Evaluating the Relative Safety of Biotechnologically Produced Foods

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There was a time when food safety was a relatively concise discipline. In those halcyon days, foods were considered safe unless eating them made one ill. People based the selection of their daily fare on fondness, not fear. But times have changed. Today, many people eat to prevent disease, especially chronic diseases such as atherosclerosis and cancer. Food safety has come to encompass much more than the prevention of foodborne illness.

1 recently heard a lecture by one who tends toward zealotry on the subject of nutrition. He charged that our food supply is *inherently unsafe* because of its composition. The enthusiast of whom I speak happens not to like fat very much—nor salt, nor meat, nor a host of other things including the cooking practices Americans routinely use, and he blamed all of this for causing cancer, heart disease, or both.

Now I happen to support the notion of eating a well balanced diet in moderation. But there is no reason to be an extremist on the topic. Moreover, it seems self-evident that a nation blessed with the world's largest and most diverse supermarkets cannot, at the same time, suffer from a compositionally unsafe food supply. That is, unless every single food is unsafe—and if such is the case, one might wonder why the Social Security system is in so much trouble. But regrettably the unsafe food charge is heard again and again, and it is having an effect. An effect, I would argue, that is not particularly healthy.

Continual harping from some quarters about the supposed "unsafeness" of the traditional food supply -

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be it too much saturated fat or too many pesticides - has eroded public confidence in its own institutions like the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA), as well as trust in the food industry, and even the pronouncements of academic scientists. (That last hits too close to home.) The simple fact is that every person in this room who wishes to market a novel food is affected by a malignant climate of mistrust that pervades the land. If the public worries about the safety of the traditional food supply, it will worry ten times more about the safety of new foods.

So we really have two tasks: convincing ourselves that a novel food is safe, and then convincing the public that it is safe. I will address the former task.

It is essential that the burgeoning food biotechnology industry develop a firm grasp of the scientific data base underlying food safety. Additionally, the scientific data base must not be confused with, or dismissed because of, concerns raised in the context of arguments that really center on non-scientific matters. I am thinking here of economic or political issues where food safety may be inappropriately raised in an attempt to bolster a particular point of view. A good example is the furor in Wisconsin over the use of bovine somatotropin.

Table 1 shows a ranking of food safety concerns. It was developed by FDA in the mid-70s. According to FDA, the most important food safety hazard is microbial contamination. This conclusion is based on tangible evidence, not theoretical possibilities. Foodborne pathogenic microorganisms and their toxins cause substantial amount of illness and economic loss (Archer and Kvenberg, 1985; Todd, 1985).

Table 1 FDA Ranking of Food Safety Priorities

1. Microbial Contamination
2. Nutritional Imbalance
3. Environmental Contaminants
4. Naturally-occurring Toxicants
5. Pesticide Residues
6. Food Additives

(Schmidt, 197$)

Next in line from microbial contamination is nutritional imbalance. By this the FDA means two things. First are the crazy, dangerous diet plans that many Americans are lured into trying each year. Serious illness and even death is a tragic, but well documented, by-product of such ill-advised personal experimentation. But in addition to this there is also the general problem of poor eating habits, in particular gluttony, which when combined with the lack of physical activity can compound a genetic tendency toward certain chronic diseases. An outcome of poor eating habits and too little exercise is obesity with its clear link to heart disease, diabetes, and some forms of cancer. Unfortunately obesity affects too many Americans.

In contrast to microbiological contamination and nutritional imbalance—risks for which clear and unequivocal scientific evidence certainly exists—there are only theoretical calculations for the possible adverse effects of environmental contaminants, naturally-occurring contaminants, and pesticide residues. One of the most comprehensive scholarly reports in the peer-reviewed scientific literature to address this issue—an epidemiological report published in 1981 by Sir Richard Doll and Richard Peto—estimated that the cancer risk associated with these sources is extremely small. And as for food additives, there is no evidence that they are harmful under the intended conditions of use. To the contrary, some additives (e.g., antioxidants) actually protect against cancer in animal experiments and may also reduce cancer risks in humans (Ames, 1983; CAST, 1987).

Given all of this, one might imagine a slightly different depiction of this table. Table 2 is the expert's view of food safety. It comes closer, but still does not do the situation true justice. Indeed, if microbiological concerns were set at, say, a million, then food additives would be "worth" at most one, if that much.

Table 2 Proportional Representation Of Food Safety Issues

Table 2 is based on science, and anyone who takes the time to become familiar with the scientific data is bound to concur. Unfortunately, the public inverts this ranking believing that the last three are major causes of human health problems. It is going to take a lot of education to straighten this mess out, made all the more challenging because of the cries from those who intentionally distort food safety issues for reasons that are not at all related to food safety or science.

But let us go back to hurdle number one—convincing ourselves that a new food is safe. How can the information in this table be applied to that?

