16

Demand Enhancement through Food-Safety Regulation: A Case Study of the Marketing Order for California Pistachios

Julian M. Alston, Henrich Brunke, Richard S. Gray & Daniel A. Sumner

The U.S. pistachio industry, which is located almost exclusively in California, has experienced phenomenal growth over the past thirty years. The value of U.S. production of pistachios grew from nearly zero in 1976 to $333 million by 2002. The U.S. share of the rapidly growing global pistachio industry has also increased. Outside California, the main pistachio growing region is the Middle East, including Turkey and particularly Iran.

In recent years, a group of California pistachio growers led an initiative to establish a federal marketing order that would mandate quality standards and establish an inspection program to assure consistency in the quality of California pistachios. The main provisions of the marketing order set standards and require testing for quality and for aflatoxin, a cancer-causing mold found in many nuts and grains. Proponents argued that the marketing order would increase consumer confidence and reduce the chance of an aflatoxin event in the pistachio market, thereby stimulating demand and enhancing consumer benefits and producer returns. Hearings were held in 2002. In early 2004, the proposal was supported by more than 90 percent of the growers who voted, and the marketing order is scheduled to take effect in February 2005.

This chapter begins with some brief background on the California pistachio industry and food-safety issues that led to development of the marketing

order. We then discuss the economic rationale for industry's collective action and the process and requirements for establishing a new marketing order. These aspects have much in common with other collective-action programs discussed in other chapters of this book, but there are some differences, and the fact that this is a new program provides an opportunity to examine the issues and costs that arise when a program is introduced—aspects that are often (sometimes appropriately) ignored when discussing the economics of collective-action programs of long standing.

The mandated quality-assurance and food-safety program for pistachios shares many elements with mandated generic commodity promotion programs. Both are funded by check-offs. Those assessments are borne by both producers and consumers in proportions that depend on quantities of the good produced and consumed and on elasticities of supply and demand. In both cases the primary purpose is to enhance producer returns by stimulating demand.

There are, however, important differences. In particular, commodity promotion programs are supposed to enhance demand every year so that their benefits are experienced for the most part during the time period when the cost of the check-off is incurred. Hence, the criterion for a program's effectiveness is whether its year-by-year benefits more than offset corresponding year-by-year costs. The pistachio marketing order, on the other hand, involves a cost borne every year for a program that aims to reduce the odds and severity of a major negative shock to demand posed by an aflatoxin outbreak in some future year. The criterion here involves comparing year-by-year costs with the expected benefits from changes in the odds of an outbreak and in its severity as an episodic, major negative shock to demand. Consequently, rather than evaluate benefits and costs in a typical year, the marketing order for California pistachios is best evaluated by a comparison of the expected values of costs and benefits over many years. Our analysis of the pistachio marketing order, therefore, involves a stochastic dynamic simulation rather than the more typical comparative static analysis.

The California Pistachio Industry

World production of pistachios has expanded rapidly during the past twenty years, and U.S. production has increased as a share of that growing total.[1] Iran is still the world's largest producer, but the United States is established as the second largest pistachio producer in the world (followed by Syria and Turkey)

and is now also the second largest exporter after Iran (California Pistachio Commission 2004).[2]

Almost all U.S. pistachios are produced in California.[3] California's production has increased more than 200-fold since 1976, when the first commercial crop of 1.5 million pounds was harvested. California produced a record crop of 302 million pounds in 2002, up from the previous record of approximately 242 million pounds in 2000.[4] Table 16.1 presents time-series data on the industry. The longer-term trends show steadily growing acreage, yields, quantities, and value of production and corresponding downward trends in price with important fluctuations around those trends. California has also steadily expanded its exports as a share of world trade and of production.

Total California pistachio acreage grew from 34,726 acres in 1980 to 106,000 acres in 2002. Normally, it takes a pistachio tree seven to eight years to mature before it produces an economically significant crop and twelve to fifteen years to reach full potential. Bearing acreage in 2002 was estimated by the California Agricultural Statistics Service (CASS) to be 83,000 acres, up 222

Table 16.1. Data on California Pistachio Area, Production, Yield, and Value, 1980–2002

Year	Bearing Acres	Nonbearing Acres	Production in Million Pounds	Yield in Pounds per Acre	Value in Million Dollars	Average Return in Dollars per Pound
1980	25,773	8,989	27.2	1,055	55.8	2.05
1985	32,332	18,739	27.3	838	36.6	1.37
1990	53,700	11,100	117.3	2,375	129.6	1.02
1991	55,700	13,300	76.4	1,465	100.7	1.25
1992	56,500	13,900	146.5	2,592	150.9	1.03
1993	57,000	15,700	150.9	2,648	161.5	1.07
1994	57,507	16,633	128.3	2,232	118.1	0.92
1995	60,300	13,400	147.7	2,449	160.9	1.09
1996	64,300	17,100	104.3	1,622	121.0	1.16
1997	65,373	17,062	179.5	2,746	202.9	1.13
1998	68,000	19,300	187.5	2,757	193.1	1.03
1999	71,000	21,000	122.4	1,724	162.8	1.33
2000	74,578	21,730	241.6	3,239	239.2	1.01
2001	78,000	23,500	160.3	2,055	166.7	1.01
2002	83,000	23,000	302.4	3,644	335.7	1.11

percent from 25,773 bearing acres in 1980. The growth in area and production has been steady for the past twenty-two years and is expected to continue. Nonbearing acreage reached 23,000 acres in 2002 (CASS 2002). The value of the crop varies with the quantity produced. The long-term trend is increasing quantities and increasing value of the crop but falling returns per pound, reflecting the fact that supply has been growing faster than demand. The trend for the past twenty-two years in price per pound (even in nominal terms) has been gradually downward—the price has fallen from the high in 1980 of $2.05 a pound to $1.11 per pound in 2002.

In 2002, California had approximately 650 pistachio producers. There is a single pistachio producer cooperative and nineteen handlers who process pistachios. About 70 percent of California pistachio producers produce less than 100,000 pounds per year; 21 percent produce more than 100,000 and less than 500,000 pounds; and about 9 percent produce more than 500,000 pounds. Based on an average grower price of $1.10 per pound, about 91 percent of California's pistachio producers generate less than $550,000 in annual revenue and 9 percent generate more than $550,000 annually. About 85 percent of California pistachio handlers handle less than ten million pounds per year and about 15 percent handle more than ten million pounds per year. The largest handler processes about 50 percent of the industry's total production.

