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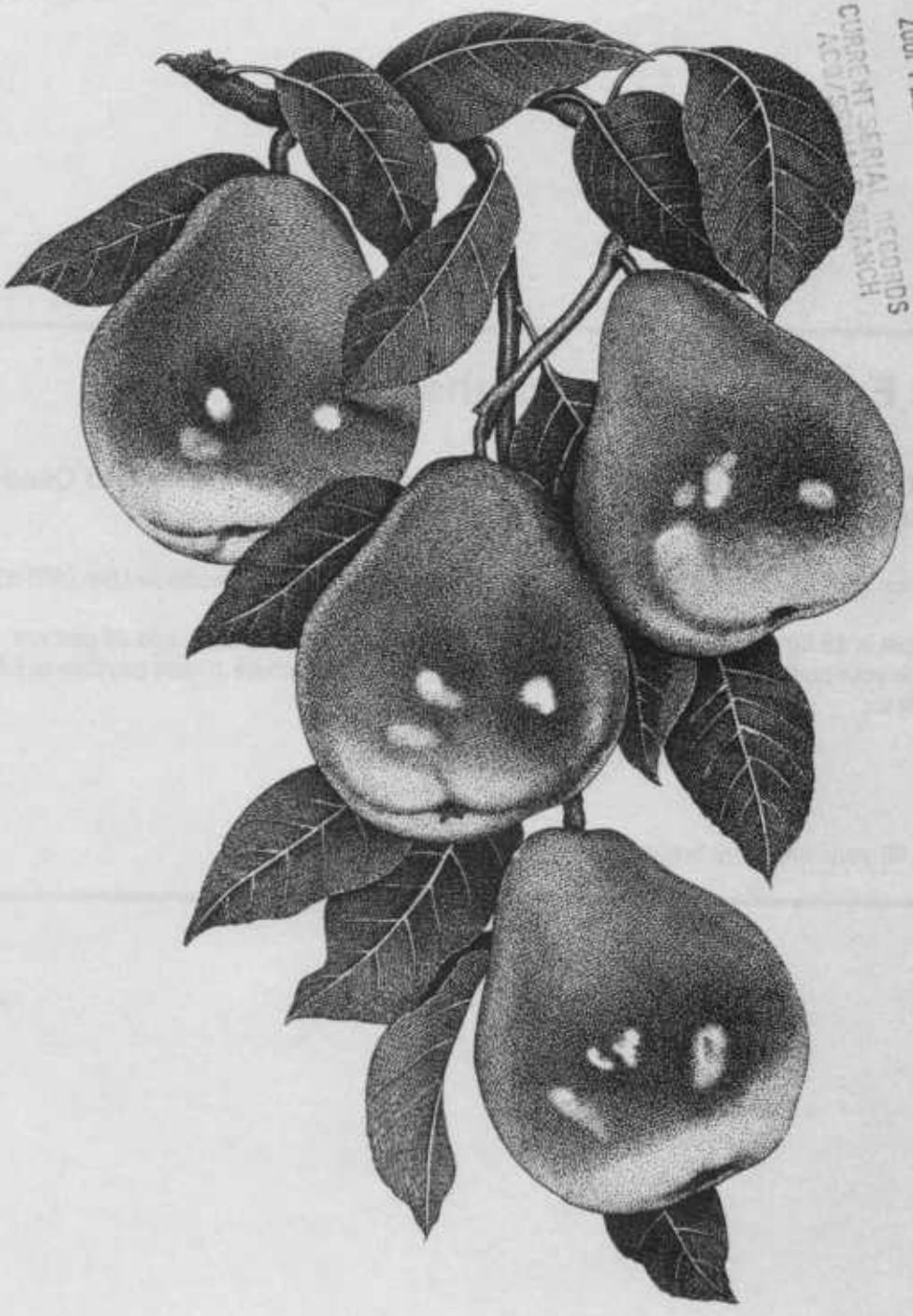
Federal Grade Standards for Fresh Produce: Linkages to Pesticide Use

Nicholas J. Powers
Richard G. Heifner



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Federal Grade Standards for Fresh Produce--Linkages to Pesticide Use.
Nicholas J. Powers and Richard G. Heifner. Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 675.

Abstract

Some have criticized Federal grading of fresh produce for setting unnecessarily high standards for external appearance. These standards allegedly encourage use of chemical pesticides by growers and packers. Federal grades play an important commercial role by helping buyers and sellers exchange information about produce quality, but grades do not convey information about pesticide use or its residues. Modifying standards or establishing a certification program (separate from grades) to include information about pesticides might help consumers signal their preferences to growers and packers for produce with fewer pesticide residues. Assessing the potential effects of such changes calls for research to measure: (1) relationships between pesticide use and product appearance, and (2) consumers' tradeoffs between product appearance and freedom from pesticides.

Keywords: Fresh produce, pesticides, grading standards, growers, packers, retailers, consumers.

Acknowledgments

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Glossary

Food retailer--A firm operating a food store.

Free-on-board (f.o.b.)--For fresh produce sold as f.o.b., the packer agrees to load the produce onto a vehicle provided by the buyer at the packer's loading dock.

Grading--The categorizing of products according to a set of rules. It involves applying standards to assess which grade designation to assign to each item or lot.

Packer--A firm that packages field-harvested fresh produce and ships it to receivers, including wholesalers, retailers, institutions, and food service organizations.

Pesticides--Natural or synthetic chemicals, including insecticides, herbicides, and fungicides, intended for controlling or inhibiting any organism such as insects, rodents, other plants (that is, weeds), fungi, bacteria, or nematodes considered undesirable in or on a food crop.

Produce grower--A firm that produces either fruits or vegetables, or both.

Produce wholesaler--A firm near a metropolitan area that receives produce from packers and distributes the produce to food retailers, institutions, food service organizations, and restaurants.

Summary

Some have criticized Federal grades for fresh produce for setting unnecessarily high standards for external appearance. These standards allegedly encourage use of chemical pesticides by growers and packers. Federal grades play an important commercial role by helping buyers and sellers exchange information about produce quality, but grades do not convey information about pesticide use or its residues.

Modifying standards or establishing a certification program (separate from grades) to include information about pesticides might help consumers signal their preferences to growers and packers for produce with fewer pesticide residues. A grading system that emphasizes appearance and does not consider pesticide use and residues may lead growers and packers to apply more pesticides than they would if consumers' preferences regarding pesticides were fully communicated. Providing consumers information about pesticides would add costs, and reducing pesticide use probably would increase growing and marketing costs or result in produce with more appearance defects. Assessing the potential effects of such changes calls for research to measure: (1) relationships between pesticide use and product appearance, and (2) consumers' tradeoffs between product appearance and freedom from pesticides.

Herein we examine the role Federal grades play in the production and marketing of fresh produce, particularly concerning pesticide use and its residues. This bulletin is a partial response to a congressional request for the U.S. Department of Agriculture (USDA) to explore whether standards for outward appearance of fresh fruits and vegetables encourage pesticide use as mentioned in the Food, Agriculture, Conservation, and Trade Act of 1990. The report describes the Federal grade standards for fresh produce, explores the link between grades and pesticide use, and identifies and examines some options for change.

Grading is the categorizing of products according to a set of rules. It involves the application of standards to determine which grade designation to assign to each particular item or lot. The grade standards for fresh produce emphasize external attributes, such as cleanness, color, surface defects, and shape as well as internal attributes, such as maturity and decay. Sixty-four fresh vegetables (excluding seed potatoes and onion sets) and 25 fresh fruits (omitting duplicates for State-specific standards) have Federal grade standards.

Little evidence is available regarding the effects of grades on pesticide use. There is evidence that pesticides reduce quality degradation for some produce items. However, many pesticides increase yield as well as quality (as measured by grades) and the effects are not easily separated. Reducing the use of pesticides would in some cases increase the share of produce with blemishes and other appearance defects and decrease per acre yields. Several studies suggest that consumers are willing to accept some types of surface defects, but not all. And higher production costs or lower yields would elevate consumer food expenditures.

To address these concerns, the following specific policy alternatives merit consideration:

- Do not change the standards
- Lower the external appearance standards
- Modify the standards to include information about pesticide use during growing and packing and pesticide residues
- Add a pesticide testing and monitoring program separate from both grades and standards and current efforts by the Food and Drug Administration.

Lowering the external appearance factors of Federal standards might cause consumers difficulties in obtaining produce with appearance attributes they desire. Marketers might develop alternative mechanisms to deliver produce with appearance attributes that consumers desire, with associated costs passed back to growers, and thus encourage pesticide use for limiting appearance defects. Consequently, pesticide use might not change much.

Grade standards that might help consumers choose produce with lower pesticide residues than the Environmental Protection Agency deems safe could be based on either: (1) measuring and reporting pesticide residues, or (2) monitoring of pesticide use from the field through the marketing channel. Either approach would add costs.

A pesticide testing or monitoring program might be separate from the existing grading program. Such a program could be voluntary, which would avoid testing or monitoring costs for the produce that is not covered. Consumers who are satisfied with the existing grading standards and pesticide tolerances would be spared the added costs.

Much of the information necessary for considering any modification or addition to existing grading and monitoring programs is unavailable at this time. For example, consumers' tolerances of pesticide use and residues as well as acceptance of blemished produce are largely unknown. Furthermore, for some crops, the importance of pesticides in the quality of produce is not firmly established.

