BI OACTIVE-NET

Assessment and dissemination of strategies for the extraction of bioactive compounds from tomato, olive and grape processing residues

Project No. FOOD-CT-2006-43035

CibusTec - Fiera di Parma,
17 Ottobre 2007

Marianna Faraldi
Tecnoalimenti S.C.p.A.
“Assessment and dissemination of strategies for the extraction of bioactive compounds from tomato, olives and grape processing residues”

SPECIFIC SUPPORT ACTION (SSA) - European Commission (6FP)

TTZ, TCA, AINIA
AMITOM, ANFOVI, CCAE, PEZA UNION, VIGNAIOLI PIEMONTESI

Duration: **24 months**

Start date: 1\textsuperscript{st} November 2006

End date: 31\textsuperscript{st} October 2008

Total eligible costs: 589,354,48 €
OBJECTIVES

- Create a board Information Platform
- Implement dissemination workshops in the South European Countries
- Strengthen the European market on natural ingredients
- Increase competitiveness of the European food industry
- Increase use of bioactive compounds in the European diet
WP 1: Definition of current conditions
- Business
- Research results
- Available technologies
- European market

WP 2: Development of dissemination modules
- Bioactive compounds
- BAT's
- Application
- Economic feasibility

WP 4: Implementation of dissemination workshops

WP 5: Dissemination activities and information campaign
- Flyers
- Information platform
- Manual
- Exhibitions / conferences

WP 3: Workshop on natural ingredients / additives
- Food Industry
- Cosmetic Industry

BIOACTIVE-NET
Bioactive compounds in tomato processing solid wastes
The processing of tomato consist of different treatment of the tomato fruit depending on the final product desired:

- Tomato puree
- Concentrate
- Tomato Pulp
- Whole Peeled Tomatoes
- Tomato sauces
- Ketchup
- Tomato juice
- Dehydrated tomato

During all these process steps, solid wastes are produced.
The tomato processing generates following wastes:

- Peels
- Seeds
- Waste water (2% in weight of fresh tomato)
- Pomace
Tomato processing wastes:

**In Italy**
- Tomatoes processed yearly: 4,400,000 tons
- Pomace produced yearly: 99,440 tons (yield=0.0226)*

**In Spain**
- Tomatoes processed yearly: 1,650,000 tons
- Pomace produced yearly: 47,190 tons (yield=0.0286)*

*Sources: BIOACTIVE-NET questionnaires*
Tomato processing wastes:

Current destination of the residue

- The by-products produced during the tomato transformation process are defined as **Secondary Raw Materials**

- **Council Directive 96/25/EC**, legislate the reuse in particular of “tomato pulp obtained by pressing tomatoes Solanum lycopersicum Karst. during the production of tomato juice” for animal feeding
Bioactive compounds in tomato processing residues

Tomato processing wastes:

Current destination of the residue

- Is it possible to extract more added value from the tomato processing residues?

- Can the health benefits from tomato be obtained from tomato wastes?

The solution may be the bioactive substances present in tomatoes solid wastes...
What is a bioactive compound?

A compound is considered bioactive if it has interaction with or effect on any cell tissue in the human body.

The effect might be beneficial or adverse.
Bioactive compounds

The level of bioactive compounds is affected by:

- Fruit variety
- Ripening stage
- Agronomic conditions
- Post-harvest manipulation
- Processing
The main bioactive compounds present in tomato processing residues are:

- Lycopene
- Tomato fibre
- Tomato seed oil
- Enzymes
### Bioactive compounds in tomato processing residues

**Lycopene**: Lycopene is the most important tomato carotenoid. From 5 to 50 mg/kg (even if it is possible, through the genetic improvement, to obtain as far as 200 mg/kg of Lycopene).

