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Commentary on agricultural biotechnology

Produce-on-demand: What's good for US markets is good for world markets too

David Evans

The sad fact most opponents to genetic engineering neglect to address is that fruits and vegetables are programmed by nature to rot. There is a biological reason for this: Rotting is a seed-release mechanism that leads to the dispersal of the next generation. Unfortunately, these natural processes conflict with modern society's drive to provide its members with a consistent supply of fruits and vegetables that can survive passage through normal distribution channels.

The postharvest losses resulting from these diametrically opposed goals of humans and nature are devastating: In the US it has been estimated to be as large as 25% of the total crop production. Losses in developing countries are much greater.

The major rot-inducing culprit is ethylene—a small, well characterized hydrocarbon. Ethylene's damaging effects go beyond its effect on fruit aging: Increased toughness of asparagus spears, bitter flavor in carrots, yellowing of broccoli florets, softening and yellowing of cucumbers, sprouting of potatoes in storage, russet spotting of lettuce, and poor flavor in watermelons are all characteristic of ethylene's cumulative effects. A byproduct of this rotting process is the proliferation of pathogens such as *Botrytis* on strawberries and *Penicillium* on oranges.

If we agree that eliminating loses from ethylene damage and postharvest diseases is a laudable goal, biotechnology has the tools to address this problem. Because many of the genes associated with ethylene biosynthesis have been identified, the most plausible biotechnology-based attack point is either slowing ethylene biosynthesis through the degrading of intermediates, or reducing the fruit's sensitivity to ethylene. The genes associated with the control points for both these mechanisms are known.

The alternative to using biotechnological intervention is to harvest many commercial horticultural crops prematurely. Because fruit is harvested prior to the onset of fruit-specific ethylene, commercial food packers must add ethylene exogeneously. The citrus, banana, and tomato industries are all based on this principle. Tomatoes subjected to this process are the produce item that consumers complain about most often to the US Department of Agriculture (USDA, Washington, DC). The contrast between green "gassed" tomatoes shipped to market from Florida and tomatoes from backyard New Jersey is no doubt the reason that tomato consumption drops by 30% in New Jersey during the winter. Genetically engineered "ethylene-regulated" tomatoes, on the other hand, can be left on the vine longer—allowing the fruit to develop its full flavor before being sent to market. Preliminary market testing with ethylene-regulated tomatoes indicate that there is a substantial increase in household tomato consumption during the winter months when good-tasting tomatoes are made available.

Beyond the fact that ethylene-treated fruits are tasteless, this process can be directly correlated with practices that lead to substantial harvest losses. Because only unripe fruit is harvested, fruits that are beyond this stage are left in the field and never harvested. Similarly, tons of bananas are left on the docks in Honduras and tons of pineapples are left in the fields in Hawaii because they are "overripe." In contrast, fruit that is blocked in ethylene biosynthesis can be left in the field for a few more days before becoming overripe or can be stored for a longer time after harvest.

The widespread cultivation of ethylene-regulated fruits, then, will provide major economic benefits world wide. Not only will crop loss be reduced from ethylene-induced rotting and the associated disease, but the quality and taste of the product will be enhanced—ensuring a longer shelf-life. There is no comparison between a mango picked off a tree in Costa Rica and one bought at the local supermarket. In one sense, it is unfair advertising to call the product in our local supermarket a mango without qualifying that it was picked green before its 3500 mile trip.

As consumer appreciation and consumption of these genetically engineered products increase because of their uniformly high quality, two other positive effects will result: First, a stable market will help promote the year-round integration of these foods into the Western diet. A number of reports have shown that a low-fat, high-fiber, high-vitamin diet—characteristic of fresh fruits and vegetables—reduces the incidence of cancer and heart disease. The National Cancer Institute's (Bethesda, MD) 1991 baseline study indicated that the average US consumer falls 1.5 servings per day short of the recommended consumption of fruits and vegetables. In addition, fruits that are rare and expensive because of their short shelf-life could become viable products through genetic engineering.

Second, because many tropical fruits are shipped to the US as unripe fruit only, their expense and poor taste never allow them to reach their economic potential. Papayas, novel bananas, pineapples, and mangoes are all examples of this problem. Genetic engineering of these fruits should open exciting new markets for these crops, grown in developing countries. For example, Charentais melons—a delicious fruit rarely found in the US—could certainly have a major market impact if delivered with the quality and flavor experienced locally.

While ethylene-regulated Charentais melons will not single-handedly increase produce consumption, anything that improves the taste, availability, and variety of produce for the US consumer should have an overall positive impact on the citizens of the world's health and wealth. ///

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