Federal Grade Standards for Fresh Produce: Linkages to Pesticide Use

Nicholas J. Powers
Richard G. Heifner*

Introduction

Some have criticized Federal grades for fresh fruits and vegetables for: (1) providing inadequate information about nutrition, flavor, taste, and freshness, and (2) specifying unnecessarily high standards for external appearance that encourage use of chemical pesticides (6, 22, 25).[1,2] The emphasis on outward appearance is believed to hamper efforts to develop and establish markets for produce grown with no or with fewer pesticides. Congress addressed some of the public concern about nutrition information by enacting legislation that encourages retailers to provide point-of-purchase nutritional labeling for major fresh fruits and vegetables, or those with high sales volume (Box 1).

Another effort spurred by such public concern is an examination of grade standards and pesticide use. This bulletin is a partial response to a congressional request for the U.S. Department of Agriculture (USDA) to explore whether high standards for outward appearance encourage pesticide use, as mentioned in the Food, Agriculture, Conservation, and Trade Act of 1990. This bulletin describes the Federal grade standards for fresh produce, explores the link between grades and pesticide use, and identifies and examines some options for change.

The Current Federal Grading System for Fresh Produce

The Federal role in produce grading began in 1912 when Congress, responding to requests from growers, packers, wholesalers, and retailers, enacted legislation establishing Federal grade standards for apples (24). Congress enacted legislation in 1915 authorizing USDA to establish price reporting for agricultural commodities, furthering the need for national standards to effectively communicate price and quality information to buyers and sellers. Congress passed the Food Production Act of 1917 (FPA) 2 years later, authorizing USDA to establish Federal grading and inspection for fresh produce. The FPA was motivated by the military's need to obtain ample and suitable food for the war effort and by increased long-distance commerce. Standards for potatoes were first established under the FPA. Standards for other products followed. The Agricultural Marketing Act of 1946 (AMA) combined produce grading as well as other Federal marketing functions, including marketing research and market news, into one USDA agency.

Sixty-four fresh vegetables (excluding seed potatoes and onion sets) and 25 fresh fruits (omitting duplicates for State-specific standards) have Federal grade standards.[3] Standards were established for 63 of the vegetables and 24 of the fruits prior to 1967. USDA's Agricultural Marketing Service (AMS) periodically reviews grade standards and assesses the need for revisions to reflect changes in varieties, production and marketing technology, and buyers' preferences. Industry and other interested parties may request new standards or revisions to current standards.

What Does Produce Grading Involve?

Grading is the categorizing of products according to a set of rules. It involves the application of standards to determine which grade designation to assign to each particular item or lot. Grade standards for fresh produce refer to external attributes, such as cleanness, color, and shape as well as internal attributes, such as maturity, decay, and other internal defects. (See boxes 2, 3, and 4 for examples of grade standards.)

* The authors are agricultural economists with the Economic Research Service, U.S. Department of Agriculture.

[1] Pesticides are chemicals, either natural or synthetic, intended for controlling or inhibiting any organism such as insects, rodents, other plants (that is, weeds), fungi, bacteria, or nematodes considered undesirable in or on a food crop. Pesticides used in food production and packing include insecticides, herbicides, and fungicides.

[2] Underlined numbers in parentheses refer to sources cited in the References.

[3] There are specific Federal grade standards for grapefruit and oranges grown in Florida, Texas, and California-Arizona.

Box 1

Retail Point-of-Purchase Nutritional Labeling

The Office of Technology Assessment (OTA) commented on the information content of produce grades in 1977, maintaining that grades, while meaningful to sellers and retailers, are confusing to consumers (19). OTA suggested that more uniform grade terminology might more effectively convey information about quality to consumers. OTA further noted that existing grade standards rest mainly on external attributes that consumers can observe before purchase, such as color, size, and shape. However, OTA questioned whether the benefits from mandatory retail nutritional labeling would exceed the costs, because the technology for effectively measuring attributes that consumers cannot observe prior to purchase remained to be developed in many cases. See (27) for recent developments in measuring nutrients.

Congress subsequently passed the Nutrition Labeling and Education Act of 1990 urging retailers to voluntarily provide point-of-purchase nutritional labeling for the 20 most frequently consumed fresh fruits and the 20 most frequently consumed fresh vegetables. Retailers are not required to continually test produce for nutrients. Rather, the posted nutritional data are based on results from a national sample of produce. If the U.S. Food and Drug Administration (FDA) determines that retailers are not substantially and voluntarily complying by 1993, the requirements become mandatory.

The Produce Marketing Association, an industry trade group, has taken the lead in developing point-of-purchase retail materials with nutritional information. Despite the development and implementation costs, which are to be shared by trade members, growers and marketers would share net benefits if sales increase sufficiently to elevate profits. Consumers who make better informed decisions when purchasing fresh produce also would benefit.

Box 2

The Four Federal Grades for Fresh Apples

Apples graded **U.S. extra fancy** must be of one variety, mature (but not overripe), clean, fairly well formed; free from decay, broken skins, and other skin defects (such as scald, scab, and Jonathan spot); free from injury caused by freezing, russeting (a color and possibly a skin defect), sunburn, limb rubs, disease, and insects; free from damage by invisible watercore (an internal flesh defect usually observed by cutting); and free from internal browning and breakdown, and bitter pit. The grade has a variety-specific color standard. For instance. McIntosh apples of U.S. extra fancy grade must be colored 50-percent striped or partially red.

The **U.S. fancy** apple grade is nearly identical, except that the color standard is looser.

The **U.S. No. 1** apple grade is similar to the U.S. fancy grade, except that the No. 1 requires even less color, allows some damage by russeting, and drops the invisible-watercore standard.

The **U.S. utility** apple grade allows for more damage by various defects including visible watercore.

Box 3

The Four Federal Grades for Potatoes

Potatoes graded **U.S. extra No. 1** must be one variety, firm, clean, fairly well matured, fairly well shaped (at least half of the lot is well shaped); free from freezing, blackheart (an internal defect), rot, and wet breakdown; free from injury caused by sprouts and other internal defects; and not less than 2.25 inches in diameter or 5 ounces in weight. In addition, they must not vary by more than 1.25 inches in diameter or more than 6 ounces in weight.

The **U.S. No. 1** potato grade is similar to the U.S. extra No. 1 grade, except that the size and cleanness standards of the U.S. No. 1 grade are looser. The shape standard for the U.S. No. 1 grade is fairly well shaped and the cleanness standard is fairly clean.

The **U.S. commercial** potato grade is similar to the U.S. No. 1, except that the potatoes must be free from serious damage and some defects and the tolerances are looser.

The **U.S. No. 2** potato grade is similar to the U.S. commercial, except that the size and shape standards are looser, and there are no firmness or cleanness requirements. The shape standard is not seriously misshaped.

Box 4

Federal Grade Standards for Other Fresh Produce

Grade standards for fresh Florida grapefruit differ mostly in the degree of discoloration of the rind. Grade standards for lettuce and many of the leafy vegetables differ mostly in the allowed degree of injury or damage to the leaves and stem.

Why Grade Fresh Produce?

Grading communicates information about product attributes between potential buyers (that is, wholesalers and retailers) and sellers (that is, packers and wholesalers) when the buyer cannot conveniently and directly observe quality.

Grading also facilitates the following marketing activities:[4]

- ***Price reporting.*** Public and private agencies gather and report prices for many produce items of varying qualities. Trade is facilitated by reducing information costs and placing all parties on a more even footing, where the qualities represented by reported prices are known and understood by potential buyers. Use of a single set of standards also facilitates transactions by allowing buyers and sellers to compare offers and bids of several opposite parties.

  Tables 1 to 6 illustrate the magnitude of the free-on-board (f.o.b.) price premiums and discounts for different grades of produce. For instance, on February 5, 1992, U.S. No. 1 fresh Florida tomatoes commanded about a 15-percent price premium over U.S. No. 2 tomatoes of comparable size (table 1). Tomato prices also vary by size. Extra large tomatoes command about a 3- to 4-percent price premium over large- and medium-sized tomatoes of comparable grade. Top-quality red delicious apples from Yakima-Wenatchee bring about a 33- to 37-percent price premium over U.S. fancy

[4] See (3) for a further discussion of grading and other public marketing programs.