<table>
<thead>
<tr>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lycopene</strong></td>
<td>Antioxidant effect</td>
<td>High quality food integrator (additive, antioxidant and colouring E160d).</td>
</tr>
<tr>
<td></td>
<td>Protection against UV induced damage</td>
<td>Pharmaceutical product</td>
</tr>
<tr>
<td></td>
<td>Protection against degenerative diseases</td>
<td>Cosmetic product (skin maintaining)</td>
</tr>
<tr>
<td></td>
<td>Decrease cardiovascular diseases risk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Immune-stimulant effect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cancer risk reduction (e.g. prostate)</td>
<td></td>
</tr>
</tbody>
</table>
Lycopene:

Availability in tomato processing residues

100kg Pomace

4kg oil
(Lycopene content 0.02%)
80mg Lycopene

3kg wax
(Lycopene content 0.01%)
30mg Lycopene

TOTAL = 110mg Lycopene

*Yields obtained during the TOM project, using Super Critical Fluid extraction

BIOACTIVE-NET
# Bioactive compounds in tomato processing residues

## Tomato fibres:

<table>
<thead>
<tr>
<th></th>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tomato Fibres</strong></td>
<td>Not defined</td>
<td>- Positive effects during the mastication mechanisms</td>
<td>Food integrator (as additives or in dietetic foods)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce the caloric contribution of foods</td>
<td>Food industry: as viscosity modifier (in soup and sauces)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Induce satiety sensation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce the glycemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce the cholesterol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tie the toxic substances</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Stimulate the digestive processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Increase the time of intestinal transit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Favour the fermentative processes in the colon</td>
<td></td>
</tr>
</tbody>
</table>
Bioactive compounds in tomato processing residues

**Tomato fibres:**

Availability in tomato processing residues

100kg Pomace

75kg Tomato fibre

*Yields obtained during the TOM project, using Super Critical Fluid extraction*
Tomato seed oil:

Availability in tomato processing residues

- Vegetable fats and oils are substances derived from plants that are composed of triglycerides. Nominally, oils are liquid at room temperature, and fats are solid; a dense brittle fat is called a wax.

*Yields obtained during the TOM project, using Super Critical Fluid extraction.*

**BIOACTIVE-NET**
Tomato seed oil:

- 75% of unsaturated fatty acids
- Good source of the essential linoleic fatty acid.

Metabolic known effects:
- Tomato seeds oil acts as:
  - Vascular protector
  - Emollient

Applications:
- Food additive rich in poly-unsaturated fatty acids
- Cosmetic additive
## Bioactive compounds in tomato processing residues

### Enzymes:

<table>
<thead>
<tr>
<th>Enzymes</th>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin Methyl Esterase</td>
<td>Not defined</td>
<td>Aggregating for vegetables</td>
<td>Food industry applications</td>
</tr>
<tr>
<td>Polygalacturonase</td>
<td></td>
<td>Disgregating of pectines</td>
<td></td>
</tr>
</tbody>
</table>
Bioactive compounds in olive processing wastes

Source: www.juntadeandalucia.es
Olive oil production is divided into three activity fields:

- Oil mills
- Refineries
- Plants where the oil cake is processed

During all the processing steps, wastes are produced.
The wastes obtained from the olive oil milling process are:

- Alperujo
- Pomace
- Oil washing water
- Waste water

Source: www.juntadeandalucia.es
Source: www.kangarooblue.com
Source: www.unex.es
Source: www.alabastercorp.com
Bioactive compounds in olive processing residues

Olive processing wastes:

355,000 tons olive oil produced in **Greece** yearly

81,650 tons pomace produced yearly
(yield of 0.23t pomace / t tomato)

177,500 tons alpechin produced yearly
(yield of 0.5t margine / t tomato)

600,000 tons olive oil produced in **Spain** yearly

408,000 tons pomace produced yearly
(yield of 0.68t pomace / t tomato)

270,000 tons alpeorujo produced yearly
(yield of 0.45t alpeorujo / t tomato)

Source: BIOACTIVE-NET questionnaires
Olive processing wastes:

Current destination of the wastes

- General EU Legislation on wastes:
  Directive 2006/12/EC

- Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment.