The California Pistachio Commission (CPC) was organized under the supervision of the California Department of Food and Agriculture (CDFA). It is distinct from the committee that will be responsible for administering the terms and provisions of the marketing order. The CPC began operation in 1981 to provide support through public relations, government relations, marketing, and production research and is funded by an assessment of $0.035 per pound of pistachios produced in California. The CPC also receives funding under the U.S. Department of Agriculture's (USDA's) Market Access Program—an average of about $800,000 per year from 1997/98 through 2001/02 (USDA Foreign Agricultural Service 2003). In 2002/03, CPC spent almost $9 million, more than $6 million of which went to promotion (Carman and Alston, this volume). Details on the CPC's history and activities can be found at its website, *www.pistachios.org*.

Food-Safety Issues and Aflatoxin in Pistachios

Aflatoxin is the main issue behind the creation of the marketing order for California pistachios. An event of aflatoxin poisoning in pistachios or some other

product—even simply concern about the possibility of such an event—can adversely affect demand.[5]

Many produce-related food scares have occurred in recent years. For the period from 1990 to 1999, the Center for Science in the Public Interest (CSPI) lists fifty-five cases in the United States alone. A recent produce-related food scare involved cantaloupes and *Salmonella* in 2000, 2001, and 2002. *Salmonella* had infected several people in the United States and Canada and, in response to potential health risks, certain cantaloupe brands were recalled nationwide (U.S. Department of Health and Human Services, Food and Drug Administration 2003). In 1996, the California strawberry industry lost an estimated 5 percent of total revenue due to a *Cyclospora* scare (see Chapter 14; details can be found in Calvin 2003). An earlier, well-known event demonstrating the public's sensitivity to food safety was the 1989 Alar scare associated with apples. A television broadcast reported that Alar was used in apple production and that it was "the most cancer-causing substance in the food supply." Apple demand dropped dramatically overnight, and apple growers suffered losses estimated at hundreds of millions of dollars (details can be found in van Ravenswaay and Hoehn 1991).[6]

The main event that directly related to pistachios occurred in Europe. Iranian pistachio imports were banned by the European Union (EU) in September 1997 because the country's shipments exceeded allowed levels of aflatoxins (*The Economist* 1997). The ban lasted nearly three months and was lifted in December 1997 (European Commission, Food and Veterinary Office 1998). However, demand for pistachios was affected for a longer period. The United Nation's Food and Agricultural Organization (FAO) (2003) presents data showing that aggregate imports into the EU, including those from the United States, the main alternative source of pistachios, dropped from 102,698 metric tons in 1997 to 59,619 metric tons in 1998 (about 40 percent for the year).

In 1997, when imports were curtailed by the ban, Germany imported 47,494 metric tons of pistachios worth $175.3 million (FAO 2003). The average for the preceding five years (1993–1997) was 43,459 metric tons per year (FAO 2003). In 1998, Germany imported only 18,937 metric tons, just 40 percent of the quantity imported the previous year. German imports during the next two years were also well below 1997 quantities. Imports were 27,059 metric tons in 1999 and were only 25,090 metric tons in 2000. The value of the imports fell to $78.9 million in 2000, or just 45 percent of the value in 1997. This drastic and protracted reduction in imports after the ban was lifted points to a decrease in consumption, perhaps resulting from negative public-

ity regarding the ban in the media. In 1999, *Oeko-Test*, a German consumer report, sampled pistachios from German supermarkets and found that aflatoxin levels in eight of eleven samples were higher than allowed and that the highest levels were in California pistachios.

In the years since 1997, shipments of pistachios have exceeded maximum aflatoxin levels on several occasions and in several countries, making news worldwide. In 2000 in Germany alone, several articles were published in national (*Der Spiegel* 2000, *Süddeutsche Zeitung* 2000) and regional newspapers following discoveries of high aflatoxin levels in pistachio ice cream. Aflatoxin problems have continued to appear worldwide. For example, recalls based on high aflatoxin levels in pistachios occurred recently in Australia and in February 2000 in Japan. Retailers were concerned about pistachios from Iran and California. Also in 2000, testing in France found high levels of aflatoxins.[7]

The central argument for establishing the marketing order was that collective action or government intervention was required to raise and assure the actual and perceived quality and safety of California pistachios given the potential for free-riders, an argument that we develop in detail later. The marketing order states that no handler shall ship for domestic human consumption pistachios that exceed an aflatoxin level of fifteen parts per billion (ppb).[8] An aflatoxin-inspection certificate must cover all domestic pistachio shipments. The marketing order further outlines procedures for aflatoxin testing that are necessary before an aflatoxin inspection certificate can be obtained. The aim is to be able to trace every certified lot of an individual handler from testing through shipment. Certification by an accredited laboratory would assure that every lot of California pistachios shipped to the domestic market meets requirements and does not exceed proscribed aflatoxin levels.

Rationale for Collective Action in Pistachio Markets

Mandated collective-action programs like the CPC and the federal marketing order for California pistachios use the coercive powers of the state or federal government to oblige individual producers to participate and contribute assessments. The programs are voluntary in the sense that their establishment requires the support of a sufficiently large majority of producers, but they do not require unanimous support and consumers, who bear a portion of the costs, do not have voting rights. Unlike truly voluntary collective-action programs, such as cooperatives or clubs, once established, these programs are mandatory for all producers of the commodity in the defined area.

The conventional economic justification in principle for use of the government's taxing and regulatory powers in this fashion to create mandated collective action programs is that there are collective goods within the industry—research, promotion, grade standards, packing regulations, public relations, and the like—that would be undersupplied otherwise.[9] In practice, whether the pistachio marketing order will yield net benefits to producers, consumers, the state, and the nation will depend on the nature and extent of the "public-good" or "external" costs and benefits associated with its minimum quality standards, mandatory testing for aflatoxin, and other provisions, and on the private cost of implementing the program.

The various regulations under the marketing order offer different types of public-good characteristics, of which some are more easily justified than others. Standardized grades and packaging have public good characteristics in that they reduce transaction costs (e.g., see Freebairn 1967, 1973). An argument for quality regulation can be made when quality is not easily distinguishable prior to purchase and the market can be spoiled as a result of distortions in incentives for producers and marketers to provide and communicate accurate information about quality (e.g., Akerlof 1970). The public-good element is that consumers who experience a particular quality of pistachios from one supplier carry that experience over to their relationship with other suppliers. Especially in the case of a food-quality issue, bad experiences associated with any pistachio producer are likely to have a large, long lasting impact on the whole industry, but individual producers will not take the industry-wide consequences of their actions entirely into account.