Table 1--Free-on-board (f.o.b.) shipping-point prices for fresh Florida tomatoes, February 5, 1992

Size	Grade		
	U.S. No. 1[1]	U.S. combination[2]	U.S. No. 2
	Dollars per 25-lb. carton of loose tomatoes		
Extra large	15.50	14.50	13.50
Large	15.00	14.00	13.00
Medium	15.00	14.00	13.00

[1] Eighty-five percent or more of the volume delivered.
[2] Defined as a mixture between U.S. No. 1 and U.S. No. 2 tomatoes. This mixture varies over time.
Source: Florida Vegetable Report, Federal-State Market News Service, U.S. Department of Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

Table 2--Free on board (f.o.b.) shipping-point prices for controlled-atmosphere stored red delicious apples from Yakima-Wenatchee, February 4, 1992

Carton size	Grade or description				
	Apples of best color and type and extra weight	Washington extra fancy	U.S. extra fancy	Washington fancy	U.S. fancy
	Dollars per 40-lb. carton of tray-packed apples				
100's[1]	18.50	16.50	15.00	13.50	13.50
113's	17.00	15.50	14.00	12.50	12.50
125's	16.50	14.50	13.50	12.00	12.00
138's	16.00	14.00	12.50	12.00	12.00

[1] Indicates the number of apples in a carton; larger number reflects smaller sized fruit.
Source: Northwest Fruit Report, Federal-State Market News Service, U.S. Department of Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

apples of comparable size (table 2). The largest sized red delicious apples bring a price premium of about 13- to 18-percent over the smallest sized apples of comparable grade. Furthermore, shipper's first-grade California navel oranges, grapefruit, and lemons command a price premium over choice grade citrus, and small- and large-sized citrus sell at a discount to medium-sized citrus of comparable grade (tables 3-5). In addition, U.S. No. 1 Bartlett pears from Yakima-Wenatchee bring about a 19- to 26-percent price premium over Washington fancy Bartlett pears of comparable size (table 6). Evaluating and describing produce quality via a standard grade nomenclature helps buyers find produce that they want and rewards growers for producing what buyers want.

- ***Development of marketing and food processing technology.*** Much of the equipment used for processing, packaging, and shipping fresh fruits and vegetables requires some degree of product standardization to operate efficiently. For instance, engineers design containers to hold a fixed number of produce items of a given size to reduce packaging and transportation costs. Packaging is also designed to maintain quality and reduce damage during handling. Grading facilitates the use and development of marketing and food processing technology by establishing industrywide norms for describing produce items.

Table 3--Free on board (f.o.b.) shipping-point prices for fresh navel oranges from the central district of California, February 3, 1992

Carton size	Grade	
	Shipper's first[1]	Shipper's choice[2]
	Dollars per 37.5-lb. carton	
32's[3]	7.75	6.75
36's	7.75	6.75
40's	7.75	6.75
48's	8.25	7.25
56's	9.25	7.25
72's	9.25	7.25
88's	8.25	7.25
113's	7.75	7.25
138's	7.75	7.00
163's	5.75	NA

NA = Not available.
[1] Shipper's first is an industry grade with the highest color and scar standards.
[2] Shipper's choice is an industry grade that allows more color and scar defects than those allowed under shipper's first.
[3] Indicates the number of oranges in a carton; larger number reflects smaller sized fruit.
Source: Western Citrus Report, Federal-State Market News Service, U.S. Department of Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

- ***Food product development.*** Grading facilitates the development of products that consumers want by providing growers and marketers information about what consumers pay for products with different attributes. By trying to meet consumers' preferences, growers and marketers could also benefit through higher sales. However, preferences cannot be met when the grades do not fully communicate consumers' preferences.

- ***Settling contractual disputes.*** Buying by Federal grade gives the buyer a basis for seeking redress if the produce does not meet standards for the grade specified in the contract. Grading also reduces contractual disputes by enabling trading parties to communicate more accurately the product's quality. When buyers and sellers of fresh and frozen produce are unable to privately settle contractual disputes, one party to the contract can file a complaint with USDA/AMS. USDA, as authorized by the Perishable Agricultural Commodities Act (PACA), then attempts to resolve the dispute through either informal or formal procedures. Grading enables AMS to resolve impartially contractual disputes by objectively verifying contract performance. Fewer contractual disputes and expedited settlements reduce costs and thereby facilitate business transactions.

What Do Grades Measure?

Each grade has a set of standards specifying the levels of specific attributes required and the amounts of defects tolerated. The higher grades allow fewer defects and generally require more specific attributes. The attributes considered differ by commodity. Most can be evaluated without cutting and tasting the produce; some require destructive testing of a sample.

Table 4--Free on board (f.o.b.) shipping-point prices for fresh grapefruit from the Coachella Valley of California, February 3, 1992

Carton size	Grade	
	Shipper's first[1]	Shipper's choice[2]
	Dollars per 37.5-lb. carton	
23's[3]	5.25	NA
27's	6.25	5.50
32's	7.12	6.00
36's	7.25	6.00
40's	7.25	6.00
48's	6.50	5.50
56's	6.00	5.50

NA = Not available.
[1] Shipper's first is an industry grade with the highest color and scar standards.
[2] Shipper's choice is an industry grade that allows more color and scar defects than those allowed under shipper's first.
[3] Indicates the number of grapefruit in a carton; larger number reflects smaller sized fruit.
Source: Western Citrus Report, Federal-State Market News Service, U.S. Department Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

Table 5--Free on board (f.o.b.) shipping-point prices for fresh lemons from the Arizona-California Desert and the south district of California, February 3, 1992

Carton size	Grade	
	Shipper's first[1]	Shipper's choice[2]
	Dollars per 37.5-lb. carton	
75's[3]	14.00	8.00
95's	16.00	8.25
115's	15.50	8.25
140's	11.00	8.50
165's	10.25	7.75
200's	10.00	7.50
235's	10.00	6.50

[1] Shipper's first is an industry grade with the highest color and scar standards.
[2] Shipper's choice is an industry grade that allows more color and scar defects than those allowed under shipper's first.
[3] Indicates the number of lemons in a carton; larger number reflects smaller sized fruit.
Source: Western Citrus Report, Federal-State Market News Service, U.S. Department of Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

Table 6--Free on board (f.o.b.) shipping-point prices for fresh Bartlett pears from Yakima-Wenatchee, September 17, 1992

Carton size	Grade	
	U.S. No. 1	Washington fancy
	Dollars per 40-lb. carton	
100's[1]	15.50	13.00
110's	14.50	11.50

[1] Indicates the number of pears in a carton; larger number reflects smaller sized fruit.

Source: Western Citrus Report, Federal-State Market News Service, U.S. Department Agriculture, Agricultural Marketing Service, Fruit and Vegetable Division.

The attributes considered in grading fresh lettuce, tomatoes, apples, and oranges are listed and explained in tables 7-10 as examples. Most standards include attributes easily observable by buyers, such as cleanness, color, shape, and size. Some standards include discolorations, skin breaks, or internal defects, including maturity and invisible watercore, that possibly only experienced buyers can identify. Possible further implications of the attribute to the produce are explained in the third column of tables 7-10.

External attributes sometimes provide information about the unobservable (internal) attributes. For instance, the size of apples and tomatoes and the color of tomatoes and oranges signal maturity. Some subtle markings and discolorations reveal possible damage to the product's internal flesh. Because these signals are imperfect, external attributes (observable by buyers before consumption) provide imprecise information about the internal attributes (observable by buyers only after consumption or cutting the product open) such as maturity, taste, and internal flesh texture.

Why do so many produce grade standards pertain to readily observable external attributes? Such standards facilitate wholesale trade by allowing buyers to enter transactions without inspecting the produce before delivery. Federal grades also allow the external quality to be described in such transactions without having to specify separately each attribute. Furthermore, the external attributes covered by grade standards reveal much about the overall extent of decay and maturity.

Size and shape are important to processors but not to all consumers. For instance, plant processing equipment is designed to operate efficiently (that is, with minimal yield loss) over a narrow range of sizes and shapes of apples, peaches, or potatoes. Furthermore, the plant equipment removes a thin layer of the apple or peach exterior, creating a product falling short of quality specifications if damaged and high-quality flesh are commingled. For this reason, bruises signaling damaged flesh are also important attributes to processors.

Most surface defects are important to wholesalers and retailers because defects change over time, some faster than others. Fresh produce with surface defects generally has a shorter shelf-life and thus is more likely to decay while in transit or temporary storage. For these reasons, marketers rely on the extent and degree of preexisting surface defects as signals of whether the product is likely to be salable when it reaches retail stores.

Defects limited to the outer skin (as opposed to the internal flesh) of apples, tomatoes, citrus, or onion bulbs, as examples, are unimportant to consumers if the skin is removed as part of normal food preparation. Some institutional cafeterias routinely remove the skins of selected fresh produce when preparing certain food dishes.

However, skin blemishes and defects of apples, potatoes, or tomatoes probably are important to most consumers who eat the product whole. In contrast, because the peel is not eaten, blemishes on the citrus rind may not be important to consumers. But some of these rind defects are important to growers, because the pests sometimes causing the defect decrease per acre yields by damaging plant growth (7, 8).

