

Are we All Transgenic?

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Abstract

Generally, society is resistant to the consumption of transgenic foods partly due to its fear of the unknown risks associated with these products. However, this aversion to the consumption of transgenic products is dismissed when technology adds immediate and palpable benefits to such a product. For example, a diabetic individual who consumes insulin produced by transgenic (TG) bacteria would hardly stop taking it, even though TG insulin has only been used to treat diabetes for less than two generations, and its long-term effect on human health is still unknown. The most serious problem is that a number of scientists also have an aversion to the term TG and to any product incorporating this technology, which is harder to understand. We all have the right to formulate our own opinions and preferences. However, when we express opinions as scientists, our preferences and beliefs should be set aside, so the evidence can be analyzed in light of the scientific method, preferably without ideological or subjective influences.

Keywords: Transgenic; Insulin; Diabetes; Precautionary principle

Introduction

Generally, society is resistant to the consumption of transgenic foods partly due to its fear of the unknown risks associated with these products. However, this aversion to the consumption of transgenic products is dismissed when technology adds immediate and palpable benefits to such a product. For example, a diabetic individual who consumes insulin produced by transgenic (TG) bacteria would hardly stop taking it, even though TG insulin has only been used to treat diabetes for less than two generations (about 35 years), and its long-term effect on human health is still unknown. The health benefit that this medicine represents is stronger than the so-called "precautionary principle". TG insulin is just one example, and this reasoning holds true for the vast majority of the drugs we consume, whether of biological or synthetic origin. The most serious problem is that a number of scientists also have an aversion to the term TG and to any product incorporating this technology, which is harder to understand. We all have the right to formulate our own opinions and preferences. However, when we express opinions as scientists, our preferences and beliefs should be set aside, so the evidence can be analyzed in light of the scientific method, preferably without ideological or subjective influences.

Natural Food: Utopia or Truth?

Let us return, then, to an already well-debated fact: there is no cultivated food that has not been genetically altered by artificial selection by humans. This is not a hypothesis or a supposition, it is a fact. Virtually nothing we buy at the supermarket or in "street fairs" was drawn from nature in its wild or natural form (with a few exceptions, such as wild fish and wild fruits, for example). With this in mind, we come to an obvious conclusion: humans have been altering everything they plant, breed, or eat for over 10,000 years, and the vast majority of the foods we eat have been genetically manipulated, at least by directed crosses and artificial selection. Some people claim we

"only" select what existed as natural variation, but they certainly forget (or do not know) that dozens of plant varieties on our kitchen tables were created by the induction of random mutations by artificial sources of radioactivity or chemicals from the 1950's to the present day. Yes, this (still current) practice has been carried out for over 50 years with minimal resistance [1].

Therefore, considering many facts that prove that practically everything we eat (planted or farmed) is modified by man, TG food aversion loses some of its power to persuade. Even so, many still continue to argue that transgenesis is not natural and therefore brings potential risks. This is not the appropriate forum to discuss the enormity of "unnatural" technologies that are part of our lives and whose potential to harm us in the long term (two generations, three, or four?) is not fully explored. In any case, we continue to use them, which in itself casts doubt on the practical usefulness of such a "precautionary principle". However, this is already a somewhat stale discussion that does not add anything new to the topic. Therefore, here we aim to discuss some new evidence arising from the latest findings. In 2001, the human genome was sequenced [2] and, over the last 16 years, we have seen overwhelming advances in DNA sequencing technology, which has allowed the entire genome of a vast variety of species to be rapidly sequenced. This astonishing technological improvement in DNA-sequencing has brought some unexpected insights to our comprehension of the genome's structure and evolution.

Are we Transgenic?

The more detailed knowledge about the structure of our genomes [3] indicates that transgenesis may be natural. To begin our discussion, we must review the concept of a transgene: "A transgene is a gene or genetic material that has been transferred naturally, or by any genetic engineering technique, from one organism to another."

In view of this concept, coming from a very popular source, let us look at a few observations: dissociation analysis and association by DNA hybridization show that a large fraction of our genome is composed of repetitive DNA [4]. Genome-wide sequencing of several

species shows that more than two-thirds of the genomes analyzed are composed of non-coding elements, which are DNA sequences that do not encode a polypeptide or protein sequence [3, 5]. This non-coding DNA (ncDNA) is mostly composed of repetitive sequences of the class of transposable elements (TE) or transposons [5,6]. Although the origin of TEs is not completely known, because of their similarity to some types of viruses, they are believed to have originated from the natural insertion of DNA from retrovirus into the genome of our evolutionary ancestor [7].

Other ways of incorporating DNA sequences from other species (horizontal gene transfer), which is nothing more than a form of natural transgeny, come from the symbiosis between the eukaryotic cell and prokaryotic cells. The origin of organelles, such as mitochondria and chloroplasts, is probably the result of the symbiotic interaction between eubacteria and primitive eukaryotic cells with the transfer of genes from bacteria to the eukaryotic genome [8,9]. Today, we know that more than half of the genes encoding mitochondrial and chloroplast proteins are located in our nuclear genome and plant genomes, respectively [9].

As well as the aforementioned symbiosis, another known relationship of parasitism is that of agrobacteria with the roots of numerous plants, with proven transfer of genes from the genome of the agrobacteria to the plant chromosomes [10]. The most surprising fact is that these viral and bacterial remnants appear to have functions in our cells, some of which are essential [10,11]. Therefore, not only is transgenesis natural, but it is also essential to our survival throughout evolution. Recently, a group of researchers [11] identified that not only do agrobacteria *A. Rhizogenes* naturally transfer a number of genes from sweet potato (*Ipomea* potatoes), which we consume in our daily lives, but also that these genes are active and produce messenger RNAs (mRNAs) in the roots of this tuber. This demonstrates that functional genes can naturally be transferred from a species of bacteria to a domesticated plant widely consumed around the world.

Therefore, according to the definition of TG, the sweet potato is a natural TG product and has been consumed by humans for over a thousand of years. This observation corroborates the findings of Barbara McClintock, who in the 1950s observed that more than 80% of domestic maize DNA is composed of transposable elements [12], with a probable viral origin [13]. This puts corn in the class of natural TG foods that have been consumed extensively over several millennia, well before the 1990's introduction of Bt-Corn (*Bacillus thuringiensis* corn) in our TG-crop menu [14].

Increasingly, genomic data support a scenario in which our genome behaves as an "ecosystem", in which several transgenic sequences combine over time to form new genomes and thus new species [13]. These facts challenge the fiercest and most compelling arguments against the consumption of TG foods by humans. After all, if most of what we eat is TG (evidence today is increasingly in favor of everything we eat), what kind of threats could man-made TG food

provoke beyond what we already have in the food we have been consuming for so many years? Indeed, if society had more access to the data we discussed here, would it be so adverse to the consumption of transgenic food?

We should have a more critical and realistic view of our positions, especially those with a scientific nature, before condemning any technology. After all, the lack of evidence is not in itself an argument, but ignoring the evidence is incomprehensible to a scientist.

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