Regulations regarding visual standards—freedom from blemishes or minimum size regulations, for example—are generally not as easy to justify on the grounds of public goods since they relate to aspects of quality that are not hidden from consumers. Such regulations may provide *de facto* supply control by diverting some of the volume of the product to nonfood uses altogether or *de facto* price discrimination by diverting a larger proportion of the crop to the processing market, which has a more elastic demand response.[10] One rationale for minimum quality standards for pistachios, however, is that aflatoxin is more often found in small and damaged nuts and eliminating those nuts from the market is consequently an indirect way of reducing the risk of aflatoxin.

Maximum aflatoxin standards and inspection and certification have a food-safety role as well as a collective-good element for the industry because aflatoxin is a serious and in some cases deadly poison. However, the standards of the marketing order are in addition to and tighter than those already estab-

lished by the U.S. government for food safety (but not as tight as standards applied elsewhere, such as in Europe).

An industry-wide food-safety issue could arise as a result of evidence of death or illness associated with consumption of pistachios containing aflatoxin with consequences for demand for pistachios in general rather than simply for firms directly responsible for incidents. As a result consumers may choose not to purchase products, retailers may choose not to stock a product that might be subject to recall or lawsuits, or governments may choose not to allow products to be sold because of heightened concerns over food safety. The same type of market problem could arise without a case of actual food poisoning. It could result from an actual aflatoxin event where levels of aflatoxin are detected that exceed the twenty parts per billion allowed by the Food and Drug Administration. Negative perceptions could also result from adverse attention to aflatoxin even if no excess amounts were discovered. For instance, there may be adverse effects on the pistachio market from the perception of a threat based on adverse publicity associated with excessive levels of aflatoxin in other products in the United States or anywhere else in the world.

Perceptions of a food-quality problem are not specific to individual suppliers; they affect the industry in a collective way. Therefore, the private incentive to assure high-quality nuts that are perceived as safe does not reflect the full industry-wide or public benefit of these actions. In such cases, voluntary actions motivated by private incentives provide less safety and quality assurance than is in the interest of the industry (and, perhaps, the general consuming public). In this case, each farm and firm benefits from a strong reputation for pistachios in general but the individual farm or firm cannot single-handedly assure such a reputation. Consequently, individual farms and firms have a private incentive to keep their direct costs low and invest less in safety testing and quality assurance than would be optimal from the view of the whole market. This is a free-rider problem in which individuals cannot be precluded from sharing in the benefits even when they fail to contribute, and one individual benefiting from the better collective reputation does not preclude benefits to others.[11]

Two characteristics of the pistachio market make public-good concerns particularly important in the context of food-safety assurances and quality standards. First, as with many fresh fruits and nuts, pistachios have little established brand identification. Thus, a customer who has a poor experience with a purchase of pistachios or who hears negative news about their safety is unlikely to associate it with a specific brand or supplier. Unlike branded,

packaged consumer items, any negative news about a largely unbranded item affects the industry at large. Second, many pistachio purchasers consume the product infrequently, purchase relatively small quantities, and know relatively little about pistachios. One would therefore expect a strong reaction from the industry to an aflatoxin event in pistachios compared with a similar event for a more familiar food, especially in the context of food-safety concerns. The wholesale trade would be even more sensitive to an event if a recall were necessary. Consequently, the pistachio industry has strong reasons in principle for acting collectively to assure industry-wide compliance with quality and food safety standards. But this is only an in-principle case. Whether collective action of this type can provide net benefits to the industry also depends on how effective the program is in reducing either the likelihood of a food scare or its severity and on the costs of the program.

The Form of Intervention and the Distribution of Costs and Benefits

We have discussed potential public-good arguments that apply to food safety and to pistachio inspection and testing. However, we should consider the alternative approaches to food safety and the potential public good associated with food standards.

First, despite the public-good aspects noted previously, individual consumers, marketers, processors, and farms have strong incentives to avoid harm from aflatoxins. Even if information is costly for individual consumers, under current market conditions, reputable marketing firms have an incentive to establish monitoring programs and to deal with suppliers they trust. Suppliers also have incentives to maintain their reputations for reliably safe products. The market-based approach to food-safety concerns is for marketers and suppliers to establish testing and monitoring programs of their own. This would facilitate their ability to assure consumers of the safety of products purchased from their outlets. Indeed, competition over traceability and reliable food safety may yield higher food standards than those established by the government. A market-based approach would allow more producer flexibility and more choice on the part of retail buyers. The fact that this approach has not been implemented for pistachios could simply mean that the anticipated private benefits are less than the costs.

At the other end of the spectrum, the government sets mandatory food-safety standards for many products, including pistachios. These standards can be enforced with mandatory and continuous government inspection like that which occurs in meat-packing plants. In the case of pistachios, current

government standards for maximum aflatoxin levels are less restrictive than the limits proposed under the marketing order. Furthermore, the government standards are not enforced with any mandatory inspection or other active program. If aflatoxin were considered a major health threat, the standards could be lowered via regulation and an active mandatory inspection procedure could be implemented without an industry-sponsored marketing order. Evidently, interest in such programs has not been strong enough to stimulate legislation or new regulation.

Under the middle approach of an industry-sponsored program requiring active consent by a majority of firms, a majority of producers must expect a net benefit, but there may still be differential benefits and net losses by some. For example, branding is becoming more prevalent in the industry and product differentiation may become more difficult when the marketing order creates generic standards. If this were important, we would expect firms that are working to establish brand identities to resist the marketing order. In fact, however, large producers and processors that are most actively pursuing branding were leaders of the committee proposing the marketing order.

Distributional differences may arise from differences among firms in the costs incurred in meeting the higher standards or in testing. This issue was investigated during development of the marketing order and no evidence of differential costs was found. The argument is that higher safety standards could disproportionately impose additional costs on operations with less fixed investment in an industry since such firms have more elastic supply functions (especially for downward shocks) and less to lose from food-safety events that cause a downshift in demand. This argument seems relatively weak when applied to the pistachio industry, where trees require many years to reach maturity and most of the acreage is relatively young. Furthermore, much of the industry's processing capacity is relatively new. In the hearing process, which we discuss next, there was no active resistance to the marketing order from any segment of the industry.