Table 7--Attributes considered in grading lettuce

Attribute	Description	Further implications for lettuce
Cleanness	Amount of dirt or spray residue on surface.	May contain chemical residues.
Color	Lack of amount or intensity of hue.	
Size	Unusually small or large.	
Broken midribs	Separation of midribs.	If unhealed, may lead to insect or other infestations.
Brown stain[1]	Oval, irregular areas, generally slightly sunken, usually affecting outer surface of head leaves, or near the midribs. Color ranges from pale straw to brown, and margins are sometimes dark and mottled.	May lead to insect or other infestations.
Bruises[1]	Flattened areas with crushed midribs.	If unhealed, may lead to insect or other infestations.
Discoloration	Leaf edges are yellow or brown. The butt is watersoaked and gray to dark brown. Midribs are oblong yellowish tan to brown or black.	May lead to insect or other infestations.
Downy mildew	Angular spots, yellowish to brown in color on the upper side of the leaf, while the lower surfaces often show whitish mold growth.	May initially cause superficial damage but will eventually destroy the tissue.
Pink rib	The base of the midribs is pink.	Leaves may be papery and tough.
Russet spotting	Small, tan, russet-brown, or olive spots occuring mostly on the midribs near the butt.	May lead to insect or other infestations.
Rusty brown discoloration[1]	Midribs of leaves or entire leaf may be discolored. Rusty brown discoloration tends to follow veins, but not limited to them. Usually only leaves in outer half of head discolored.	May lead to insect or other infestations.
Tipburn	Leaf edges have small spots or narrow lesions, which are bleached light yellow to off-white. Areas can enlarge and turn yellowish brown to brown. Leaf margins are irregular veined, not clean cut.	May lead to insect or other infestations.
Worn and unhealed insect injury	Large punctures, canals, or tunnels.	If unhealed, may lead to insect or other infestations. Worm or insect or their excreta may be present in tissue.
Various fungal, viral, and bacteriological decay	Varied.	May initially cause superficial damage, but will eventually destroy the tissue.

[1] Attribute is not specifically listed in the standard, but is identified in the instructions provided to inspectors, and evaluated on the basis of free from damage or serious damage by other means.

Source: U.S. Department of Agriculture, Agricultural Marketing Service.

Table 8--Attributes considered in grading fresh tomatoes

Attribute	Description	Further implications for fresh tomatoes
Cleanness	Dirt or spray residue on surface.	May contain chemical residues.
Color	Lack of amount or intensity of hue.	May be immature.
Shape/smoothness	Unusual physical features.	Possible insect infestation or poor development.
Size	Unusually small or large.	Possible immaturity if too small.
Abnormally soft and watery[1]	Walls appear translucent and watery.	Taste may be affected.
Freezing injury	Watersoaked, translucent shriveled appearance.	May provide entry for organisms that cause decay.
Puffiness	Flattened sides, spongy texture, low weight.	
Soft	Fruit appears dull, translucent, watery, and soft over entire surface.	May provide entry for organisms that cause decay.
Bacterial spot[1]	Dark, raised scablike spots on surface.	Spots may enlarge.
Bacterial speck[1]	Small, smooth, slightly raised spots.	
Bruises[1]	Various sized flat, indented areas.	Underlying flesh may be damaged; possible entry for organisms that cause decay.
Catfaces	Misshapen, puckered blossom ends, leathery scars and/or tunnels into flesh.	Channels that penetrate into locules may leak and provide entry for organisms that cause decay.
Cuts and broken skins	Cuts or broken skins.	May provide entry for organisms that cause decay.
Growth cracks	Surface cracks around stem scar and over shoulders.	If unhealed, may provide entry for organisms that cause decay.
Nailhead spot[1]	Small, circular, slightly sunken spots.	
Scars	Light colored, smooth to dark, deep and rough.	
Skin checks[1]	Numerous small slitlike cracks on cuticle (surface).	May provide entry for organisms that cause decay.
Waxy blister[1]	Small blisterlike areas on surface.	
Ghost spots[1]	Silvery white rings beneath skin (visible on surface).	
Cloudy spot[1]	Light colored blotches in flesh (visible on surface).	Affected areas will not color normally, may affect flesh.
Sprayburn and dustburn spots[1]	Small brownish spots on surface.	

See footnote at end of table.

Continued--

Table 8--Attributes considered in grading fresh tomatoes--Continued

Attribute	Description	Further implications for fresh tomatoes
Discolored around stem[1]	Dark brown to black areas at margins.	May affect flesh, but perhaps not taste.
Sunken discolored areas[1]	Various-sized discolored areas scattered over surface of fruit.	Underlying flesh may be damaged.
Abnormal coloring[1]	Uneven, blotchy coloring.	May be caused by insect, disease, heat, or inadequate ventilation.
Sunburn[1]	Discoloration of tissue over shoulders.	May affect flesh.
Gray wall and other discolorations[1]	Grayish-brownish discoloration apparent through walls.	May affect entire fruit through walls.
Unhealed worm holes, worm and insect injury	Punctures, canals, and/or tunnels present.	May lead to insect or other infestations; may affect normal ripening and development; taste may be affected.
Healed insect stings	Small punctures with slight discoloration.	May contain eggs or larvae.
Sunscald	Light colored wrinkled or shriveled areas covering up to entire surface.	May affect flesh.
Fungal, viral, and bacteriological pathogens that cause decay	Varied.	May initially cause superficial damage, but will eventually destroy the flesh.

[1] Attribute is not specifically listed in the standard, but is identified in the instructions provided to inspector, and evaluated on the basis of free from damage or serious damage by other means.
Source: U.S. Department of Agriculture, Agricultural Marketing Service.

How Widespread Is the Use of Federal Grade Standards?

Federal grades are used for specifying quality in many produce transactions between packers, wholesalers, and retailers. In many cases, quality is specified by modifying the standards set forth in Federal grades. Moreover, packer brands often indicate quality levels that follow Federal grades.

Grading and inspection of fresh fruits and vegetables is voluntary, except when a Federal marketing order establishes minimum grade requirements, for produce sold to the Federal Government, and for certain commodities imported and exported.[5] (See box 5 for how grading and inspection work.) However, certain provisions of PACA and AMA apply when Federal grade standards are used to specify quality in a business contract. For instance, sellers must ship produce that meets grade standards when USDA grades are specified in business contracts. The inspection certificate is prima facie evidence that the seller fulfilled contract specifications. Furthermore, packers can stamp packages and containers with a USDA grade without prior inspection, but only if the produce meets standards for the designated grade. To use the USDA shield on packages and containers, packers must have the produce inspected by USDA. In addition, PACA requires commercial buyers and sellers of fresh and frozen fruits and vegetables to obtain a license from USDA. The license can be suspended or revoked if the buyer or seller is found to have committed repeated and flagrant unfair practices, including misrepresenting the quality of produce or not fulfilling contractual obligations.

[5] Congress passed the Agricultural Marketing Agreement Act of 1937 (AMAA) authorizing USDA to establish Federal marketing orders for fruits, vegetables, tree nuts, and milk. Section 8e of AMAA establishes that the minimum marketing order grade requirements for selected commodities apply to imports of that commodity. Thus, inspection of such imports is also mandatory when required under Section 8e.

Box 5

How Does the Grading and Inspecting Work?

To provide uniform grading and inspection, USDA established an impartial, third-party grading service. Official inspectors determine and certify the grade, quality, and condition of fresh produce and, upon request, issue inspection certificates. The grading and inspection of produce for quality and condition is based on standards of Federal or State grades or specifications of a marketing order or written business contract. Official inspectors are either USDA employees or State employees licensed by USDA and are adequately trained to grade and inspect. There are about 180 Federal inspectors of fresh produce working at terminal markets and other destination points. USDA also has cooperative agreements with State agencies, trade organizations, and one university to grade and inspect fresh produce at shipping points in each State and Puerto Rico. There are almost 6,000 federally licensed State inspectors. Any person who has a financial interest in the produce can obtain inspection. The person requesting the inspection pays a fee. Any person who has a financial interest in the produce and is dissatisfied with the results stated in the inspection certificate may appeal.

Table 11 categorizes commodities by frequency of use of Federal standards (including using Federal standards as a reference point) by packers, wholesalers, and retailers. Products included in the table were selected based on volume of shipments in four groups: fresh vegetables, melons, deciduous fruits, and citrus fruits. There is probably some variation across producing regions and buyer and seller types that is not fully reflected in table 11.

Federal grades are used in a limited way to describe the quality of produce to consumers. Retailers sometimes post the grade for potatoes, apples, dry onions, carrots, and fresh citrus. Packers and shippers sometimes place a grade on the outside of the container or the bag of prepackaged fresh produce. Grades for other fresh produce items generally are not posted in retail food stores.

Buyers and sellers use alternative mechanisms for describing the quality of produce. The following sections present examples of how minimum quality requirements under marketing orders, State grades, and private standards are used to describe quality.

Marketing Orders

Some Federal marketing orders for fresh fruits and vegetables have minimum quality regulations requiring that produce shipped to designated market uses meets certain minimum maturity, size, or grade standards (table 12). For example, the Federal marketing order for California kiwifruit permits 15 percent of the kiwifruit in a lot to be misshapened. The Federal marketing order for lemons sometimes prohibits sales of small-sized citrus in fresh domestic use.

State Grades

There also are State grade standards. For example, California has standards for asparagus; Washington for pears (looser tolerances than Federal standards) and apples (identical to Federal standards, except for a stricter color tolerance); and California, Montana, and Washington for sweet cherries (looser tolerances than Federal standards). Washington also has standards for apples stored in controlled atmospheres that are different from standards for apples stored in noncontrolled atmospheres.

Private Standards

Some firms have private standards for fresh produce. For instance, Sunkist, a large grower-owned marketing cooperative of western citrus, has its own grade standards for navel oranges, Valencia oranges, lemons, grapefruit, tangelos, and tangerines. Private standards are similar to Federal standards, except with stricter tolerances. There also is an informal industry grade standard for cucumbers, specifying only size. To develop market niches and buyer loyalty, packers (especially those shipping larger volumes) frequently label shipping containers, boxes, and packages.