- Such directive is applicable to any substance or which the holder discards or intends or is required to discard.
The main bioactive compounds present in olive processing residues are:

- Polyphenols
- Oleuropein
- Hydroxytyrosol
Bioactive compounds in olive processing residues

Polyphenols:

Description

- subdivided into tannins, and phenylpropanoids such as lignins and flavonoids

- Present in berries, tea, beer, wine, olive oil, chocolate/cocoa, walnuts, peanuts, yerba mate, and other fruits and vegetables (high levels in fruit skins)
Bioactive compounds in olive processing residues

Polyphenols:

Metabolic known effect

- antioxidant characteristics
- reduce the risk of cardiovascular disease and cancer

Applications

- cosmetic industry
- health food products (biscuits, bakery products, dietetic products)
- nutraceuticals
## Bioactive compounds in olive processing residues

### Hydroxytyrosol and Oleuropein:

<table>
<thead>
<tr>
<th></th>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydroxytyrosol</strong></td>
<td>Polyphenols concentrations in oil oscillate from 100 to 1000 mg/kg</td>
<td>Antioxidant and inhibiting towards pro-inflammatory oxygenasic enzymes</td>
<td>Food (as natural additives alternatively to synthesis compounds), chemical, pharmaceutical and cosmetic industries</td>
</tr>
<tr>
<td><strong>Oleuropein</strong></td>
<td>(Polyphenol)</td>
<td>Antioxidant and antibacterial properties</td>
<td>Food, chemical, pharmaceutical and cosmetic industries</td>
</tr>
</tbody>
</table>
Bioactive compounds in grape processing wastes

Source: www.ace76.blogia.com
Bioactive compounds in grape processing residues

Grape Processing:

Wine production

- Wastes are produced during all the production steps of wine production!
Bioactive compounds in grape processing residues

Grape processing residues

- Grape stems (MASHING)
- Pomace (PRESSING)
- Lees (FERMENTATION)
- Filter cake (CLARIFICATION)
- Waste water (WASHING of the equipment)

• The solid components form the **dregs of grapes**.

BIOACTIVE-NET
The pressing of 100kg grapes during wine production results in:

- 25kg pomace
- Skins (50%)
- Grape seeds (25%)
- Grape Stalks (25%)
# Bioactive compounds in grape processing residues

## Grape processing wastes:

**Source:** BIOACTIVE-NET questionnaires

<table>
<thead>
<tr>
<th>GRAPE STEMS produced yearly</th>
<th>570.000 tons</th>
<th>90.133 tons</th>
<th>259.000 tons</th>
<th>206.800 tons</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grapes processed yearly for the production of wine</th>
<th>France</th>
<th>Greece</th>
<th>Italy</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.605.000 tons</td>
<td>521.000 tons</td>
<td>7.400.000 tons</td>
<td>4.700.000 tons</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POMACE produced yearly</th>
<th>1.400.000 tons</th>
<th>88.000 tons</th>
<th>740.000 tons</th>
<th>409.000 tons</th>
</tr>
</thead>
</table>
### Grape processing wastes:

#### Filter cake produced yearly
- **France**: 68,445 tons
- **Greece**: 24,000 tons
- **Italy**: 133,200 tons
- **Spain**: 42,300 tons

#### Grapes processed yearly for the production of wine
- **France**: 7,605,000 tons
- **Greece**: 521,000 tons
- **Italy**: 7,400,000 tons
- **Spain**: 4,700,000 tons

#### Lees produced yearly
- **France**: 335,000 tons
- **Greece**: 27,000 tons
- **Italy**: 392,000 tons
- **Spain**: 517,000 tons

Source: BIOACTIVE-NET questionnaires
Grape processing wastes: Current destination of the wastes

- General EU Legislation on wastes: Directive 2006/12/EC

- Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment.

- Such directive is applicable to any substance or which the holder discards or intends or is required to discard.
Grape processing wastes: Current destination of the wastes

- Council Regulation EC/1493/1999. Article 27

- Any natural or legal person or group of persons having made wine, shall be required to **deliver for distillation all the by-products of that winemaking** (grapes and pressing of wine lees).

