

Let's define some terms...

What is a GMO?

- A Genetically Modified Organism (GMO) is one whose genetic make-up has been altered by any means

What is a GMM?

- A Genetically Modified Microorganism (GMM) is specifically a microorganism that has an altered genetic make-up

What is an enzyme?

- A specialized protein which occurs in all living things and acts as catalyst to bring about a specific biochemical reaction.

What is modern biotechnology?

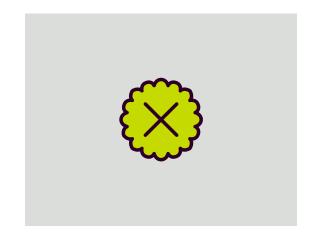
- Modern biotechnology is a set of tools used to make well characterized and specific genetic modifications to organisms

What is self-cloned?

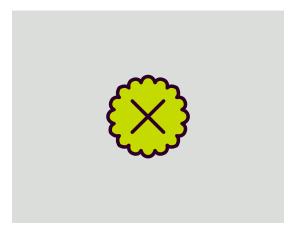
- Introduction of genetic material from the same, or closely related, species



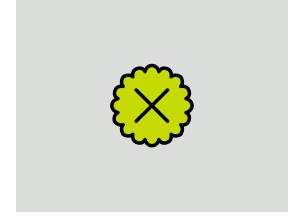
A quick answer to a big question - Why aren't enzymes GMOs?



Enzymes are not GMOs



Enzymes do not contain GMOs



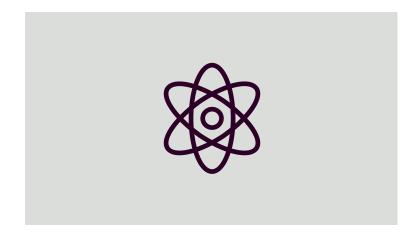
Enzymes are not organisms, therefore enzymes can never be "GMOs"

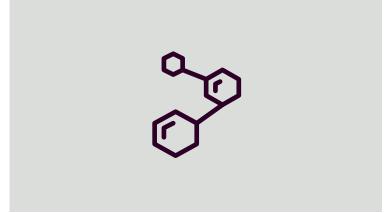
Why this discussion about enzymes and GMOs?

- We start with microorganisms being the best tool for producing enzymes for a few reasons:
 - Commercial scalability
 - The best quality level
 - Most sustainable
- These microorganisms can be improved by modern biotechnology – more details to follow
- It's important to remember that the microorganisms making the enzymes are absent from the product leaving our facilities



Which techniques does Novozymes use to improve production microorganisms?







Traditional biotechnology

The production microorganism could be developed using conventional breeding or mutagenesis. This is how farmers got the plants they wanted for centuries. This type of change has not been considered in most GMO/GMM regulatory definitions, labeling and public perception.

Self-cloning

A self-cloned microorganism has been modified to contain several copies of a gene that is already present in it.

Modern biotechnology (GMM)

To produce the best and most effective enzymes, a gene of interest coming from another microorganism has been inserted into the production microorganism using precise techniques.





How are enzymes produced?

- Enzymes are generally produced by fermentation of microorganisms
- Microorganisms are grown with nutrients in a fermenter
- They multiply, produce the desired enzymes and secrete them out of their cells
- The liquid containing the enzymes is separated from the production microorganisms
- The enzyme products (liquid or granulate) do not contain any production microorganism



Why does Novozymes use GMMs to produce enzymes?

- With GMMs, it is possible to produce enzymes that would not otherwise be commercially available
- Microorganisms improved by modern biotechnology produce enzymes with a better yield, and with the following benefits:
 - Less use of raw materials, water and energy
 - Less waste
 - Better economy
- Enzymes produced by GMMs are normally free of side activities, resulting in technological benefits in their applications
- Novozymes GMMs are well characterized and are safe for the production of enzymes used in food, including distilling

Greatly reduced impact to the environment when using enzymes produced by GMMs

Relative impact 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 **Acidification Global warming Nutrient Photochemical Energy resources** enrichment ozone formation Without modern biotechnology With modern biotechnology



Are enzymes produced by GMMs approved by authorities?

All enzymes – no matter the source – must have the same review and approval by US authorities

Authorities require review of the following information:

- Safety of the production organism whether GMM or not
- Safety of the enzyme product
- Hygiene of the manufacturing process
- Safety in the intended use of the enzyme

Many countries require approval of food enzymes, including those produced by GMMs



Summing up

Enzymes
are specialized
proteins and
are not GMOs

Novozymes uses GMMs to produce enzymes for commercial scale and sustainability

The enzyme products do not contain the GMM

All of Novozymes enzyme products are reviewed for safety in the intended use





Rethink Tomorrow