Table 9--Attributes considered in grading fresh apples

Attribute	Description	Further implications for fresh apples
Cleanness	Dirt, dust, or spray residue on surface.	May contain chemical residues.
Color	Lack of amount or intensity of hue.	
Shape	Unusual physical features.	Possible insect infestation, immaturity, or growth imbalance indicating undesirable taste.
Size	Unusually small or large.	Possible immaturity if too small.
Bruises	Various sized flat depressed areas.	Underlying flesh may be damaged and/or inedible.
Hail marks	Small to large depressed areas.	If unhealed, may lead to insect or other infestations.
Limb rubs	Various shaped surface scars.	
Russeting	Slightly to moderately raised, pattern-like scarring.	
Stem and calyx cracks	Surface type cracks.	If unhealed, may lead to insect or other infestations.
Bitter pit or Jonathan spot	Numerous small brown sometimes pitted spots.	May damage flesh and spot indicate undesirable taste.
Cedar rust	Grayish yellow to yellow spots on calxy end of apple.	May extend into and damage flesh.
Cork, fruit, or brook spot[1]	Depressed, dimple-like, slightly discolored spots.	Flesh is usually brown corky tissue.
Red skin spots	Discolored spots in a variety of patterns.	
Scald	Light to dark brown areas covering up to entire surface.	May affect flesh.
Sprayburn or sunburn	Discolored, bleach-like area.	When severe, underlying flesh may be damaged.
Fly speck	Numerous small black circular spots caused by a fungus growing on insect excrement.	
Healed insect	Small punctures with mild discoloration.	May contain insect eggs or stings larva.
San Jose scale	Small circular to crescent shaped, discolored spots.	May contain small insects on the surface.
Sooty blotch	Dark granular spots or smudges on surface caused by fungus.	
Worm holes and unhealed insect injury	Large punctures, canals, or tunnels.	If unhealed, may lead to insect or other infestations. Worm or insect may be in flesh.

See footnote at end of table.

Continued--

Table 9--Attributes considered in grading fresh apples--Continued

Attribute	Description	Further implications for fresh apples
Various fungal, viral, and bacteriological decays	Varied.	May initially cause superficial damage but will eventually destroy the flesh.
Watercore	Watersoaked areas of the skin and/or flesh.	If visible externally, flesh appearance affected, but perhaps not taste.

[1] Attribute is not specifically listed in the standard, but is identified in the instructions provided to inspectors, and evaluated on the basis of free from damage or serious damage by other means.

Source: U.S. Department of Agriculture, Agricultural Marketing Service.

Buyers recognize and associate the label with a specific product quality when packers consistently ship a product of well-defined quality. The quality of produce sold with a label is implicitly based on Federal grade standards.

Buyers and sellers often specify the quality of produce when negotiating business deals by modifying one or more of the tolerances for attributes listed in Federal grade standards. Sometimes they add or delete factors and defects. For instance, a buyer may specify U.S. fancy McIntosh apples, except that the apples must be colored 60-percent striped or partially red and must not vary in diameter by more than 1 inch. Or a buyer may specify U.S. No. 1 grapefruit, except that not more than 10-percent of the surface, in the aggregate, may be discolored and the grapefruit shall not be larger than 5 inches in diameter and vary in diameter by more than 1 inch. These examples show how Federal grades are used as reference points for specifying quality in business transactions.

Pesticide Use in Producing and Marketing Fresh Produce

In this section, we explain reasons why growers and marketers use pesticides, review findings from an AMS program measuring pesticide residues in selected fresh produce items, review findings from surveys measuring consumers' concerns about pesticide use and residues, and explain Federal regulations governing pesticide use on fresh produce.

Why Do Growers and Packers Use Pesticides?

Pesticides serve to reduce stress on growing plants by eliminating undesired plants (that is, weeds) that compete for water, soil nutrients, and sunlight; to protect growing plants and produce from insects, rodents, fungi, bacteria, and nematodes (26); and to protect produce from insects, fungi, and bacteria during movement to market.

For example, consider tomatoes. About 80 chemical pesticides are registered with the Environmental Protection Agency (EPA) for preplanting, preharvest, or postharvest application to tomatoes (10). Herbicides tend to control weeds in the fields; acaracides kill mites; nematicides kill nematodes and small worms in the soil that damage the tomato plant's roots; fungicides reduce fungi that afflict the tomato plant with diseases; and insecticides kill insects that attach and damage the tomato plant (10).

Several studies have estimated the effects of pesticides on production. Two of the studies dealt with citrus thrips in California's Central Valley and are particularly interesting because they illustrate that pesticides affect yields as well as quality (7, 8). Citrus thrips feed around the stem of newly formed navel oranges, causing scarring. While damage resulting from citrus thrips is limited to the rind (internal quality and fruit size are unaffected), the affected orange typically is not marketable to fresh uses if the scarring exceeds about 5 percent of the orange's surface area. Citrus thrip damage can weaken fruit, elevating losses resulting from the natural dropping of fruit and, thereby reducing per acre yield. In a controlled experiment with young navel orange trees, the share of oranges severely scarred was lower, and per unit yield was higher, for trees treated with pesticides to control citrus thrip populations compared with oranges from untreated trees (7). In a 3-year controlled experiment with mature navel orange trees, dimethoate was applied to control citrus thrip populations. The share of oranges severely scarred (that is, scarred sufficiently to be graded down by the packinghouse) ranged from 0.5 to 0.8 percent for trees treated with one strategic application and

Table 10--Attributes considered in grading fresh oranges

Attribute	Description	Further implications for fresh oranges
Cleanness	Dirt or spray residue on surface.	May contain chemical residues.
Color	Lack of amount or intensity of hue.	May be immature.
	Excessive coloring.	Possible premature rind breakdown.
Shape	Unusual physical features.	
Size	Unusually small or large.	
Smoothness	Unusually rough textured rind.	Possible excessively thick rind.
Ammoniation	Dark brown, glossy spots on rind of various sizes and shapes.	May lead to cracks as fruit develops, which provide entry for insect or other infestations resulting in decay.
Bruises	Flattened sides or indentations.	Flesh may be damaged and inedible.
Buckskin	Surface of rind slightly roughened and grayish.	Possible excessively thick rind.
Caked melanose	Small brown raised spots that can be coalesced.	Fungus infection leading to flesh damage.
Creasing	Transparent irregular pattern of the rind.	Possible entry of bacteria infections leading to decay.
Green spots	Green areas on rind of various sizes.	
Hail injury	Pock marks or depressions.	Possible entry for bacteria infections leading to decay.
Hard or dry skin	Injury to the oil cells causing hard or dry rind.	Possible dehydration and shriveling of fruit.
Oil spots	Irregularly shaped yellow, green, or brown spots with oil glands prominent.	May progress into skin breakdown and flesh damage.
Orchid thrip	Brown discoloration occurring as rings or roughened areas similar to rust mite.	Possible dehydration and shriveling of fruit.
Pulled stems[1]	Torn rind adjacent to stem button.	Possible entry for insect or other infestations leading to decay.
Rust mite/russeting	Smooth brown discoloration to brown scarring and cracking of rind.	Possible dehydration and shriveling of fruit.
Scab	Irregular scabby areas or warty protuberances ranging from buff colored to dark olive-gray.	If severe, may cause misshapen fruit.
Scale	Purple scale with brownish-purple covering roughly the shape of an oyster shell.	May delay ripening.
Skin breakdown	Dry, darkened, and sunken oil cells in rind.	Possible entry for insect or other infestations leading to decay.
Scars	Range from smooth and light in color to rough and dark in color.	

See footnote at end of table.

Continued--

Table 10--Attributes considered in grading fresh oranges--Continued

Attribute	Description	Further implications for fresh oranges
Split, rough, or protruding navel	Split, rough, or protruding navel.	Possible entry for navel insect or other infestations leading to decay.
Sunburn	Bleached or deep yellow toughened rind and fattened surface.	Flesh may be inedible.
Thorn scratches	Deep discolored scratches or shallow like russeting.	Possible entry for insect or other infestations leading to decay.
Various fungal, viral, and bacteriological decay	Varied.	May initially cause superficial damage, but will eventually destroy the flesh.

[1] Attribute is not specifically listed in the standard, but is identified in the instructions provided to inspectors, and evaluated on the basis of free from damage or serious damage by other means.
Source: U.S. Department of Agriculture, Agricultural Marketing Service.

Table 11--Frequency of use of Federal grades by produce packers, wholesalers, and retailers[1]

Most frequent[2]	Less frequent[5]
Potatoes	Celery
Apples[3]	Corn, sweet
Pears[3]	Cantaloupes
Sweet cherries[3]	Honeydews
Frequent[4]	**Infrequent[6]**
Onions, dry	Broccoli
Tomatoes	Cucumbers
Carrots	Lettuce, iceberg, romaine, and other
Cabbage	Peppers, bell
Grapes, table	Watermelons
Peaches	Strawberries
Plums-prunes	California-Arizona oranges, grapefruit, and lemons
Nectarines	
Florida oranges and grapefruit	
Texas oranges	

[1] Includes use of Federal standards as a reference.
[2] Signifies more than three-fourths of commercial volume.
[3] The approximate share of commercial volume includes volume described using either State or Federal standards.
[4] Signifies more than one-half to three-fourths of commercial volume.
[5] Signifies more than one-fourth to one-half of commercial volume.
[6] Signifies less than one-fourth of commercial volume.

from 0.3 to 1.1 percent for trees treated with three strategic applications (8). In contrast, the share of oranges severely scarred ranged from 19.6 to 22.9 percent for untreated trees. Per plot yield was about 14 percent greater for trees treated with the three applications, and about 8 percent larger for trees treated with one application, compared with the untreated trees.