- The market foresees compulsory distillation of by-products of wine-making.
The most important bioactive compounds present in the grapes’ dregs are:

- Proanthocyanidins
- Quercetin
- Anthocyanins
- Resveratrol
- Grape seed oil
## Bioactive compounds in grape processing residues

### Grape bio-components

<table>
<thead>
<tr>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stilbens</strong> e.g. Resveratrol (the most important grape polyphenol)</td>
<td>Not defined</td>
<td>Cardiovascular system protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antioxidant action and photoprotective effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anticancer action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Against Alzheimer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cosmetic use: - in combination with normal ultraviolet filters as photoprotective effect; - against skin spots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>As integrator</td>
</tr>
<tr>
<td><strong>Anthocyanins (flavonoids)</strong></td>
<td>Not defined</td>
<td>Antioxidant and anti-inflammatory action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Against cancer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cosmetic use (e.g. skin protection after sun-bathe)</td>
</tr>
<tr>
<td><strong>Proanthocyanidins</strong></td>
<td>Not defined</td>
<td>Antioxidant activity (very used for skin health)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cosmetic use: anti-wrinkles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ocular protection (retina)</td>
</tr>
</tbody>
</table>
### Bioactive compounds in grape processing residues

#### Grape bio-components

<table>
<thead>
<tr>
<th>Quercetin (flavonoids)</th>
<th>Amount of extractable molecule</th>
<th>Metabolic known effects</th>
<th>Sector of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not defined</td>
<td>Anti-inflammatory activity</td>
<td>Mainly used as a food integrator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antioxidant activity and vitamin C-sparging action</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>May have positive effects in combating or helping to prevent: cancer, prostatitis, heart disease, cataracts, allergies/inflammations, respiratory diseases such as bronchitis and asthma</td>
<td></td>
</tr>
</tbody>
</table>
From a legislative point of view, natural ingredients are regulated as:
- Food additives (Directive 89/107/EEC) and/or
- Cosmetic products (Council Directive 76/768)

Global market of functional food
= 33 billion US$ (for Europe = 2 billion US$)

Functional food (or nutraceuticals) is any food claimed to have a health-promoting and/or disease-preventing property beyond the basic nutritional function of supplying nutrients.

Global market for “nutricosmetics”
= $1bn (will double over the next five years)

Nutricosmetics are supplements aimed at outward appearance
Obtaining of bioactive compounds out of tomato/olive/grape processing wastes

**PRE-TREATMENT**

To store and transport the raw material easier

To prepare the raw material for the extraction

**EXTRACTION**

To obtain a product with greater purity and therefore greater value added

**PURIFICATION**

To store easily the bioactive compounds

**DRYING of bioactive compound**
Obtaining of bioactive compounds out of tomato/olive/grape processing wastes

**Draining:** to eliminate a first part of the important amount of water present in the residues (Tomato pomace ~70% moisture, Olive pomace ~55% moisture, Grape pomace ~50% moisture)

**Drying:** to achieve a moisture of 10% in the residues

**Milling:** to have a common particle size of 2mm

**Homogenization:** to have the same composition throughout the volume to treat
Obtaining of bioactive compounds out of tomato/olive/grape processing wastes

- Conventional solid-liquid extraction
- Supercritical Fluid Extraction (SFE)/SC-CO2 extraction
- Sonicated-assisted extraction (ultrasound)
- Microwave-assisted extraction (MAE)
- Accelerated solvent extraction (ASE)
Obtaining of bioactive compounds out of tomato/olive/grape processing wastes

- **Chromatographic techniques**
  - partition chromatography
  - adsorption chromatography
  - size-exclusion or gel filtration
  - ion exchange chromatography
  - affinity chromatography

- **Membranes**
  - microfiltration
  - ultrafiltration
  - reverse osmosis

- **Crystallization**
Obtaining of bioactive compounds out of tomato/olive/grape processing wastes

- Freeze Drying
- Spray drying
- Rotary Vacuum drying

DRYING of bioactive compound
Cost calculation examples for the industrial extraction of bioactive compounds from tomato/olive/grape processing wastes:

- **Example 1:** Supercritical Fluid Extraction (SFE) /SC-CO$_2$ extraction
- **Example 2:** Solvent extraction
Assessment of the economic feasibility of the extraction of bioactive compounds from tomato/olive/grape processing wastes

<table>
<thead>
<tr>
<th></th>
<th>Tomato (quantities yearly produced)</th>
<th>Olives (quantities yearly produced)</th>
<th>Grape (quantities yearly produced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum hypothesis</td>
<td>2000 tons</td>
<td>500 tons</td>
<td>75 tons</td>
</tr>
<tr>
<td>Maximum hypothesis</td>
<td>40000 tons</td>
<td>11000 tons</td>
<td>50000 tons</td>
</tr>
</tbody>
</table>

The minimum hypothesis for the cost calculation considers that the extraction of bioactive compounds is performed in single factories.

