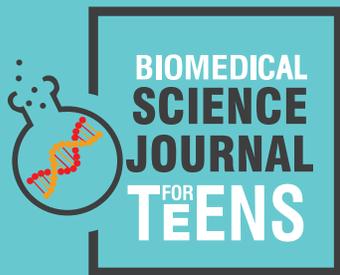


# How can GM tomatoes help fight cancer?



BIOMEDICAL  
SCIENCE  
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FOR  
TEENS

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## Abstract

Did your parents ever tell you that eating your fruit and veggies is good for you? Well, they're right! Fruits and vegetables contain powerful agents called *antioxidants* that can help us fight many diseases, including one of the biggest killers of all: cancer. With *genetic engineering* techniques, we created a new tomato that is even healthier than its traditional counterparts. In this study, we not only show

that it contains more compounds that are beneficial to our health, but also that it has higher cancer-fighting powers than traditional tomatoes. We believe that our new tomato can aid in cancer prevention, either by simply eating it or by turning it into food supplements or cancer prevention medicine.

## Introduction

Cancer is one of the leading causes of death for humans: it kills millions each year. There are many different kinds of cancers, but in all of them the body's cells begin to divide without stopping and spread into surrounding tissues. This often causes significant damage or even death.

Scientists are working hard on finding or developing substances that help fight or prevent cancer. Some promising candidates for cancer prevention are substances called antioxidants. These compounds fight cancer either by stopping cancer cells from growing or by stimulating our *immune system* (the system that fights diseases in our body).

Lucky for us, these antioxidants can be found in some of the food we're eating: fruit and vegetables (Figure 1). So what your parents have been saying about them is true after all! Studies have shown that eating them can reduce the risk of various diseases, including many cancers (such as breast, lung, pancreatic or colon cancer).

Tomatoes, for instance, contain certain antioxidants (called *flavonoids*) that can help fight or prevent cancer and other diseases. Wouldn't it be great if they had even more healing



**Figure 1:**

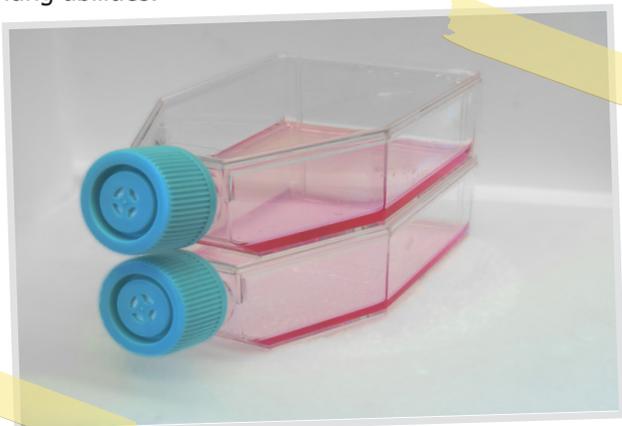
Many fruit and vegetables contain powerful compounds called antioxidants that help our bodies fight diseases and even cancer.

powers? Many scientists (including us!) think so and have tried to increase their amount of flavonoids through either traditional plant breeding or genetic engineering techniques.

We recently made such a *genetically modified* (GM) tomato with increased antioxidant levels. Now we wanted to know if this tomato (or its extract) indeed has more cancer-fighting power. To do so, we tested its cancer fighting activity in our lab, and also compared the nature and amount of antioxidants in our GM tomato to that of regular tomatoes.

## Methods

First, we grew GM tomatoes and traditional tomatoes plants from seeds under the same conditions in a greenhouse. Later we picked the tomatoes and immediately froze them for use in our experiments. We then turned them into extracts that contained all their flavonoids. Finally, we exposed isolated breast cancer cells (Figure 2) to each extract (some of extract of GM tomatoes and some to that of traditional tomatoes) in test tubes (*"in vitro"*) to compare their cancer-fighting abilities.



**Figure 2:**  
Flasks with breast cancer cells.

We used three types of special equipment/technology to analyze the impact of each extract on cancer cells:

- 1) **Fluorescence microscopy:** cancer cells are stained with special colors that make them light up ("fluoresce") under a special kind of light under the microscope. That allows us to distinguish between live and dead cells.
- 2) **Flow cytometry analysis:** this technique helps us to detect a certain cell type with the help of a laser beam. The samples light up differently depending on what kind of cells there are.
- 3) **Gene expression analysis:** we isolated *RNA* as a measure of gene activity in cancer cells to understand better how our extract kills cancer cells.

Lastly, we ground up whole tomatoes of both types and analyzed their antioxidant content with two methods called *chromatography* and *mass spectrometry* (see glossary for more info) to identify which compounds might be helpful for fighting cancer cells.