Another study found that fungicides reduced per acre yield losses as well as quality degradation for apples grown in North Carolina, while insecticides reduced only quality damage (4). Preventing quality degradation was the reason given for all of the insecticide use, but only 15 percent of the fungicide use. The study estimated that orchard growers use more insecticides and fungicides than profit considerations merited. However, some studies conclude that growers use too few pesticides (15).

Table 12--Fresh fruits and vegetables with mandatory Federal marketing order quality inspection[1]

Deciduous fruits	Citrus fruits	Potatoes
California nectarines	California-Arizona lemons (Size only)	Colorado
California peaches	Florida citrus	Idaho-East Oregon
California kiwifruit	Texas oranges and grapefruit	South Oregon-North California
Southeastern California desert grapes		Virginia-North Carolina
California Tokay grapes		Washington
Florida avocados	Vegetables	
Hawaiian papayas (Grade only)	Florida tomatoes	
Washington apricots	Idaho-East Oregon onions	
Washington sweet cherries	South Texas onions	
Washington-Oregon fresh prunes	Texas melons (Grade only)	

[1] Nine Federal marketing orders authorize minimum quality requirements, but the requirements are not in effect. Therefore, quality inspections are not performed. The nine orders are for California olives, Pacific Coast winter pears, Washington-Oregon Bartlett pears, California-Arizona navel oranges, California-Arizona Valencia oranges, Florida celery, Rio Grande Valley (Texas) tomatoes, South Texas lettuce, and Maine potatoes.
Source: U.S. Department of Agriculture, Agricultural Marketing Service.

Many factors affect growers pesticide use including net returns, aversion to low yields, and the availability and price of alternatives. Profit considerations encourage growers to monitor pest populations and use selective pesticides only when populations reach threshold levels that cause economic losses. Risk-averse growers may also apply more chemical pesticides to reduce the chance of low yields due to pest-related damage. Cost-effective biological controls without side effects are currently available for controlling some pests that affect some plants and other controls are being developed (1, 9, 27). The distribution of public funding and institutional rigidities may have influenced the development of chemical pesticides as opposed to alternatives, including biological controls (17).

In a closely related topic, several recent studies explored the effects of restricting or banning selected pesticides commonly used in the production of some feed grains, fresh vegetables, and nut crops (14, 31, 33). The effects depend largely on the availability of cost-effective substitutes, the extent production can shift to other areas (possibly where the pesticides are not restricted), and consumers' responsiveness to a price change. Because present substitutes are less effective or more expensive, restricting or banning the most widely used pesticides generally would elevate shortrun production costs and would reduce growers' profits. This would reduce quantities produced and would elevate consumer prices. Consumers lose more under a ban when they are less willing to reduce purchased quantities of the produce as price increases. Furthermore, the effects would vary across regions. For instance, production would concentrate in the relatively low-cost producing areas not requiring heavy use of the banned or restricted pesticides. The ban elevates growers' profits in these areas. The effects of reducing pesticide use may vary by farm size (33).

Packers apply post-harvest pesticides to produce to kill insects, fungi, viruses, and bacteria that cause quality degradation leading to eventual spoilage. Reducing and slowing quality degradation extends the feasible shipment distance and shelflife. To the extent that existing substitutes are less effective and more expensive, restricting the use of postharvest pesticides generally would elevate marketing costs (by increasing product spoilage), leading to higher prices for consumers and lower prices for growers. However, only a few empirical research efforts measure the magnitude of these effects.

Does Fresh Produce Contain Pesticide Residues?

The FDA monitors fresh produce for pesticide residues (See "How Does the Federal Government Oversee Pesticide Use on Fresh Produce?" on page 17). In addition, USDA has conducted special surveys about the incidence and level of residues for specific crops. A program was initiated in May 1991 to measure pesticide residues in grapes, lettuce, and potatoes near the consumer level (28). Apples, bananas, grapefruit, and oranges were added by September 1991. Samples initially were analyzed for the presence of 8 pesticides, but were expanded to 11 by November 1991. Included are eight chlorinated pesticides and three organophosphate pesticides that interest EPA because of health concerns and prevalence of use. The analysis for residues was expanded to 34 pesticides by December 31, 1991.

A total of 1,963 samples were analyzed for the 7 selected commodities (28). The samples were randomly selected from terminal produce markets and chain store distribution centers located in California, Florida, Michigan, New

York, Texas, and Washington, and included imports as well as domestically grown products. Twenty-three percent of the samples had detectable residues of at least 1 of the 11 pesticides. About 36 percent of the apple samples were positive, 35 percent of the grapes, 27 percent of the potatoes, 23 percent of the oranges, 17 percent of the lettuce and the grapefruit, and none of the bananas. All but four of the residues detected were at levels substantially below EPA's legal tolerances, which are deemed not to pose a human health risk. In the four cases, EPA had established no residue tolerance for the pesticides involved on those produce items. The USDA has continued this program, and test results for samples analyzed more recently are forthcoming.

Are Consumers Concerned About Pesticide Use and Residues?

Several recent surveys suggest that consumers are concerned about pesticide residues on produce, and about pesticide use during the growing and packing of produce (5, 18, 21, 23, 30, 32). Reasons for pesticide concerns vary, and include personal health risks as well as potential adverse effects to farm laborers, wildlife, ground water, and the environment. Responding to the concerns, some consumers have changed eating patterns, and many would like further assurances that pesticide residues are absent from the food supply. However, there are relatively few estimates of the amounts that consumers are willing to pay, or the amount of defects in appearance consumers would accept, to reduce or eliminate pesticide residues.

How Does the Federal Government Oversee Pesticide Use on Fresh Produce?

All pesticides used on domestically grown or imported produce must be registered with the EPA for that crop. Only pesticides approved by the EPA for specific crops can be applied to fresh produce. The FDA monitors pesticide residues on fresh produce and enforces compliance.[6]

Before a pesticide is used commercially, manufacturers are required to submit to the EPA results of experiments demonstrating the effectiveness and the health and environmental risks for each crop use. The manufacturer must also determine the maximum residue expected to be found on the produce when it leaves the farm field if the chemical is applied to effectively control the target pest(s).[7] This maximum expected residue is EPA's legal tolerance for the pesticide on that crop. Based on consumption patterns for different age groups and the legal tolerance, the EPA subsequently estimates the cumulative daily human intake of the pesticide from all food sources. If the EPA determines that the estimated cumulative daily intake of the pesticide probably exceeds a threshold value, registration of the chemical for that crop use is not approved. The threshold value is a scientifically determined level of chemical ingestion deemed not to pose a human health hazard. If a pesticide is approved for a crop, the EPA also specifies the application rates and other restrictions on use.

The FDA enforces EPA's tolerances and assesses the frequency and amount of pesticide residues in produce by routinely sampling fresh produce and testing for pesticide residues.[8] Sampling may be targeted to specific produce lots if there is a history of violations or evidence of probable violation. FDA is empowered to remove domestically grown produce from the market and to prevent importation when the tolerances are violated. FDA results for residue testing are not representative of the food supply because samples are partly selected to focus on pesticides likely to be of greatest health risk. For this reason, FDA also conducts an annual Total Diet Study to estimate the human dietary intake of pesticides. In this study, a bundle of food items, representing items purchased by households (as indicated by a national household survey), is sampled from retailers in 12 U.S. cities (that is, 3 cities in 4 regions) and tested for pesticide residues. The EPA uses these findings to help evaluate the registration of pesticides.

[6] This discussion is largely based on (2, 11, 13, 29).

[7] The maximum residue expected to be found on the produce is partly based on the manufacturer's maximum recommendation of the number of applications of the chemical, the timing of the applications, and the chemical dosage in each application for the pesticide to effectively control the targeted pest(s).

[8] The FDA also monitors raw and processed foods and livestock feeds for pesticide residues. The USDA monitors meats and poultry products for pesticide residues. Both departments monitor eggs and their products.

Grade Standards and Pesticide Use

In this section, we explore the relationship between Federal grades and pesticide use, and consider possibly changing grade standards or adding a testing and monitoring program separate from grades and standards to inform consumers about either pesticide use when the produce was grown and packed, or pesticide residues, or both.

Do Federal Grade Standards Affect Pesticide Use?

We have noted that sellers and buyers make extensive use of Federal grades to exchange information about produce quality. The existing grades convey information about external and internal product attributes, but not about the use of pesticides in production and packing or pesticide residues. The grades consequently do not help consumers choose or express preferences for produce grown and packed with reduced use of pesticides, or produce known to be low in pesticide residues. Such a grading system that disregards pesticide use and residues may lead growers and packers to apply more pesticides than they would if consumer preferences regarding pesticides were fully communicated.