Development of the Marketing Order for California Pistachios

USDA's Agricultural Marketing Service (AMS) specifies how an industry should proceed to establish a federal marketing order. First, after identifying mutual marketing problems, a steering committee of key industry members submits a preliminary proposal to USDA. This proposal should indicate the degree of industry support and the problems the program would address. Second, a request for a hearing on the proposal must be submitted that in-

cludes a proposed hearing site and approximate date. The hearing is presided over by a USDA administrative law judge, and a verbatim record is compiled of the testimony of opponents, proponents, and others. Third, the proponent group bears the burden of proof and must therefore present evidence in support of the need for the program. In addition to evidence of its benefits to the industry and consumers, a positive ruling generally requires evidence that the proposed marketing order will not disadvantage small businesses (producers, processors, or marketers) and generally has widespread support. Fourth, based on the evidence from the hearing, USDA issues a recommended decision and then, after allowing time for comment, a positive final decision by USDA allows the proposed order to be put to a grower referendum. Finally, at least two-thirds of the growers voting by number or by volume must approve the proposal before the secretary of agriculture can issue the marketing order.

The pistachio industry spent several years preparing to submit its proposal and succeeded in making its case to USDA. In July 2002, hearings were held in Fresno, California, on the proposal to establish a federal marketing order for pistachios grown in California. The stated objective of the program was to enhance grower returns through delivery of higher-quality pistachios to consumers.[12] Hitherto, industry quality-control practices have been limited to voluntary testing for aflatoxin and other quality requirements under the California Pistachio Marketing Agreement, which was entered into by a number of pistachio handlers under the authority of CDFA. The agreement has been limited to issues relating to blending of artificially and naturally opened pistachios and with bleaching pistachios. Under this agreement, aflatoxin testing and sampling guidelines were used only for exports to specified countries.

The proposed federal marketing order sets standards for the quality of pistachios produced and handled in California by establishing a maximum aflatoxin tolerance level, maximum limits for defects, a minimum size requirement, and mandatory inspection and certification. These standards will apply solely to pistachios from California that are marketed in the United States. An eleven-member committee consisting of eight producers, two handlers, and one public member will administer the program, which will be financed by assessments on handlers of pistachios grown in the production area.

The two-day hearing in Fresno in 2002 featured written submissions and oral testimony from growers, processors, and other industry members. The proponent committee retained experienced legal council to put together a case for the positive net benefits from the marketing order and to satisfy all of the legal specifications required under USDA regulations. The proponents'

case included testimony by food-safety experts so that the health aspects of aflatoxins and the usefulness of the testing regime could be established in the hearing record and so the hearing judge and USDA officials could ask questions. Economic testimony and responses to questions by USDA were used to establish the argument that the proposed order would benefit producers and consumers and not unfairly burden small businesses. Overall, the process required hundreds of hours from proponent committee members and is likely to have cost hundreds of thousands of dollars in legal fees and related costs.

After the hearing, USDA took more than a year to study the record and prepare its positive preliminary recommendation. Based on evidence contained in the hearing record, USDA found that the proposed order met the requirements that it would have a net benefit for the industry and also benefit small firms. After the hearing, the proposed order was recommended by AMS and released for comment in 2003 and a grower vote in 2004. Results of the vote were announced on March 1, 2004. AMS reported that valid ballots representing 338 California pistachio producers were cast. Of those voting in the referendum, 90.8 percent favored establishing the order (these voters represented 90 percent of the total volume of production). Overall, the process took more than three years from beginning active preparation to approval. The order is scheduled to take effect in February of 2005.

A Model of the Industry and the Impacts of the Marketing Order

We developed a multiperiod, stochastic dynamic-simulation model and used it to simulate markets for California pistachios and project production, prices, and allocation of pistachios for fifty years, beginning with the year 2000. Yields vary over time as a reflection of alternate bearing and random influences. Aflatoxin events also occur at random. In our model, both the probability of an event and the severity of the demand response to a given event are lower in the case in which the marketing order is in place. For each "draw" of a time series of future yields, we simulated the outcomes for economic variables in the industry with and without the marketing order. By considering one hundred draws of future time paths of yields, we were able to estimate the effects of the marketing order on variables of interest, represented by both average values and the range of values for the variables (or other measures of variability).

We specified equations representing domestic and export demands for pistachios, including storage demand, using estimates of elasticities and data on market shares, quantities, and prices. The marketing order applies solely to the domestic market. It imposes regulations that entail costs of compliance

with requirements for aflatoxin testing and meeting quality standards that are borne in the first instance by processors plus other relatively minor costs that are financed by an assessment on processors. The potential increases in demand, on average, relative to a scenario without a marketing order include the effects of (1) a reduced probability of a negative shock to demand associated with an aflatoxin event and a reduction in the size of the negative shock associated with a given event, and (2) an increase in demand in every year owing to greater consumer and buyer confidence in the product associated with USDA testing and certification. Later in this section we discuss these two demand elements, but first we turn to the costs of compliance they are meant to offset.

Cost of Testing and other Compliance Issues

The quantitative economic analysis required information on the costs of aflatoxin testing and compliance with other quality standards that are regulated under the marketing order. The initial incidence of this additional cost would be on the processing sector. Depending on the current level of testing and other characteristics, processing firms face different costs of complying with the standards. A telephone conference with the seven major processors in California provided data on the costs that various processors in the industry would face under the marketing order (Pistachio Processor Group 2002).

In his testimony at the hearings on July 25, 2002, Daniel Sumner described in detail how to estimate these costs for three different types of processors depending on their current testing practices, the size of their processing operation, labor requirements and wage rates for inspectors, lot sizes, and various other factors. The resulting estimate of the direct per-unit cost of compliance was a weighted average (across the different types of processors) of $0.00525 per pound on the two-thirds of production to which the proposed marketing order rules apply. This figure seems to represent a consensus of views in the industry.[13] The weighted cost of compliance applied across all California pistachio production was $0.0035 per pound. These figures were based on an assumption that few undersized pistachios are currently sold in the standard market such that the implementation of the other features of the marketing order would not have significant implications for the total quantity available to the domestic market.[14]

Effects on the Probability of an Aflatoxin Event and its Consequences

Direct evidence does not exist on the probability of an aflatoxin event that would cause a major negative shock to demand or on the likely severity of such a shock. We assumed that increased aflatoxin testing reduces the probability of such an event and may reduce the severity of a shock as well, but, again, we have no direct quantitative evidence on relevant magnitudes. To calibrate the potential effects of a pistachio food scare, we used information from other produce-related food scares in the United States along with information from an event involving pistachios in Germany, and we conducted sensitivity analyses in which we varied the relevant parameters.

