.

A FOUR-YEAR PROJECT
- 2 academics
- 6 SMEs
- 1 large entreprise
- Portugal (1), Italy (3), Spain (1), Israel (1), The Netherlands (1), France (1), USA (1).

Coordinated by ALGAFUEL (P)
Step 1: Identification of the value

-Strain 1:
  - TAG (0.6$/kg)
  - PUFAs (100$/kg)
  - Pigments:
    (100-1000$/kg)
    - violaxanthin,
    - vaucherixanthin
  - Vitamins: E > 100$/kg)

Step 2: Physiological/Topological analyses

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Step 3: Conceptual process design and modelling

*C. vulgaris*: CO$_2$ capture, food grade

- around 50% proteins
- around 6% of TFA
- around 4% of pigments

Additional value implementation possible with:
- Pigment / protein / lipid fractionation (no purification here)
- No drying
- Continuous and intensified processes (scalable ones)
Cell destruction does not allow for a selective extraction, leading to emulsion, increase energy consumption and costs.

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Step 4: Experimental model validation, Upscaling

- for 100g biomass, dry matter basis

Culture, 10 L 100 g

Cell disruption

Solvents 3 L

Centrifugal Extraction
Solvent partitioning

Pigments 3 g
TFA 2 g

Non-soluble matter 32 g
Pigments 0.4 g
TFA 1 g

Residue 95 g

Centrifugation

70% proteins recovery
85% depigmentation
50% delipidation

pH=4 precipitation

Supernatant 25 g
Pigments, TFA 0 g

Protein extract 38 g
Pigments 0.6 g
TFA 3 g

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Step 5: Techno-Economic optimization, LCA analysis

Wet Extraction

Valorization of a high value compound

Residues → Hydrothermal Liquefaction → Bio Bitumem → Bio Road

AlgoRoute Project
Step 5: Techno-Economic optimization, LCA analysis

Biomass pretreatment → Hydrothermal Liquefaction 350 °C, 180 bars → Bio-bitumen

HEAT RECOVERY
1000 ton/year bio-bitumen process capacity
CAPEX < 1000 k€
OPEX 0.7 k€/ton excluding biomass cost and cost of capital
price compatible with current commercial bio-bitumen markets
Project feasibility demonstrated, project phase 2 has been submitted to funding scheme with a large industrial company in France
AlgoSource : integrated on the whole value chain

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Biorefining for a sustainable microalgae development

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Algorefining generic process

- **Exo metabolites**
  - Product 1

- **Fresh Biomass**
  - Extraction 1
    - Extraction 2
      - Additional treatment
        - Final residue

- **Microalgal oil**
  - Product 3

- **Structural molecule**
  - Product 4

- **Product 2**

- **Product 5**

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Conclusion

- Biorefining can unlock your microalgae potential value

- We provide Process design and early economic evaluation to identify solutions that works

- We use Process modeling and standard engineering tools for a comprehensive economic, environmental and risk analysis for a sustainable development

- We use and develop Algorefining in our daily operation since 2008
Our team gathers expertise on the whole value chain

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Deloitte Technologies Fast 50 WEST AWARD 2013

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