First, let us talk about *microbiological issues.* In general, foods derived through biotechnology will not carry greater risks of contamination with pathogenic microorganisms or microbial toxins than do conventional foods. In this regard it is worth reviewing the factors that control microbial growth in food: pH, type and concentration of acid, water activity, the concentration of sodium chloride and other electrolytes, the availability of nutrients and growth factors, and the levels of microbial growth inhibitors. Any change in the composition of a food that affects one or more of these factors will influence the chances of that food becoming a vehicle for foodborne illness (Pariza, 1990).

For example, most varieties of tomato exhibit a pH value no higher than 4.5 which is sufficiently low to preclude the growth of pathogens such as *Clostridium botulinum,* the causative agent for botulism. However, the pH of some tomato varieties is above 5, clearly too high to prevent the growth of *C. botulinum* and many other pathogens (Powers, 1976). Hence, foods prepared with high pH tomatoes may have to be handled differently than foods prepared with conventional tomatoes. It is very important to keep this sort of thing in mind when developing low acid varieties of fruits and vegetables.

A second consideration is the intentional removal of a microbial growth inhibitor. For example, one might imagine some bright geneticist coming up with the idea of intentionally removing genes involved in caffeine synthesis from coffee plants. The development of such a "naturally" decaffeinated coffee bean might be desirable for a variety of reasons including making the marketing department happy. But it could also have a down side. Caffeine is reported to be an effective suppressor of aflatoxin biosynthesis by certain toxigenic molds (Nartowicz *et al,* 1979). Hence, coffee beans without caffeine could be at greater risk for contamination with aflatoxin, which is a potent carcinogen in laboratory animals.

Another potential problem could arise from the intentional introduction of a new nutrient into a food plant. Suppose, for example, that the nutrient should happen to be a required growth factor for a particular pathogen. Suppose further that the pathogen does not now grow in the traditional food because that nutrient is lacking. The conclusion is that some other means will now have to be found to control the pathogen in the new food containing the nutrient.

Fortunately there are bright sides too. Biotechnology has great potential to aid in controlling the contamination of food by some microbial toxins. A case in point is a project in my department aimed at preventing aflatoxin production in the field, thereby controlling this mold-generated carcinogen at the source. Later this year we hope to begin testing the idea in the controlled environment of our Biotron.

There is also a big future for biotechnology in the development of special foods for persons with special medical problems (e.g., peanuts minus the major peanut allergens) foods for those who must avoid certain other dietary factors, and so on.

The next major issue on FDA's list is *nutritional imbalance,* which includes poor eating habits. An important consequence of poor eating habits is obesity which is linked to increased risk of several chronic diseases including diabetes, heart disease, and cancer. One of the most important contributing factors in obesity is the excessive consumption of dietary fat (Pariza and Simopoulos, 1987; CAST, 1987). Biotechnology can certainly help here, through the development of new lower fat animal and plant based foods.

There is also a big future for biotechnology in the development of special foods for persons with special medical problems, (e.g., peanuts minus the major peanut allergens), foods for those who must avoid certain other dietary factors, and so on. One must also be careful about understanding the nutritional role of traditional foods in the diet. For instance, it would be unwise to inadvertently reduce the vitamin C content of an orange while in the process of introducing other changes.

With regard to *environmental contaminants,* it is difficult to imagine biotechnology contributing to the problem. But one can easily envision engineering microorganisms, for example, that are able to efficiently degrade industrial waste products.

Naturally-occurring contaminants represent a potential focus of concern. It is well known that some food plants produce potentially toxic substances, some of which are involved in protection against insects (Ames, 1983; NAS 1973). Obviously in developing new plant foods, the level of

naturally-occurring toxic constituents that may be hazardous to humans should not be increased either through direct introduction of relevant genes or through an unintended pleiotropic effect, that is, a secondary phenotypic alteration resulting from a single genetic change (Tiedje *et al.*, 1989). In this regard one should investigate new food plants developed by biotechnology for increased levels of naturally-occurring toxicants known to be associated with the species.

Biotechnology offers opportunities for reducing *pesticide* dependence through the introduction of naturally-occurring pesticides that exhibit limited host range and are also biodegradable. An important example is the introduction of the gene for *Bacillus thuringiensis* toxins into food plants such as tomatoes and corn.

Finally, on the list is *food additives,* long the bane of the so-called consumer movement. It is worth recalling that food additives are used because they have important beneficial effects— effects which are not clearly articulated for the public as they might be. Among these effects, for example, is the control of microbial pathogen growth in food. Prospects for the production via biotechnology of safe and effective antimicrobials for addition to food is an area of particular interest in my department. There are, of course, many additional opportunities for the use of biotechnology in the manufacture of antioxidants and other beneficial products.

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