Some direct evidence is available on the market response to an aflatoxin event in pistachios but not for an event in the United States. As described previously, the EU banned pistachio imports for three months in the last quarter of 1997 because of aflatoxins. After the ban was lifted, German imports were substantially reduced over the next three years by an estimated 40 to 50 percent. The pistachio market is relatively small, and other nuts and snack foods are likely to be close substitutes for pistachios. This may be why losses for pistachios in the EU market were larger than observed after some other food scares in the United States, but the differences also may reflect some differences between the United States and other countries—in terms of institutions and consumer behavior—that affect the response.

Taking a conservative approach, we assumed that an aflatoxin event in the domestic market for U.S. pistachios in year t would cause a 30 percent reduction in demand in the year of the event (i.e., $\delta_t = 0.3$, where δ stands for the proportion by which demand decreases in year t). The evidence from Germany suggested that the negative demand effects from a single aflatoxin event would continue to affect demand for several years. In the model, the negative demand shock decayed at a rate of 30 percent per year (i.e., $\delta_{t+n} = 0.7^n\delta_t$).

Aflatoxin events do not happen every year, but the market always faces some probability of a food scare. The marketing order cannot eliminate the chance of a food scare associated with aflatoxin in pistachios, but it has provisions that make such an event less likely. The benefit from additional testing is a reduction of the probability of an aflatoxin event or food scare. For the base case of no mandatory testing, we used an annual probability of 4 percent for an outbreak that affects demand as previously specified. We assumed that, with mandatory testing, the chance of an aflatoxin outbreak would fall to 2 percent and that an event, when it occurred, would have a smaller effect on

demand. We assumed an initial downward shock of 15 percent under the marketing order and 30 percent without the order.

Effects on Consumer and Buyer Confidence

Demand for pistachios could increase as a result of official USDA certification ensuring a good quality product. Many agricultural products take advantage of USDA grading and other services, and buyers for major food outlets and many consumers in the United States are well aware of USDA standards. In general, USDA standard-setting is thought to convey a positive benefit in a market as reflected by use of this claim in product promotion, labels, and displays. We were not aware, however, of empirical evidence of the magnitude of the impact of such certification. We used a small increase in demand to reflect greater buyer confidence in pistachios due solely to USDA's participation in the standards process.

In addition, but similarly, the demand for pistachios increases with mandatory minimum quality standards and buyers' more favorable perception of safety. It is anticipated that the standards in the order will reflect well on the product as a whole and shift out demand for all pistachios because buyers will anticipate a smaller probability of acquiring low-quality shipments. This demand effect involves two aspects. The first is the general notion that buyers are willing to pay more for nuts of a higher quality. Second, a minimum quality standard assures buyers that they have a smaller chance of a low-quality shipment. This effect relies on more information being available to buyers that all pistachios from the marketing order area meet minimum standards. One of the provisions under the marketing order prohibits the sale of inferior pistachios. Although these represent a tiny fraction of total production, removing them from the market altogether will result in an increase in the general quality of pistachios, albeit a small one. To reflect both of these elements in the simulations, we allowed for a small increase in demand in every year, relative to the base case, in response to introduction of the marketing order: an increase in U.S. consumers' willingness-to-pay for pistachios equal to 1 cent per pound (about 1 percent of recent prices).

Benefit-Cost Analysis

To estimate the impact of the marketing order, we computed and compared a pair of fifty-year simulations (i.e., one with and one without the marketing order) using baseline values for the parameters as shown in Table 16.2. For each year of the fifty-year simulation, the model determined a market-clear-

ing price, bearing acres, acres planted, yield, production, domestic quantity demanded, export quantity demanded, ending stocks, revenue, and consumer surplus. To capture the effects of random yield variability and aflatoxin-related demand shocks, the fifty years of simulated equilibrium values were calculated for a set of one hundred equally likely futures that differed in terms of values for randomly generated yields and aflatoxin shocks. Hence, in a given scenario, each simulated variable of interest has a fifty-year time path that is affected by the marketing order with a random distribution in each period. It is important to keep this time path and the random nature of the variables in mind as we report summary statistics and average impacts so.[15]

Under the marketing order, as shown in Table 16.2, the annual probability of an aflatoxin event was reduced from 4 percent to 2 percent, and the demand impacts of such an event were assumed to be half as large (i.e., an initial drop in demand of 15 percent versus 30 percent applied to both the domestic market and relevant export markets). In addition to this benefit, the marketing order was assumed to increase domestic consumers' willingness-to-pay for pistachios by 1 cent per pound. The cost of compliance with the marketing

Table 16.2. Key Parameters for the Simulation Model

Parameter	Baseline Value
Underlying Market Conditions	
Elasticity of Domestic Demand	−1.00
Elasticity of Export Demand	−3.30
Elasticity of Demand for Stocks	−2.00
Long-Run Annual Growth Rate of Demand (percent)	3.60
Elasticity of New-Plantings Response to Profitability	1.00
Impact Parameters without a Marketing Order	
Probability of an Aflatoxin Event (percent per year)	4.00
Initial Impacts of an Event (percentage reduction in domestic demand)	30.00
Foreign Demand Shock / Domestic Demand Shock (percent)	21.50
Impact Parameters with a Marketing Order	
Probability of an Aflatoxin Event (percent per year)	2.00
Initial Impacts of an Event – Domestic Demand (percentage reduction)	15.00
Initial Impacts of an Event – Foreign Demand (percentage reduction)	21.50
Compliance Costs (cents per pound)	0.525
Domestic Demand Enhancement from Certification (cents per pound)	1.00

Table 16.3. Simulation Results: Benefit-Cost Analysis of the Pistachio Marketing Order