The maximum hypothesis for the cost calculation considers that the extraction of bioactive compounds is performed by a big extractor for the processing residues of the whole region.
Example 1: Supercritical Fluid Extraction

Economic feasibility of the extraction of tomato bioactive compounds
Economic feasibility of the extraction of tomato bioactive compounds

Example 1:

Supercritical Fluid Extraction on Tomato

Tomato processing residues (Pomace)

- Decanter: Draining
- Belt Dryer: Drying
- Hammermill: Milling
- Supercritical Fluid Extractor: Extraction
- Spray Dryer: Drying
Economic feasibility of the extraction of tomato bioactive compounds

Example 1:

Supercritical Fluid Extraction on Tomato

Estimated costs:

PRE-TREATMENT
- Initial investment for equipments
- labour costs, energy costs, maintenance & repair, quality control

EXTRACTION
Initial investment for SFE EXTRACTOR
CO2 consumption (recycling 75%)
- labour costs, energy costs, maintenance & repair, quality control

DRYING
Initial investment for equipments
- labour costs, energy costs, maintenance & repair, quality control

Other costs: supervisory control, average transport needed, raw material transport (0,25€/t/km)
### Economic feasibility of the extraction of tomato bioactive compounds

**Example 1:**

**Supercritical Fluid Extraction on Tomato**

- **TOTAL costs**

<table>
<thead>
<tr>
<th>TOTAL COSTS yearly</th>
<th>Minimum Hypothesis (2,000t/year)</th>
<th>Maximum Hypothesis (40,000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs / kg pomace to treat</td>
<td>€2,625,668</td>
<td>€49,223,770</td>
</tr>
<tr>
<td>total initial investment</td>
<td>€4,690,000</td>
<td>€101,650,000</td>
</tr>
</tbody>
</table>
### Example 1:

#### Supercritical Fluid Extraction on Tomato

**Economic feasibility of the extraction of tomato bioactive compounds**

<table>
<thead>
<tr>
<th>Selling prices</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil 0,02% Lycopene</td>
<td>€/kg</td>
</tr>
<tr>
<td>wax 0,01% Lycopene</td>
<td>€/kg</td>
</tr>
<tr>
<td>fibre</td>
<td>€/kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extraction yield</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>oil</td>
<td>4%</td>
</tr>
<tr>
<td>wax</td>
<td>3%</td>
</tr>
<tr>
<td>fibre</td>
<td>70%</td>
</tr>
</tbody>
</table>

#### Estimation of the revenues

<table>
<thead>
<tr>
<th>Estimation of the revenues</th>
<th>Minimum Hypothesis (2.000t/year)</th>
<th>Maximum Hypothesis (40.000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>revenues oil</td>
<td>€ 160.000</td>
<td>€ 3.200.000</td>
</tr>
<tr>
<td>revenues wax</td>
<td>€ 240.000</td>
<td>€ 4.800.000</td>
</tr>
<tr>
<td>revenues fibre</td>
<td>€ 2.520.000</td>
<td>€ 50.400.000</td>
</tr>
</tbody>
</table>

| Estimated revenues        | € 2.920.000                      | € 58.400.000                     |
Economic feasibility of the extraction of tomato bioactive compounds

Example 1:

Supercritical Fluid Extraction on Tomato

- Yearly Profit -

<table>
<thead>
<tr>
<th></th>
<th>Minimum Hypothesis (2000t/year)</th>
<th>Maximum Hypothesis (40000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue</td>
<td>2,920,000€</td>
<td>58,400,000€</td>
</tr>
<tr>
<td>Total Costs</td>
<td>2,625,668€</td>
<td>49,223,770€</td>
</tr>
<tr>
<td>Profit Per Year</td>
<td>294,332€</td>
<td>9,176,230€</td>
</tr>
</tbody>
</table>

*Total initial investment:

- Minimum Hypothesis: 4,690,000€
- Maximum Hypothesis: 101,650,000€

BIOACTIVE-NET
Economic feasibility of the extraction of tomato bioactive compounds

Example 2: Solvent Extraction

Conventional extraction laboratory scale plant.
(http://www.pignat.com/default.aspx?idwsgpage=7&idwsglangue=2&idwsgmodulecataloguecategorie=7&idwsgmodulecatalogueproduit=64)
Economic feasibility of the extraction of tomato bioactive compounds

Example 2:

Solvent Extraction

Tomato processing residues (Pomace)

- Decanter
- Belt Dryer
- Hammermill
- Homogenisator
- Stirred Tank
- Decanter
- Evaporator
- Spray Dryer

Draining
Drying
Milling
Homogenisation
Extraction
Decantation
Evaporation
Drying
Example 2: Solvent Extraction on Tomato

Estimated costs:

**PRE-TREATMENT**
- Initial investment for equipments
- Labour costs, energy costs, maintenance & repair, quality control

**EXTRACTION**
- Initial investment for SFE EXTRACTOR
- CO2 consumption (recycling 75%)
- Labour costs, energy costs, maintenance & repair, quality control

**DRYING**
- Initial investment for equipments
- Labour costs, energy costs, maintenance & repair, quality control

**Other costs:** supervisory control, average transport needed, raw material transport
### Economic feasibility of the extraction of tomato bioactive compounds

#### Example 2:
**Solvent Extraction on Tomato**

- **TOTAL costs**

<table>
<thead>
<tr>
<th>TOTAL COSTS yearly</th>
<th>Minimum Hypothesis (2,000t/year)</th>
<th>Maximum Hypothesis (40,000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs / kg pomace to treat</td>
<td>1,06€</td>
<td>0,89€</td>
</tr>
<tr>
<td>total initial investment</td>
<td>1,040,000€</td>
<td>2,490,000€</td>
</tr>
</tbody>
</table>
Economic feasibility of the extraction of tomato bioactive compounds

Example 2: Solvent Extraction on Tomato

- Revenues -

<table>
<thead>
<tr>
<th>Selling prices</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil price lycopene 0,1%</td>
<td>€/kg</td>
</tr>
<tr>
<td></td>
<td>45,00€</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extraction yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil 0,02% Lycopene</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimation of the yearly revenues</th>
<th>Minimum Hypothesis (2.000t/year)</th>
<th>Maximum Hypothesis (40.000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>revenues oil</td>
<td>€ 1.800.000</td>
<td>36.000.000</td>
</tr>
<tr>
<td>revenues wax</td>
<td>€ 0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>€ 1.800.000</td>
</tr>
<tr>
<td>36.000.000</td>
</tr>
</tbody>
</table>
### Economic feasibility of the extraction of tomato bioactive compounds

#### Example 2: Solvent Extraction on Tomato

#### – Yearly Profit –

<table>
<thead>
<tr>
<th></th>
<th>Minimum Hypothesis (2,000t/year)</th>
<th>Maximum Hypothesis (40,000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL REVENUE</strong></td>
<td>1,800,000€</td>
<td>36,000,000€</td>
</tr>
<tr>
<td><strong>TOTAL COSTS</strong></td>
<td>2,126,554€</td>
<td>35,765,401€</td>
</tr>
<tr>
<td><strong>PROFIT PER YEAR</strong></td>
<td>-326,554,28€</td>
<td>234,599,12€</td>
</tr>
</tbody>
</table>

*Note: Total initial investment*

- **minimum hypothesis**: 1,040,000€
- **maximum hypothesis**: 2,490,000€
## Economic feasibility of the extraction of tomato bioactive compounds

### SYNTHESIS on Tomato:

<table>
<thead>
<tr>
<th></th>
<th>Minimum Hypothesis (2,000t/year)</th>
<th>Maximum Hypothesis (40,000t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supercritical Fluid Extraction</strong></td>
<td>Yearly profit: 294,332€</td>
<td>Initial investment: 4,690,000€</td>
</tr>
<tr>
<td></td>
<td>Time needed to recover initial investment: 16 years</td>
<td>101,650,000€</td>
</tr>
<tr>
<td><strong>Solvent Extraction</strong></td>
<td>Yearly profit: -326,554€</td>
<td>Initial investment: 1,040,000€</td>
</tr>
<tr>
<td></td>
<td>Time needed to recover initial investment: 10 years</td>
<td>2,490,000€</td>
</tr>
</tbody>
</table>
Economic feasibility of the extraction of olives bioactive compounds