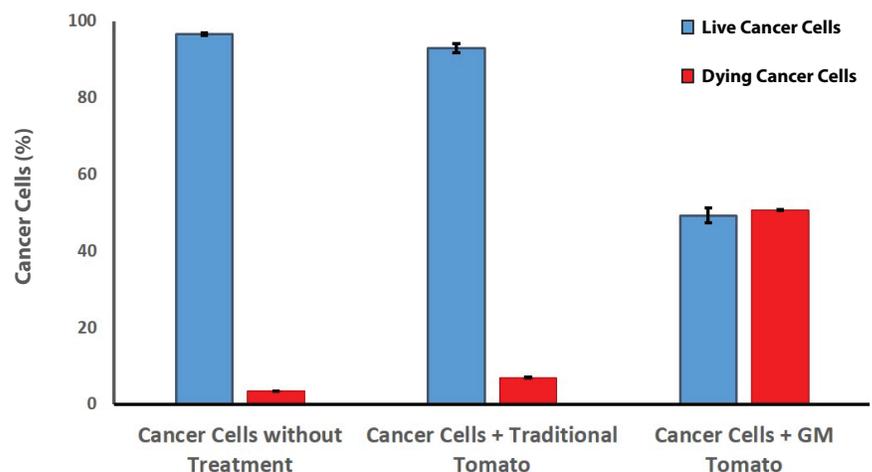
## Results

Our GM tomatoes contained 37%-50% more *phenolic compounds* (a group that also contains flavonoids) than the traditional tomatoes.

When exposed to breast cancer cells in test tubes, the GM tomato extract killed more cancer cells than the extract of

traditional tomatoes (Figure 3). We obtained these results both with the fluorescent microscopy as well as the flow cytometry method. The later one showed that extract of GM tomatoes killed up to half the cancer cells in our test tubes.

Which tomato extract had the highest cancer fighting power?



**Figure 3:**  
Death of breast cancer cells when exposed to traditional or GM tomato extract. The first bar is the control, so it shows the normal rates of cell death for cancer cells that are not treated with any tomato extract.

## Discussion

Tomatoes are great for our health because they naturally contain special compounds (antioxidants) that help fight diseases, including many cancers. Our GM tomato has even more of these beneficial antioxidants, and could be useful for cancer prevention, whether as a whole fruit or as an extract or food supplement. In fact, our lab experiments showed that the extract of our GM tomatoes killed more cancer cells than traditional tomatoes. We were even able to identify various compounds of our tomato extract that might be key players in cancer defense (for instance, Naringenin and Kaempferol).

Our gene expression analysis showed that the GM tomato extract had a different effect on the gene activity of cancer cells than the traditional tomato extract. The genes affected seem to involve the production of DNA and RNA in the cancer cells, which are crucial for their survival and multiplication.

Our research is a promising step in understanding the health benefits of certain food components. We need more research like ours to identify more of these compounds and what gives these compounds their cancer- and disease-fighting powers.

## Conclusion

Scientists and doctors have believed for thousands of years that certain foods are beneficial for our health. Now, with genetic analysis, we can prove that is true, and even show what exactly is happening when beneficial compounds from our food come in contact with harmful cells in our body. Fruits and vegetables especially are high in beneficial compounds

called antioxidants that can help fight cancer and other diseases. So next time you hear "Eat your veggies," don't just roll your eyes or ignore this advice. If you follow it, you'll stay healthier and happier in the long run. And now you can even quote current research like this one to explain what's going on!

## Glossary of Key Terms

**Antioxidants** – chemical compounds that delay some types of cell damage. They can be found in many foods, including fruits and vegetables.

**Chromatography** – a laboratory method of separating a mixture of different compounds (in our case, the antioxidants in our tomato extracts). The mixture is dissolved in a fluid called the mobile phase, which carries it through a structure holding another material called the stationary phase. The various constituents of the mixture travel at different speeds, causing them to separate.

**Flavonoids** – a group of chemical compounds in plants with many functions, including given certain plant parts like flower petals or fruits color. ("Flavus" means "yellow" in Latin). They act like antioxidants when consumed by humans.

**Genetic engineering** – the process of altering the DNA of genes.

**Genetically modified (GM) plant** – plant in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination. In our case, we modified tomatoes genetically to produce higher levels of antioxidants.

**Immune system** – a body's defense system against pathogens and other intruders. It consists of a network of cells, tissues, and organs that work together to protect the body.

**In vitro** – Latin for "in glass." It describes experiments done in test tubes (like our experiment of exposing our tomato extract to breast cancer cells). The opposite would be "in vivo" which are medical tests done in living organisms.

**Mass spectrometry** – an analytical technique that measure the mass of substances. We can then compare the mass with a database of masses of known substances to identify what we're looking at (in our case: antioxidants in tomatoes).

**Phenolic compounds** – a group of chemical compounds in plants that have a certain structure. Flavonoids also belong into this group.

**RNA** – short for RiboNucleic Acid, a nucleic acid present in all living cells. Its main role is to act as a messenger carrying instructions from DNA for controlling the synthesis of proteins.

## Check your understanding

1 What are antioxidants, and how can they help fight cancer?

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2 Can you think of other foods that contain antioxidants?

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3 What did the extract of our tomato do to cancer cells in the lab?

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4 What do you think – could you just eat lots of antioxidants supplements and lots of vitamins (rather than fruit and vegetables) to stay healthy?

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