
# BIOENERGY

Yeast is a powerful ally to explore innovative applications and sustainable solutions for bioenergy and in particular biofuels.

Biofuels are renewable energy sources derived from biological material, known as biomass. Used as alternatives to fossil fuels, they can help reduce greenhouse gas emissions and improve the EU's security of fuel supply. At a time of growing food security concerns, integrated food and energy systems (IFES) could be a smart way of ensuring the multi-purpose use of the feedstocks concerned (food, feed and energy), **provided they do not compete with food and feed production**.

## ROLE OF YEAST

Yeast, in particular *Saccharomyces cerevisiae*, is essential for bioethanol production, as it ferments sugars and converts them into ethanol.

### FIRST-GENERATION BIOETHANOL:

They use crops such as cereals (mainly corn and wheat), sugar beet and sugar cane, whose simple sugars are transformed into ethanol by fermentation. First-generation biofuels are widely used in the transport sector, in various blending ratios (e.g. E10, E85) or even as a single, clean energy source (E100).

### SECOND-GENERATION BIOETHANOL:

They use lignocellulosic biomass (e.g., agricultural residues, wood chips, and grasses). Their production involves pretreatment and enzymatic hydrolysis to break down cellulose and hemicellulose into sugars that will further be fermented by yeast. Second-generation bioethanol are more sustainable as they use non-food biomass. However, their development is slowed by higher costs in the production process.

## FORMAT OF YEAST USED

At the beginning, yeasts were used in a dry format.
However, recently plants have started to use a liquid form of yeast that have advantages because they are already hydrated. Some have been stabilised for longer shelf life.

## A SHORT HISTORY

The development of biofuel started in the late 20th century. In the EU, biofuel production and consumption truly soared from the 2010s:

- **1970s Oil Crises:** The search for renewable energy sources intensified, leading to the use of yeast for bioethanol production from crops like corn and sugarcane.
- **Late 20th century:** Advances in genetic engineering began to enhance yeast's efficiency and expand its applications in biofuel production. However, nowadays, most yeast used for bioethanol production in the European union are still non-GMOs.
- **Early 21st century:** Yeasts were engineered to produce biodiesel, biogas, and advanced biofuels, including jet fuel, from various biomass sources.

## KEY DATA

- **Ethanol reduces greenhouse gas emissions by 70-90%** (excluding land-use changes) due to its sulphur-free composition and higher-octane rating than petrol.
- **Biomass accounted for 59% of renewable energy consumption in the EU in 2021**, with the industry sector consuming 21.1 million tonnes of oil equivalent (Mtoe) of biomass.

## PROSPECTS AND INNOVATIONS

With the ambition to decarbonize all transport in the EU as shown by the recently adopted Fit for 55 Package, demand for sustainable alternatives to fossil fuels is expected to grow dramatically by 2030. Optimizing yeast-based bioproduction processes is therefore essential. Here are the main prospects:

**1. Improve the bioethanol production process and the efficiency of fermentation** during which the yeast converts the substrate into bioethanol.

**2. Biodiesel production:** this promising research has not yet led to industrialization. Some yeasts can accumulate high levels of lipids (oils) which can be converted to biodiesel by transesterification. Oleaginous yeasts, such as *Yarrowia lipolytica*, *Cryptococcus curvatus* and *Rhodotorula glutinis*, can use a variety of raw materials, including waste, agricultural residues and industrial by-products.

**3. Biogas Production (through Anaerobic Digestion):** Yeast can improve the efficiency and stability of microbial communities in anaerobic digesters, where organic matter is broken down by microorganisms to produce biogas (a mixture of methane and $CO_2$).

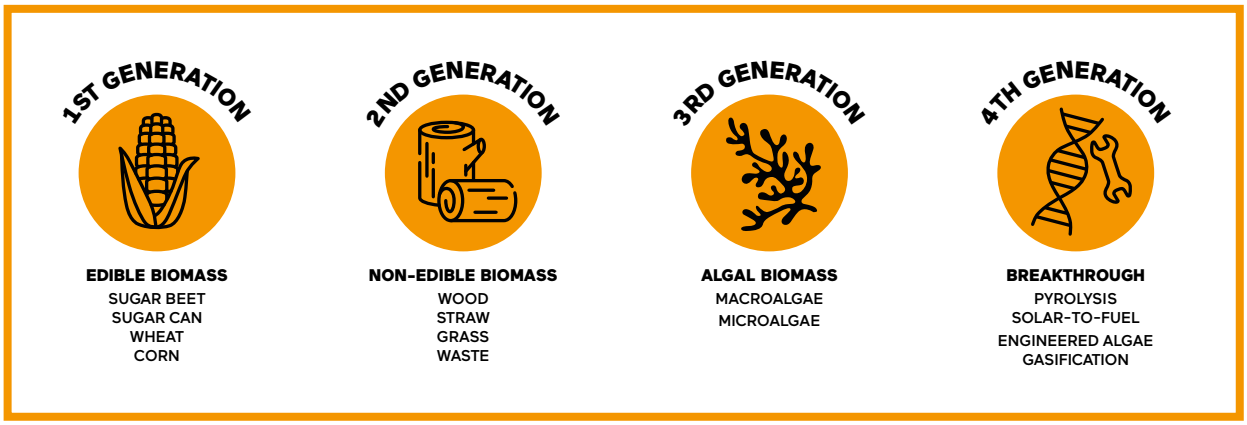
**4. Biohydrogen Production (through Dark Fermentation):** Yeasts, in combination with bacteria, can be used in dark fermentation processes to produce hydrogen gas from organic substrates. Yeast is used to break down complex substrates, making them available for hydrogen-producing bacteria.

**5. Butanol Production(through A-B Fermentation):** Genetically engineered yeasts can be used to produce butanol, with higher energy content and lower volatility than ethanol. Yeasts can be engineered to produce butanol directly from sugars.

**6. Alcohol to jet advanced fuels:** Yeasts can be engineered to produce alcohols, which are then catalytically upgraded into jet fuel by processes like alcohol-to-jet (ATJ) conversion. The alcohols undergo dehydration, oligomerization, and hydrogenation to form high-density hydrocarbons suitable for aviation fuel. Ethanol can hence be used as a platform molecule to produce sustainable aviation fuels (SAF).

**7. Production of 3rd generation bioethanol from algal biomass:** A promising process that does not compete with agricultural land, and also captures $CO_2$ through photosynthesis. Its cost remains high due to the complex structure of algae sugars, requiring pre-treatment and the use of specialized yeasts.

**8. 4th generation bioethanol:** Its principle is to use genetically modified yeasts and bacteria to produce ethanol directly from $CO_2$ or plastic waste! This technique, which is still under development, would therefore make it possible to produce a biofuel while capturing $CO_2$ during the production process.

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