**Olive processing residues (Pomace)**

- **Supercritical Fluid Extraction**
  - Belt Dryer
  - Hammermill
  - Supercritical Fluid Extractor
  - Spray Dryer
  - Extraction
  - Drying

- **Solvent Extraction**
  - Belt Dryer
  - Hammermill
  - Homogenisator
  - Stirred Tank
  - Decanter
  - Ultrafiltration
  - Evaporator
  - Spray Dryer
  - Drying
### Economic feasibility of the extraction of olives bioactive compounds

**SYNTHESIS on Olives:**

#### Supercritical Fluid Extraction

<table>
<thead>
<tr>
<th></th>
<th>Minimum Hypothesis (500t/year)</th>
<th>Maximum Hypothesis (11,000/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yearly profit</strong></td>
<td>179,429 €</td>
<td>13,739,899 €</td>
</tr>
<tr>
<td><strong>Initial investment</strong></td>
<td>2,410,000 €</td>
<td>30,900,000 €</td>
</tr>
<tr>
<td><strong>Time needed to recover initial investment</strong></td>
<td>14 years</td>
<td>3 years</td>
</tr>
</tbody>
</table>

#### Solvent Extraction

<table>
<thead>
<tr>
<th></th>
<th>Minimum Hypothesis (500t/year)</th>
<th>Maximum Hypothesis (11,000/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yearly profit</strong></td>
<td>-35,029 €</td>
<td>1,690,861 €</td>
</tr>
<tr>
<td><strong>Initial investment</strong></td>
<td>1,370,000 €</td>
<td>1,840,000 €</td>
</tr>
<tr>
<td><strong>Time needed to recover initial investment</strong></td>
<td>2 years</td>
<td></td>
</tr>
</tbody>
</table>
Economic feasibility of the extraction of grape bioactive compounds

Grape

Supercritical Fluid Extraction

Grape processing residues (Pomace)

BELT DRYER  
MILLING  
SUPERCritical FLUID EXTRACTOR  
SPRAY DRYER  
Extraction

Solvent Extraction

Grape processing residues (Pomace)

BELT DRYER  
HAMMERMILL  
HOMOGENISATOR  
STIRRED TANK  
DECANTER  
ULTRAFILTRATION  
EVAPORATOR  
SPRAY DRYER  
Drying

Drying  
Milling  
Homogenisation  
Extraction  
Decantation  
Filtration  
Evaporation  
Drying

BIOACTIVE-NET
### Economic feasibility of the extraction of grape bioactive compounds

#### SYNTHESIS on Grape:

<table>
<thead>
<tr>
<th>Method</th>
<th>Minimum Hypothesis (75t/year)</th>
<th>Maximum Hypothesis (50.000/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supercritical Fluid Extraction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly profit</td>
<td>-58.161 €</td>
<td>69.243.162 €</td>
</tr>
<tr>
<td>Initial investment</td>
<td>2.410.000 €</td>
<td>139.900.000 €</td>
</tr>
<tr>
<td>Time needed to recover initial investment</td>
<td>2 years</td>
<td></td>
</tr>
<tr>
<td><strong>Solvent Extraction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly profit</td>
<td>-30.151 €</td>
<td>20.131.800 €</td>
</tr>
<tr>
<td>Initial investment</td>
<td>1.370.000 €</td>
<td>2.940.000 €</td>
</tr>
<tr>
<td>Time needed to recover initial investment</td>
<td>1 year</td>
<td></td>
</tr>
</tbody>
</table>
Economic feasibility of the extraction of tomato bioactive compounds

Remarks:

- Working time of 330 days annually
- 24 hours a day
- Costs of sales and marketing, shipping, handling and storing have not been considered
- Recovery costs of solvent have not been considered