Consequences of the Marketing Order	Baseline	High Impact	Low Impact
Induced Changes in Average of Annual Values, 2000–2050			
Price of California Pistachios (real cents per pound)	0.501	0.726	0.371
Bearing Area of California Pistachios (acres)	1,866	2,716	1,279
Production of California Pistachios (million pounds)	12.55	18.31	8.63
Domestic Consumption of California Pistachios (million pounds)	11.54	16.91	8.15
Exports of California Pistachios (million pounds)	1.01	1.40	0.51
Stocks of California Pistachios (million pounds)	−0.62	−1.05	−0.47
Present Values for Net Benefits in Year 2000 in Millions of Dollars			
Changes in U.S. Consumer Surplus (*CS*)	165.4	246.7	109.8
Changes in California Producer Surplus (*PS*)	68.9	103.7	49.6
National Benefits (*NS* = *CS* + *PS*)	234.3	350.4	159.4
Net Changes in Foreign Surplus (*FS*)	−25.0	−36.5	−19.2
Global Net Benefits (*GS* = *NS* + *FS*)	209.3	313.9	140.2
Present Values for Marketing Order Costs in Year 2003 in Millions of Dollars			
Cost of Compliance (*CC*)	36.7	34.9	38.4
Benefit-Cost Ratios			
Global Benefit-Cost Ratio (1+ [*GS* / *CC*])	6.7	10.0	4.7
National Benefit-Cost Ratio (1 + [*NS* / 1.1 *CC*])	6.9	10.2	4.8
Grower Benefit-Cost Ratio (1+ [*PS* / 0.15 *CC*])	13.5	20.8	9.6

order, 0.525 cents per pound consumed domestically, was reflected as a reduction in the price to growers for domestic sales.

The impacts of the marketing order are reported in the first column of Table 16.3. To summarize the effects of the marketing order over the fifty-year simulation, we report average effects over the fifty years for some variables; for others, we report the net present value in 2003 of the effects over the fifty years. The marketing order modestly increases the average price received by growers (by 0.5 cents per pound, or 0.6 percent), along with average bearing acres (by 1,870 acres or 1.3 percent) and production (by 12.6 million pounds per year or 1.5 percent). These increases in production are associated generally with increases in domestic consumption (by 11.5 million pounds per year

or 2.8 percent) and in exports (by 1 million pounds per year or 0.2 percent) and decreases in stocks (by 0.6 million pounds per year or 0.3 percent). These averages mask the fact that, as noted previously, the effects on some of these variables change over time because of trends (the production response to the order increases with time whereas the domestic demand response begins immediately) and from year to year (through the interaction of order-induced changes in bearing acres and variable yields). This is true in particular for the effects of the marketing order on exports—the small average effects reflect negative impacts in some years, especially initially, and positive impacts in others, especially the later years.

The dynamics of the impact of the marketing order on revenue per bearing acre, bearing acres, and domestic consumer surplus are particularly interesting. The marketing order increases grower price and revenue per acre by increasing consumer confidence and reducing the odds and the impact of an aflatoxin event. The impact on revenue is greatest in the first few years after introduction of the order because supply is not affected during this period of time. The increase in revenue per acre eventually causes an increase in the time path of bearing acres. The increase in bearing acres results in increased production, driving down prices and revenue per acre and dissipating the benefits for producers. Consumers gain initially from improved food safety, and that benefit is then augmented by subsequent reductions in price resulting from increases in production.

The net benefits from the marketing order—reflecting the consequences of both the assessment and the regulations and of the demand and supply responses to them—are expressed as present values (in 2003) of changes in economic surplus accruing to different groups. These net benefits included $68.9 million to domestic producers and $165.4 million to domestic consumers, yielding a total national net benefit of $234.2 million.[16] From a global perspective, U.S. net benefits were slightly offset by net losses in foreigner surplus (the "consumer surplus" measured off the demand for U.S. exports) worth $25 million, leaving global net benefits with a present value in 2003 equal to $209.2 million.[17]

We also estimated the total cost of the marketing order (in terms of expenditures incurred by processors in complying), which had a present value in 2003 of $36.7 million. The initial incidence of this cost falls on processors, but the incidence is redistributed over time through supply and demand responses. To evaluate the final incidence, we ran a simulation with just the assessment (modeled as a reduction in domestic buyers' willingness-to-pay of 0.525

cents per pound). In present-value terms, we found that 15 percent of the cost was borne by growers and 85 percent by domestic and foreign consumers combined. Domestic consumers paid 95 percent of the total cost (this is more than the 85 percent attributed to domestic and foreign consumers, combined, because foreign consumers are net beneficiaries of a tax on domestic consumers). Hence the incidence of the global cost of $36.7 million was $39.7 million on the United States, including $5.5 million on U.S. producers. By dividing each measure of net benefits by the corresponding measure of the incidence of the costs, we obtained a ratio of net benefits to costs (i.e., $(B - C) / C$), to which we added one to compute conventional benefit-cost ratios (B / C) for domestic producers (13.5), the United States (6.9), and the world (6.7).

To examine the general sensitivity of the results to modeling assumptions, we devised a "high-impact" scenario and a "low-impact" scenario, and the summary results for the simulations under these scenarios are reported in the second and third columns of Table 16.3. For the high-impact scenario, we altered most of the parameters of the model by 10 percent in the direction that would increase the impact of the marketing order; for the low-impact scenario, we altered the parameters by 10 percent in the opposite direction. These scenarios reveal how the results are affected by a modest but consistent upward or downward bias in parameter values. As shown at the bottom of the table, the combined effect of the parameter changes creates more than 10 percent variation in the estimated impacts of the marketing order. Compared with a benefit-cost ratio for producers of 13.5 in the base scenario, the ratio is 20.8 (50 percent higher) in the high-impact scenario and 9.6 (30 percent lower) in the low-impact scenario. Similarly, for the United States as a whole, compared with a benefit-cost ratio of 6.9 in the base scenario, the ratio is 10.2 (50 percent higher) in the high-impact scenario and 3.8 (45 percent lower) in the low-impact scenario. Nevertheless, the benefit-cost ratios are all significantly greater than zero even in the low-impact scenario, indicating that the order entails substantial net benefits for both producers and the nation as a whole.

Conclusion

An aflatoxin event could impose serious costs on the California pistachio industry. The marketing order is intended to reduce the odds of an event, to mitigate the consequences if an event should occur, and to provide some quality assurance to buyers to offset the negative consequences of concerns over the potential for a food scare affecting pistachios. We modeled the market for California pistachios to provide an *ex ante* assessment of the benefits and costs

and other consequences of the marketing order looking forward fifty years from its anticipated introduction in 2004. Our approach used a stochastic, dynamic simulation of the industry under scenarios with and without the marketing order to compare the stream of simulated outcomes and the consequences for measures of economic welfare for producers in the industry, for consumers, for the nation as a whole, and globally.