Little evidence is available regarding the effects of grades on pesticide use. There is evidence that pesticides reduce quality degradation for some produce items (4, 7, 8). However, many pesticides serve to reduce both yield damage and quality degradation and the effects are not easily separated.

Will Consumers Sacrifice Outward Appearance for Lower Pesticide Residues?

Reducing the use of pesticides would in some cases increase the share of produce with blemishes and other defects (4, 7, 8). The acceptability of such produce to consumers is a key unknown.

Results of several surveys suggest that consumers are willing to accept some types of surface defects, but not all. The degree of consumers' acceptance is limited and probably varies across produce items. For example, in a survey of 560 consumers in State College, Pennsylvania, most respondents felt that tomatoes tested and certified as free of pesticides have more surface defects (30). Slightly more than half of the respondents would not buy tomatoes tested and certified as free of pesticides that had surface defects. However, more than 85 percent of the respondents expressed a strong willingness to buy nonuniform shaped or smaller sized tomatoes tested and certified as free of pesticides and also free of surface defects.

In a survey of 315 shoppers at 9 supermarkets in suburban Atlanta, about 38 percent of the respondents would not purchase fresh produce tested and certified as free of pesticides if it had more appearance defects than conventionally grown fresh produce (20). Only 12 percent of the respondents were willing to purchase fresh produce tested and certified as free of pesticides if it had insect damage.

Respondents to a 1991 national survey of 681 households were willing to accept only very minor amounts of surface defects (for example, apple scabs and plum curculio) to obtain apples with reduced residues (32). The tradeoff between residue reduction and surface defects was estimated as holding price constant. Respondents were willing to accept apples with about 12 percent surface defects if the apples were certified to have no pesticides, and with about 7.5 percent surface defects if the apples were certified to have either no detectable pesticide residues or no residues exceeding EPA's tolerances. Furthermore, focus group studies found worm damage to apples unacceptable.

In a survey of 229 shoppers at 12 grocery stores in northern and southern California, respondents were more accepting of scarred oranges after receiving information about the pesticides used to help achieve scar-free oranges (5). Initially, 22 percent of the respondents expressed a willingness to buy navel oranges with 10 percent scarring on the surface of the rind compared with a scar-free navel orange, and about 13 percent of the respondents were willing to purchase an orange with 20 percent scarring on the rind's surface area over a scar-free orange. After receiving the information, about 63 percent of the respondents were more willing to purchase oranges with 10-percent surface area scarring, and about 58 percent of the respondents were more willing to purchase oranges with 20-percent surface area scarring compared with the scar-free oranges.

Should Grade Standards for Outward Appearance Be Lowered?

Responding to concerns about the health and environmental effects of pesticides, some persons have proposed lowering Federal grade standards for external appearance, alleging that pesticide use would thereby be reduced. There is little evidence, however, about the effects of grades on pesticide use.

Some consumers might experience shortrun difficulties obtaining produce with appearance attributes they desire if standards for external appearance were lowered. Marketers, in turn, might develop alternative mechanisms to Federal standards, including expanded use of brands and business contracts specifying attributes, to deliver produce with appearance attributes that consumers desire. These incentives might eventually be passed back to growers, encouraging pesticide use for limiting appearance defects. Consequently, pesticide use may not change much. Growers and packers who can use brands most effectively probably would gain market share.

In sum, the net effect on consumers as a group from lowering grade standards for outward appearance is unclear. Consumers who are particularly concerned about pesticide residues and degrading the environment would benefit. Other consumers might have to do without the appearance attributes they value. However, pesticide use might not change much if marketers use alternative mechanisms for communicating preferences for appearance attributes.

Should Grade Standards Include Information on Pesticide Use and/or Pesticide Residues?

Can grade standards or a testing and certification program (separate from grade standards) be designed so that consumers can reliably choose produce with pesticide residues even lower than those already generally deemed safe for the public? The standards or testing and certification program might possibly be based on: (1) a uniform set of rules to be followed when measuring and reporting pesticide residues in fresh produce, or (2) monitoring of pesticide use from the fields through the marketing channels. Either approach would involve added costs. For example, the cost of testing for pesticide residue varies, depending on the sensitivity and comprehensiveness of the tests. Monitoring and presumably some spot-testing for pesticide residues would be necessary to assure that produce is grown and packed without pesticides.

Other Federal programs provide some information on residues and use of pesticides in production and marketing. For example, the recently enacted national organic food standard establishes a uniform standard that produce must meet to be labeled or represented as organic (16). (Organic produce is grown either with natural pesticides or with none at all rather than with synthetic ones.) Furthermore, some retailers interested in maintaining and perhaps expanding market share by providing quality assurance have established their own quality check programs, including residue testing and certification (11, 12). These independent programs may be confusing to consumers because of wide variation in retailers' scope of testing and reporting.

The pesticide testing and monitoring program could stand alone from the current grading program much like organic produce certification programs. Regardless, a voluntary program avoids the testing or monitoring costs for that portion of the produce that is not graded with the pesticide standards. It also would not impose such costs on those consumers who are satisfied with the existing standards and EPA's pesticide tolerances.

The extent to which adding pesticide testing to grade standards or establishing a separate testing and monitoring program would change the composition of fresh produce purchases depends on consumers' sensitivity to health and environmental risks, price differences, and product quality differences.[9] There is little empirical evidence regarding the magnitude of these changes. However, many consumers would probably continue buying nontested fresh produce, which sometimes contains pesticide residues within EPA's tolerances, if the health risks are low compared with the benefits. Many individual consumers probably would not pay the higher price for produce grown with reduced pesticides or pesticide-free produce purely for environmental benefits that are enjoyed by everyone. Many consumers who prefer visually attractive and tasty, fresh produce, but are sensitive to higher prices, would probably continue to buy fresh produce grown with pesticides.

[9] Consumers may interpret a grading system based on pesticide residues to mean that the health risks from produce vary by grade. This may result in predominantly lower income families purchasing produce with higher (but legally permissible) levels of pesticide residues, particularly if the prices were lower. A grading standard based on multiple pesticide residues may imply that society's health risk standard is partly based on the individual's wealth.

Marketers more likely would report pesticide testing results if consumers were expected either to pay an adequate premium to offset additional costs, or to expand purchases of the produce. Several surveys have attempted to measure consumers' willingness to pay for produce tested and certified as free of pesticides. In a survey of Georgia households, 46 percent of the 379 respondents (who answered the question) expressed a willingness to pay a premium for fresh produce tested and certified as free of pesticides (18). Based on the subsample of 168 households who were willing to pay a premium, 54 percent of the respondents were willing to pay a premium not exceeding 10 percent of the current price, but only 9 percent of the respondents were willing to pay a premium of more than 10 percent (18). In a survey of 560 consumers in State College, Pennsylvania, about 19 percent of the respondents would not pay a premium for tomatoes tested and certified as free of pesticides, 25 percent of the respondents would pay a premium of up to 5 percent, 30 percent of the respondents would pay a premium of up to 10 percent, and about 26 percent of the respondents would pay a premium exceeding 10 percent (30).

In a national survey, consumers' willingness to pay for an apple with a label describing different levels of pesticide residues versus an unlabeled apple was explored using data from the 681 households who sufficiently completed the mail survey (32). Consumers were willing to pay an average increase of 37.5 cents per pound for apples tested and certified as free of pesticides, about 23.6 cents per pound for apples tested to have no detectable pesticides, and about 23.6 cents per pound for apples tested to have pesticide levels within EPA's legal tolerances.

Grading based on pesticide residue testing has several potential problems. The time required for testing might slow shipment flows, increasing marketing costs and possibly elevating product degradation. Despite these problems, some retailers already voluntarily test for pesticide residues (11, 12). Samples are randomly selected from the lot of produce sold as free-of-selected pesticides and delivered to a laboratory for testing. Chemists perform tests and report the results the following day to the receiver. Much of the produce arriving in many cities is in transit for at least a day, so delays from testing and verification should be minimal. More comprehensive testing and reporting might cause further delays, however.

Providing information to consumers about pesticide use in growing and packing (in contrast to pesticide residue testing and reporting) would require a different approach to grading. Methods for verifying levels of pesticide use throughout the growing and packing periods would have to be developed and implemented. This might require several visits by inspectors to the field or orchard, packing shed, and shipping and storage facilities, possibly including unannounced spot checks. Alternatively, growers and packers might have to verify use of accepted practices much like requirements under organic produce certification programs.

References

1. Angier, Natalie. "Plants Defy Microbes with Immune Defense and Self-Mutilation," *The New York Times*. Aug. 18, 1992.

2. Archibald, Sandra O., and Carl K. Winter. "Pesticides in Food: Assessing the Risks," *Chemicals in the Human Food Chain*. Editors, Carl K. Winter, James N. Seiber, and Carole F. Nuckton. Pp. 1-47. University of California, Agricultural Issues Center. 1989.

3. Armbruster, Walter J., Dennis R. Henderson, and Ronald D. Knutson, Eds. *Federal Marketing Programs in Agriculture: Issues and Options*. The Interstate Printers and Publishers, Inc. 1983.

4. Babcock, Bruce A., Erik Lichtenberg, and David Zilberman. "Impact of Damage Control and Quality of Output: Estimating Pest Control Effectiveness," *American Journal of Agricultural Economics*, 74: 163-72. 1992.

