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Symposium Introduction

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Human Health and Transgenic Crops Symposium Introduction

As far as we are aware, the topic of human health and transgenic crops is not one that has been the focus of a symposium, although there have been many publications related to this topic since commercial transgenic crops were first introduced in 1994 (Flavr Savr tomato). The transgenic approach to crop modification allows relatively rapid generation of desirable crop traits that in some cases are impossible to achieve by conventional breeding. The popular media have generated many reports that imply there are or may be health hazards associated with transgenic crops, despite the facts that these crops are highly regulated and have a strong safety record. Therefore, under the joint auspices of the Agrochemical and the Agricultural and Food Chemistry Divisions of the American Chemical Society, we organized a short symposium at the 244th National Meeting of the American Chemical Society, held August 19–23, 2012, in Philadelphia, PA, to examine an array of issues dealing with this general topic. The eight papers that follow in this issue of the *Journal of Agriculture and Food Chemistry* are based on some of the oral presentations from that symposium. These papers deal with currently grown transgenic crops, as well as transgenic crops with potential health benefits that might be grown in the future.

There has been wide adoption of transgenic plants/crops since the first commercial introduction in 1994 because of the clear economic benefits seen with their use.[1] There have been substantial environmental benefits of some of these crops. For example, the technology has resulted in reduced pesticide spraying by 393 million kilograms worldwide, thus decreasing the environmental impact associated with herbicide and insecticide use on these crops by 17.1%.[2] Herbicide-resistant crops have also reduced the need for tillage to manage weeds, resulting in less soil loss and less fuel consumption (reviewed by Cerdeira and Duke[3] and others). However, there has been no general review of the potential effects of transgenic crops on human health.

The first generation of successful commercial transgenic crops introduced was genetically modified for resistance to insects, plant diseases, or herbicides. These crops are being followed by transgenic crops with altered agronomic traits and improved nutritional or industrial value, such as improved drought stress and altered amounts or types of starch, oils, enzymes, or amino acids. We are now seeing transgenic plants being developed to produce traits for nonfood plants (such as switchgrass for biofuel production).

There has also been interest to alter the metabolism of plant secondary metabolites through transgenic approaches to increase the yield of or to introduce desired secondary metabolites for improved nutraceutical or aesthetic value. An example of this kind of effort is the study from our symposium by Chandler et al.,[4] in which successful engineering of the anthocyanin pathway was achieved, resulting in blue-colored carnations. These flowers do not naturally accumulate delphinidin-based anthocyanin, which is responsible for the blue/violet color in flowers and fruits, due to the absence of the gene encoding the enzyme flavonoid 3′,5′-hydroxylase (F3′5′H), which is critical for delphinidin biosynthesis. However, introduction of the gene encoding F3′5′H resulted in transgenic plants with blue/violet flowers. Chandler et al.[4] also obtained data to show that the transgenic flowers pose no environmental risk. Engineering the production of a class of secondary metabolites known as lignan is the subject of the review paper by Satake et al.[5] from the symposium. An example provided is the engineering of sesamin, a lignan in sesame seeds that is known to be hepatoprotective. Sesamin was produced using *Forsythia koreana* transgenic cells that were stably transformed with a sesame gene for the cytochrome P 450, CYP81Q, and an RNA interference sequence against an *F. koreana* endogenous lignan enzyme, pinoresinol/lariciresinol reductase. The production of sesamin was found to be increased under blue light.

Agrobacterium rhizogenes-mediated transformations using plant cells or whole plants have been commonly employed in the engineering of plant biosynthetic pathways to increase the production of desired phytochemicals. However, hairy roots, obtained through induction of genetically transformed hairy root phenotype, have emerged as a robust biotransformation platform, and use of hairy root culture transformation system has increased in the recent years. Hairy root cultures are preferred over plant cells, callus, and suspension cultures, due to genetic and biochemical stability and having the biosynthetic machinery of the differentiated parent plant.[6] Hairy root cultures can also be treated with elicitors to induce and enhance secondary metabolite production. One paper in this cluster, by Nopo-Olazabal et al.,[7] is an illustration of the use of hairy root culture to produce secondary metabolites. The authors report the establishment, for the first time, of hairy root cultures of muscadine grape and characterization of the mechanisms that affect the stilbenoid biosynthesis, accumulation, and metabolism in muscadine grape of stilbenoids, a group of natural compounds that have been demonstrated in numerous studies to have a multitude of biological properties beneficial to humans, as well as to plants. The authors report that resveratrol, piceid, and ε-viniferin were observed in the tissues, whereas piceatannol was found only in the medium. Higher levels of the stilbenes were obtained with methyl jasmonate treatment. This study showed that hairy root culture is a transgenic system amenable to study the biosynthesis of secondary compounds and can be a sustainable source of health-promoting stilbenoids.

Wenefrida et al.[8] wrote a review of mutational breeding and genetic engineering techniques to improve protein and essential amino acid contents in rice grain, encompassing studies over the past 50 years summarized into four approaches: (1) manipulation of seed protein bodies or fractions, (2) deregulation of certain biosynthetic pathways to overproduce essential amino acids that are limiting, (3) nitrogen relocation

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to the grain through the introduction of transgenes, and (4) exploration of genetic variance. The paper of Lakshman et al.[9] describes the *Agrobacterium*-mediated transformation of tobacco, *Arabidopsis*, and wheat plants to produce transgenic plants expressing the bovine lactoferrin gene. Lactoferrin is a milk glycoprotein known to exert broad-spectrum defense against bacteria, fungi, protozoa, and viruses in mammals. Transgenic plants or detached leaves are reported to have resistance against *Rhizoctonia solani* and *Fusarium graminearum*. The symposium paper by Abbas et al.[10] deals with the influence of transgenes for *Bacillus thuriengensis* (*Bt*) toxins in crops on the presence of mycotoxins such as aflatoxins and fumonisins in those crops. Some scientists, such as Wu,[11] have claimed that the decreased insect damage in these crops leads to less infection by mycotoxin-producing plant pathogens and, thus, lower mycotoxin levels. Abbas et al.[10] discuss their extensive work in this area, showing that the effects of transgenic *Bt* toxin on mycotoxins in these crops is complex, being influenced by the insect, plant pathogen, weather, and other factors.

Analytical methods are a critical part of studies concerning transgenic organisms, not only for the purpose of comparing transgenic and nontransgenic plants but also to monitor successful or failed transgenic events. The review paper of Natarajan et al.[12] discusses approaches for the analysis of soybean seed proteins, including proteomic techniques and mass spectrometry, to examine changes in seed protein profiles of transgenic soybeans. Analysis of soybean protein is useful in determining intended and unintended changes, especially for regulatory purposes.

The safety of transgenic crops, effects on human and animal health, and impact on the environment (such as changes in weed communities, gene flow, and evolution of resistance to pests) remain concerns. Long-term effects of using transgenic crops are still not entirely clear, although no scientifically documented health problems have arisen after almost 20 years of consumption of transgenic products. Herman and Price[13] of our symposium address some of the concerns in their review paper, concluding that "suspect unintended compositional effects that could be caused by genetic modification have not materialized on the basis of ... substantial literature" amassed over the past 20 years.

The few papers included here do not represent all of the papers presented at the symposium, nor do all of the papers of the symposium adequately deal with all of the human health issues related to transgenic crops that have been brought up. As the number and adoption of approved transgenic crops increase and the possibilities of this technology increase, the topic of human health effects of transgenic crops also expands. This relatively new technology offers potential human health benefits, as long as the technology is carefully and thoughtfully regulated.

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Notes

The authors declare no competing financial interest.

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