Assessing the implications of the marketing order required incorporating into the simulation a number of parameters representing the odds of an aflatoxin event, its consequences for demand, and the extent to which a marketing order could reduce those magnitudes. Many of the parameters are hard to estimate because relevant historical data for pistachios are not available. As well as simulating the consequences implied by "best-guess" values for key parameters, we undertook sensitivity analysis. Across the full range of parameters used in the analysis, the benefit-cost analysis was always favorable to the marketing order: the measured benefits to producers, the nation, or the world always well exceeded the corresponding measure of costs, typically by many times. The benefit-cost ratios were generally greater than five to one and often greater than ten to one, providing substantial leeway to accommodate potential errors in assumptions and still have favorable findings. In present-value terms, the benefits to producers were estimated at $68.9 million. Two-thirds of the benefits, $165.4 million, would accrue to domestic consumers. These are significant values and are large relative to the cost of compliance with the program, which is a very small amount–about half of one percent of the current value of domestic sales.

Notes

1 Statistical information in this section was supplied by the California Pistachio Commission unless otherwise noted.

2 Iran's exports peaked in 1996, when it exported 308 million pounds of pistachios, but fell to 127 million pounds in 1997, when Iranian pistachios were banned by the European Union because of aflatoxins. Iranian exports returned gradually to near pre-ban levels in the following few years.

3 In 2000, Arizona had 2,700 acres and produced four million pounds of pistachios, just 1.5 percent of national production in that year (Arizona Agricultural Statistical Service 2003) and too small to significantly impact the national market for pistachios. New Mexico had 391 acres of pistachios in 1999, less than half a percent of total acreage (New Mexico Agricultural Statistics 2000).

4 Pistachios exhibit alternate bearing with low yields tending to follow high yields. Thus, 2001 was a relatively low-yield, low-production year. The yield cycle is an important factor

in quantity produced, price received, total value of the crop, and gross revenue per bearing acre (U.S. Department of Agriculture, Risk Management Agency 2003).

5 Aflatoxicosis is poisoning that results from ingestion of aflatoxins in contaminated food or feed. The most pronounced contamination has been encountered in tree nuts, peanuts, and other oilseeds, including corn and cottonseed. Aflatoxicosis in humans rarely has been reported; however, cases are not always recognized. In affluent countries, aflatoxin contamination rarely occurs in foods at levels that cause acute aflatoxicosis in humans, but there have been important aflatoxin events in pistachios. (Information here is taken from *http://vm.cfsan.fda.gov/~mow/chap41.html*.)

6 Additional studies of the impact on demand of food-safety events and information on demand can be found in Smith, van Ravenswaay, and Thompson (1988), Brown and Schrader (1991), Richards and Patterson (1999), and Piggot and Marsh (2004).

7 Information here was supplied by Karen Reinecke, president of the California Pistachio Commission, in 2002 in preparation for the federal marketing order hearing.

8 This is a tighter standard than the current maximum allowed by the U.S. Food and Drug Administration of twenty parts per billion.

9 This is the standard public-good argument for government intervention. The services in question are "public goods" in the sense that they are nonrival (benefit by one consumer does not reduce availability for others) and not price excludable (if the service is provided at all, it is very costly to preclude benefits by others even if they refuse to pay), but these public-good benefits are confined to the producers and consumers of a particular commodity and are associated with consumption or production of the commodity. The collective goods could be provided using the general revenues of the relevant state or national government, but it is likely to be fairer and more efficient to finance their provision using a tax on the commodity with which the collective goods are associated.

10 Alston et al. (1995) analyzed the impacts of the allocated reserve policy applied by the Almond Board of California under a federal marketing order, which is an example of this type of supply control that can be mimicked by using quality regulations to divert some fraction of production from the market. Chalfant and Sexton (2002) analyzed an interesting example of *de facto* price discrimination associated with grade standards in the California prune industry.

11 Naturally, some of the free-rider problems could be avoided if pistachios were differentiated, say by brands. Then individual firms could provide private testing and quality assurance and capture at least some of the benefits. But branding and product differentiation is costly and not predominant in the industry. Moreover, the existence of brands does not eliminate all (or even most) of the externalities that can be associated with food scares. We thank John Crespi for causing us to elaborate this point.

12 Details here are based on the proposed rule published in the *Federal Register* (2003).

13 The *Federal Register* (2003, p. 46017) reports "The average cost of compliance, as identified by several witnesses and reiterated in Dr. Sumner's analysis, is approximately one half cent per pound of domestic pistachio production, or $0.00525 per pound."

14 In any event, under the marketing order, undersized pistachios could still be diverted to the export market so the consequences of this element of the regulations for prices, quantities, and values would be negligible.

15 Further details on the simulation model and alternative parameterizations may be found in the more comprehensive full report on the study (Gray et al. 2004).

16 On 78,000 bearing acres in 2001, the producer benefit is worth $2,120 per acre, but the benefits would not be confined to these acres.

17 The positive effect on export quantity seems to contradict the higher average price and the reduction in foreign "consumer" surplus associated with the order. The effect on foreign "consumer" surplus is complicated. First, there are some benefits to foreigners from the order because in the baseline case there is a spillover effect of an aflatoxin event from U.S. demand to foreign demand and the order-induced reduction in probability and severity of an aflatoxin event applies to export markets as well as domestic ones. These benefits are offset at least somewhat by the larger domestic demand responses that drive up prices, especially in the early years; in later years, those effects in turn are offset at least somewhat by the consequences of the U.S. supply response to the policies. The benefits to foreigners are greater in the earlier years and, given discounting, the net present value is negative even though the average effect on quantity of exports, undiscounted, is slightly positive.

References

Akerlof, G.A. "Market for 'Lemons': Qualitative Uncertainty and the Market Mechanism." *Quarterly Journal of Economics* 84(August) (1970):488–500.

Alston, J.M., H.F. Carman, J.A. Chalfant, J.M. Crespi, R.J. Sexton, and R.J. Venner. *The California Prune Board's Promotion Program: An Evaluation.* Berkeley CA: University of California Agricultural Experiment Station, Giannini Foundation Research Report 344, March 1998.