5. Bunn, David, Gail W. Feenstra, Lori Lynch, and Robert Sommer. "Consumer Acceptance of Cosmetically Imperfect Produce," *Journal of Consumer Affairs*, 24: 268-79. 1990.

6. Curtis, Jennifer, Lawrie Mott, and Tom Kuhnle. *Harvest of Hope: The Potential for Alternative Agriculture to Reduce Pesticide Use*. Natural Resources Defense Council. May 1991.

7. Elmer, H.S., W.H. Ewart, and O.L. Brawner. "Effect of Citrus Thrips Populations on Navel Orange Fruit Yield and Tree Growth in Central Valley," *Citrograph*, 61: 9-10, 20-22. 1975.

8. Elmer, H.S., and O.L. Brawner. "The Effect of Citrus Thrips and Citrus Red Mite on Navel Orange Fruit Production in California's San Joaquin Valley," *Proceedings of the 1988 International Society of Citriculture*. 1988.

9. Feder, Barnaby J. "Biosys's Pest Killers Go Underground," *The New York Times*. Aug. 18, 1992.

10. Garbus, Joel, Susan Hummel, and Stephanie Willit. "The Life Story of a Tomato," *EPA Journal*, Vol. 16, No. 3, pp. 23-27, Envir. Prot. Ag. May-June 1990.

11. Hotchkiss, Joseph H. "Pesticide Residue Controls to Ensure Food Safety," *Critical Reviews in Food Science and Nutrition*, 31: 191-203. 1992.

12. Kaufman, Phil, and Doris J. Newton. "Retailers Explore Food Safety and Quality Assurance Options," *National Food Review*. Vol. 13, Iss. 4, pp. 11-15. U.S. Dept. Agr., Econ. Res. Serv. Oct.-Dec. 1990.

13. Labuza, T.P., and W. Baisier. "The Role of the Federal Government in Food Safety," *Critical Reviews in Food Science and Nutrition*, 31: 165-76. 1992.

14. Lichtenberg, Erik, Douglas D. Parker, and David Zilberman. "Marginal Analysis of Welfare Costs of Environmental Policies: The Case of Pesticide Regulation," *American Journal of Agricultural Economics*, 70: 867-74. 1988.

15. Lin, Biing-Hwan, Sharon Jans, Kevin Ingram, and LeRoy Hansen. "Pesticide Productivity in Pacific Northwest Potato Production," *Agricultural Resources: Inputs Situation and Outlook Report*, AR-29, pp. 44-48. U.S. Dept. Agr., Econ. Res. Serv. Feb. 1993.

16. Lynch, Lori. "Congress Mandates National Organic Food Standards," *Food Review*, Vol. 14, Iss. 1, pp. 12-15. U.S. Dept. Agr., Econ. Res. Serv. Jan.-Mar. 1991.

17. MacIntyre, Angus A. "Why Pesticides Received Extensive Use in America: A Political Economy of Agricultural Pest Management to 1970," *Natural Resources Journal*, 27: 533-78. 1987.

18. Misra, Sukant K., Chung L. Huang, and Stephen L. Ott. "Consumer Willingness to Pay for Pesticide Free Fresh Produce," *Western Journal of Agricultural Economics*, 16: 218-27. 1991.

19. Office of Technology Assessment. *Perspectives on Federal Retail Food Grading*. June 1977.

20. Ott, Stephen L. "Supermarket Shoppers' Pesticide Concerns and Willingness to Purchase Certified Pesticide Residue-Free Fresh Produce," *Agribusiness: An International Journal*, 6: 593-602. 1990.

21. Ott, Stephen L., Chung L. Huang, and Sukand K. Misra. "Consumers' Perceptions of Risks for Pesticide Residues and Demand for Certification of Residue-Free Produce," *Economics of Food Safety*, pp. 175-88. Julie A. Caswell, ed. Elsevier Science Publishing Co., Inc. 1991.

22. Rosenblum, Gene. *On the Way to Market: Roadblocks to Reducing Pesticide Use on Produce*. Public Voice for Food and Health Policy. Mar. 1991.

23. Sachs, C., D. Blair, and C. Richter. "Consumer Pesticide Concerns: A 1965 and 1984 Comparison," *The Journal of Consumer Affairs*, 21: 96-107. 1987.

24. Smith, Maryanna S., and Dennis M. Roth. *Chronological Landmarks in American Agriculture*. AIB-425. U.S. Dept. Agr., Econ. Res. Serv. Nov. 1990.

25. *Supermarket News*. "Group Criticizes Cosmetic Standards." Sept. 26, 1988.

26. Terpstra, Ellen. "Right to the Core," *Fruit Grower*. May 1992.

27. U.S. Congress, Office of Technology Assessment. *A New Technological Era for American Agriculture*. OTA-F-474. Aug. 1992.

28. U.S. Department of Agriculture, Agricultural Marketing Service. *Pesticide Data Program: Calendar Year 1991 Report, Addendum*. 1992.

29. U.S. General Accounting Office, U.S. Comptroller General. *Food Safety and Quality: Who Does What in the Federal Government*. RCED-91-19B. Dec. 1991.

30. Weaver, Robert D., David J. Evans, and A.E. Luloff. "Pesticide Use in Tomato Production: Consumer Concerns and Willingness-to-Pay," *Agribusiness: An International Journal*, 8: 131-42. 1992.

31. Whittaker, Gerald, Biing-Hwan Lin, and Utpal Yasavada. "Restricting Pesticide Use: The Impact on Profitability by Farm Size," *Agricultural Resources: Inputs Situation and Outlook Report*, AR-28, pp. 43-46. U.S. Dept. Agr., Econ. Res. Serv. Oct. 1992.

32. van Ravenswaay, Eileen, and John P. Hoehn. *Consumer Willingness to Pay for Reducing Pesticide Residues in Food: Results of a Nationwide Survey*. SP-91-18. Michigan State University, Dept. Agr. Econ. Mar. 1991.

33. Zilberman, David, Andrew Schmitz, Gary Casterline, Erik Lichtenberg, and Jerome B. Siebert. "The Economics of Pesticide Use and Regulation," *Science*, 253: 518-22. 1991.

U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Restricting Chemical Use on the Most Vulnerable Cotton Acreage Can Protect Water Quality With Only Minor Effects on Cotton Yields and Prices

Number 6, January 1993

Contact: Stephen R. Crutchfield, (202) 219-0444.

Environmental damage to surface and ground water posed by cotton farming may be reduced, with only limited effects on yields and prices, if restrictions on agrichemical use or production are applied to just those acres most vulnerable to water-quality problems. The most widespread potential damage is from nitrates in fertilizer that can pollute ground water and pesticides that can contaminate surface water.

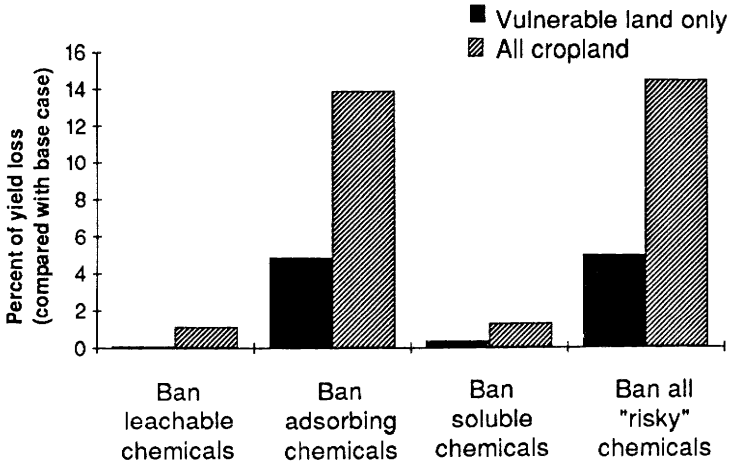
Production of cotton appears less likely than other crops to cause erosion-induced water-quality problems because cotton acreage is not the major source of cropland erosion in most regions. Widespread restrictions on the use of chemicals likely to leach, dissolve in cropland runoff, or attach to eroding soils may reduce the risk of water-quality degradation, but may also raise cotton prices by reducing yields. These conclusions flow from USDA's 1989 Cotton Water Quality Survey that gathered data on cotton agricultural chemical use and related production practices and resource conditions in 14 cotton States. Data gathered on the use of fertilizers, herbicides, insecticides, and other agricultural chemicals were analyzed to assess the potential water-quality problems that may be associated with cotton production.

Widespread Restrictions Could Raise Cotton Prices

The study's results highlight the importance of targeting pollution-prevention programs to attain the most cost-effective environmental protection strategies. Restricting the use of environmentally damaging chemicals on all cotton acreage could reduce the overall potential for water-quality impairment, but could raise cotton prices by as much as 31 percent. More specific chemical-use restrictions, targeted to acreage considered at greatest water-quality risk, could achieve nearly the same level of environmental protection, but would limit price increases and reduce yield losses. Modifying production practices to reduce soil erosion could generate $25 million in economic benefits by reducing sedimentation in surface water systems.

Yield losses from chemical restrictions on cotton acreage

Yield losses are minimized if chemical restrictions are targeted to only cotton acreage at greatest water-quality risk.



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