A case study of the Italian tomato processing industry: a comprehensive evaluation from production, water, and energy consumption to waste valorization and LCA point of view

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- Energy consumption in food industry is 200EJ, 30% of total energy
- Food industry generates one-quarter of the world’s greenhouse gas emissions
- 10% of total water is used in the food industry
- Global water demand is predicted to increase about 50% until 2050
- Food waste generation is 1.6 billion tons (10% is during food processing)
- Food industry generates one-quarter of the world’s greenhouse gas emissions
- Population growth will be over 9 billion until 2050
- Global demand will be 20 fold
The main objective is optimization of water consumption in the food industry by developing of water-waste-energy nexus.

- It is a European project funded by EU Horizon 2020.
- Represented by 4 countries (Italy, Greece, Iceland & Spain).
- focuseing on sectors of the food and beverage industry consuming a high amount of water and energy.
Tomato Processing Demonstrator

Problem

Aim

Method

Result

Conclusion
Tomato is The World’s Top Vegetable for Processing

In 2021, about 39 million tons of tomatoes were used in tomato processing industry.

Italy is the largest tomato processing sector in Europe and the second in the world (6M tons in 2021).
Problem Statement in Tomato Processing Industry

Tomato processing consumes a high level of water and energy and generates a high amount of waste.
Energy Usage Reduction

Water Usage Reduction
Water Recycling
Wastewater Treatment

Waste Valorisation
Waste Reduction

Near-Zero Discharge

Problem
Aim
Method
Result
Conclusion
Company Workflow

Electrical energy  Water  Natural gas

- Peeled tomato production line
  - Pre processing
  - Processing
  - Packaging
  - Peeled Tomato
  - Tomato Sauce

- Tomato sauce production line
  - Sludge (Soil, Stone) Leaves, branches damaged tomatoes (10-16%)
  - Tomato waste (2-5%)
  - Depurated Wastewater: (70%)

Literature data

Packaging

Pre processing

Processing

Packaging

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Current Value Stream Map of Tomato Sauce Production

- **Farm**
  - **Water**
    - Receiving, washing
    - Manual/Optical sorting
      - Sludge (stones, soil): Leaves, branches
      - Wastewater treatment
      - Solid waste to disposal
      - Wastewater treatment
    - To be sold as cattle feed
    - Wastewater treatment
  - Energy
    - Wastes: (recycled to the sauce processing line)
    - Manual/Optical sorting
      - Waste/Green tomato:
    - Chopping
    - Hot Break
    - Juice Extraction
      - Tomato wastes (peels and seeds)
    - Evaporation (8.5°Brix)
      - Tomato evaporate
    - Heating
      - To be sold as cattle feed
    - Jar hot filling
      - Recirculate to cooling towers
    - Sterilization/cooling

- **Customer**
  - Store
  - Energy

**Conclusion**

- **Problem**
- **Aim**
- **Method**
- **Result**
Current Value Stream Map of Peeled-Tomato Production

**Water**
- Receiving, washing
- Manual/Optical sorting
- Thermophysical Peeling
- Wastes: Tomato peel and pulp
- Optical/Manual Sorting
- Dicing or cutting
- Canning
- Juice adding (8.5 °Brix)
- Sterilization/Cooling

**Energy**
- Farm
- Customer
- Store

**Problem**

**Aim**

**Method**

**Result**

**Conclusion**

**Solid waste to disposal**
- Wastewater treatment

**Wastewater treatment**

**Wastes process**
- (recycled to the sauce processing line)
Water and energy consumption are often linked, energy is required to transport, heat, and cool water, and water in the form of steam is used to generate energy. These relationships are termed the water-energy nexus (WEN).
Water-Energy Nexus (WEN) & WEN points

- Reservoir
- Boiler
- Peeling
- Pasteurization
- Hot Break
- Evaporation
- Concentrator
- Cooling tower
- Accumulation tank
- Vacuum pump
- Washing 2
- Washing 1
- Facility Cleaning
- Wastewater Discharge
- Pasteurization Facility
- Cleaning
- Discharge
- Accumulation tank
- Peeling
- Boiler
- Reservoir
- Wells
Water Usage

Problem

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- **Cooling**: 17%
- **CIP**: 2%
- **Vacuum pump**: 6%
- **Boiler**: 5%
- **Washing 1**: 20%
- **Washing 2**: 50%

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Thermal Energy Usage

- Pasteurization Unit: 40%
- Concentration Unit: 40%
- Hot break Unit: 10%
- Peeling Unit: 10%

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Electrical Energy Usage

General Electricity Distribution
Electrical energy consumption in WEN and non WEN points

- WEN: 43%
- Non WEN: 57%

Electricity Distribution for WEN
Most Consuming Energy in WEN points

- Only pumps: 80%
- Other equipment: 20%

Problem
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Electricity Distribution In WEN

- **WS**: Water supply
- **WW**: Wastewater
- **FC**: Facility cleaning
- **NTP**: Non-thermal processes
- **TP**: Thermal processes
- **CT**: Cooling tower
- **SG**: Steam generation
Life Cycle Assessment (LCA) Of The Tomato Processing Industry

**Scope**
From gate to gate of tomato processing

**Unit Function**
- A can of peeled tomato (500 gr)
- A bottle of tomato sauce (540 gr)

**Goal**
Environmental impact of tomato processing
Environmental Impact

A can of peeled tomato (1 kg)
Global warming: eq 0.513 kg CO₂

A bottle of tomato sauce (1 kg)
Global warming: eq 0.47 kg CO₂

Problem
- Climate Change
- Material use
- Carcinogen
- Ozon layer
- Radiation

Aim
- Land use
- Ecotoxicity
- Acidification
- Eutrophication

Method
- Fossil fuel
- Minerals

Result

Conclusion
Comparison Between Peeled Tomato And Tomato Sauce LCA


Comparing 1 kg ‘peeled tomato’ with 1 kg ‘tomato sauce’;
Critical Points in Tomato Processing Industry

1. **Most Water Demanding**
   - Washing phase consume 70% of total water

2. **Most Thermal Energy Demanding**
   - Pasteurization and evaporation 80%

3. **Most Electrical Energy Demanding**
   - Pumps consume 80% of the electricity in WEN points

4. **LCA**
   - Packaging has the highest environmental impact (more than 90%)
Accelerating Water Circularity in Food and Beverage Industrial Areas around Europe

Thank you for your attention