Alston, J.M, G.W. Norton, and P.G. Pardey. *Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Ithaca NY: Cornell University Press, 1995.

Alston, J.M., H.F. Carman, J. Christian, J.H. Dorfman, J.R. Murua, and R.J. Sexton. *Optimal Reserve and Export Policies for the California Almond Industry: Theory, Econometrics and Simulations.* Berkeley CA: University of California Agricultural Experiment Station, Giannini Foundation Monograph 42, February 1995.

Arizona Agricultural Statistical Service. "Publications." Available online May 2003 at *www.nass.usda.gov/az/rlsetoc.htm*.

Brown, D.J., and L.F. Schrader. "Cholesterol Information and Shell Egg Consumption." *American Journal of Agricultural Economics* 72(3) (1990):548–555.

California Agricultural Statistical Service. "Pistachio Acreage and Forecast Reports." Available online April 2002 at *www.nass.usda.gov/ca*.

California Agricultural Statistical Service. "Pistachio Acreage Report, 2000." Available online March 2002 at *www.nass.usda.gov/ca/rpts/acreage/pistachio/008pstac.htm*.

California Pistachio Commission. "Proposed United States Standards for Grades of Pistachio Nuts." Available online March 2003 at *www.pistachios.org*.

California Pistachio Commission. "History." Available online December 2003 at *www.pistachios.org*.

California Pistachio Commission. "Statistics." Available online April 2004 at *www.pistachios.org/data/statistics.xls*.

Calvin, L. "Produce, Food Safety, and International Trade: Response to U.S. Foodborne Illness Outbreaks Associated with Imported Produce" *International Trade and Food Safety, Economic Theory and Case Studies.* J.C. Buzby, ed. U.S. Department of Agriculture, Economic Research Service Agricultural Economic Report 828, 2003.

Chalfant, J.A., and R.J. Sexton. "Marketing Orders, Grading Errors, and Price Discrimination." *American Journal of Agricultural Economics* 84(1) (2002):53–66.

Center for Science in the Public Interest (CSPI). "Produce-Related Outbreaks, 1990." Available online July 2002 at *www.cspinet.org/new/prodhark.html*.

Der Spiegel. "Giftiges Pistazien Eis (Poisonous pistachio ice cream)." Issue 26, June 24, 2000.

European Commission, Food and Veterinary Office. "Summary of Inspection of Iran's Food and Veterinary Office, 1998." Available online May 2003 at *http://europa.eu.int/comm/food/fs/inspections/fnaoi/reports/contaminants/iran/fnaoi_rep_iran_1492-1998_de.html*.

Federal Register. Vol. 68, No. 149, 45990-46033, Monday, August 4, 2003, Part III, Department of Agriculture, Agricultural Marketing Service, 7 CFR Part 983. Details available at *www.ams.usda.gov/fv/moformal/fv029831sd.pdf*.

Freebairn, J.W. "Grading as a Market Innovation." *Review of Marketing and Agricultural Economics* 35(3) (1967):147–162.

Freebairn, J.W. "The Value of Information Provided by a Uniform Grading Scheme." *Australian Journal of Agricultural Economics* 35(3) (1973):127–139.

Gray, R.S., D.A. Sumner, J.M. Alston, and H. Brunke. "Economic Consequences of Mandated Grading and Food Safety Assurance: *Ex Ante* Analysis of the Federal Marketing Order for California Pistachios." Draft monograph, Department of Agricultural and Resource Economics, University of California, Davis, March 2004.

Hermes, Peter. "Iranisches Roulett (Iranian Roulette)." *Oeko-Test* (monthly German Consumer Report), November 1999.

New Mexico Agricultural Statistical Service. "NM Publications". Available online May 2003 at *www.nass.usda.gov/nm*.

Piggott, N.E., and T.L. Marsh. "Does Food Safety Information Impact U.S. Meat Demand?" *American Journal of Agricultural Economics* 86(1) (2004):154–174

Richards, T.J., and P.M. Patterson. "The Economic Value of Public Relations Expenditure: Food Safety and the Strawberry Case." *Journal of Agriculture and Resource Economics* 24(2) (1999): 440–462.

Smith, M.E., E.O. van Ravenswaay, and S.R. Thompson. "Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii." *American Journal of Agricultural Economics* 70(3) (1988):513–520

Süddeutsche Zeitung "Verschimmeltes Pistazieneis (Moldy Pistachio Ice Cream)." June 26, 2000.

The Economist. "Nuts to the EU." September 20, 1997, p.52.

United Nations, Food and Agricultural Organization. "Statistics." Available online June 2003 at *www.fao.org/waicent/portal/statistics_en.asp*.

U.S. Department of Agriculture, Agricultural Marketing Service. "Steps in Developing a Fruit and Vegetable Marketing Order or Marketing Agreement Program." Available online July 2003 at *www.ams.usda.gov/fv/moabsteps.html*.

U.S. Department of Agriculture, Agricultural Marketing Service. "Pistachios Grown in California; Secretary's Decision and Referendum Order on Proposed Marketing Agreement and Order Number 983." Docket Numbers AO-F&V-983-2; FV02-983-01. Available online January 2004 at *www.ams.usda.gov/fv/moformal/fv029831sd.pdf*.

U.S. Department of Agriculture, Economic Research Service. "Fruit and Tree Nut Situation and Outlook" Various issues. Available online October 2003 at *www.ers.usda.gov/Briefing/FruitAndTreeNuts/marketoutlook.htm*.

U.S. Department of Agriculture, Foreign Agricultural Service. "Market Access Program Allocations, Fiscal Year 2002." Available online October 2003 at *www.fas.usda.gov/excredits/quarterly/2002/2002-sum/03-01%20TABLE-MAP.pdf*.

U.S. Department of Agriculture, Risk Management Agency. "An Economic Assessment of Pistachios: Executive Summary." Available online June 2003 at *www.rma.usda.gov/pilots/feasible/txt/pistchio.txt*.

U.S. Department of Health and Human Services, Food and Drug Administration. "Press Release: Nationwide Recall of Susie Brand Cantaloupes due to Potential Health Risk." Available online May 2003 at *www.fda.gov/oc/po/firmrecalls/kunik05_02.html*.

Van Ravenswaay, E.O., and J.P. Hoehn. "The Impact of Health Risk Information on Food Demand: A Case Study of Alar and Apples." *Economics of Food Safety*. J.A. Caswell, ed. New York NY: Elsevier, 1991.