

# Safety of Consumer Handling of Fresh Produce from the Time of Purchase to the Plate: A Comprehensive Consumer Survey

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## ABSTRACT

A national mail survey focusing on consumer handling of fresh fruits and vegetables was conducted among 2,000 randomly selected households in the United States. The objective was to quantify consumer practices relating to the purchase, transport, storage, and preparation of fresh produce, with emphasis on practices that affect safety. Following an additional mailing procedure, a response rate of 33% was obtained. Six percent of the consumers responded that they seldom or never wash fresh produce, and more than 35% indicated that they do not wash their melons before preparation. Twenty-three percent of the respondents indicated placing their meat, poultry, and fish on a refrigerator shelf above other foods, and 9% do not place their produce at any specific location in the refrigerator. Almost half of the respondents indicated not always washing their hands before handling fresh produce. Ninety-seven percent of respondents reported that they always wash their food preparation surfaces after contact with meat products, yet 5% and 24% dry wipe or wash with water only, respectively. The results from this study suggest that women, lower-income households, people 65 years and older, and non-college graduates practice safer food handling methods than men, higher-income households, people younger than 65 years, and college or postcollege graduates. The survey findings suggest that consumer education materials should emphasize safe handling practices from purchase through consumption. Educational outreach should target specific subpopulations, men, college graduates, higher-income households, and people younger than 65 years because of their higher frequency of unsafe handling and washing practices.

Foodborne disease is a major health problem in the United States. It is estimated that there are 76 million cases of human illnesses in the United States caused by foodborne pathogens (45). Between 1993 and 1997, 2,751 foodborne disease outbreaks were reported by the Centers for Disease Control and Prevention, and 86,058 persons became ill in association with these outbreaks (48).

Although fresh produce is not a common vehicle for foodborne diseases compared with other types of foods, the number of reported foodborne outbreaks and cases of illness associated with the consumption of fresh produce in the United States has increased from 2% (1973 to 1987) to 5 and 8% (1988 to 1991), respectively (60). Between 1988 and 1992, 64 (6%) of 1,072 foodborne disease outbreaks in which a specific food was identified and 2,448 (5%) of 48,475 cases of illness were associated with the consumption of fresh produce (69).

Various foodborne pathogenic microorganisms have been linked to cases of foodborne infection and isolated from many different varieties of fresh fruits and vegetables (9, 27, 60). The changing patterns of food consumption in the United States, the recognition of fresh fruits and vegetables as possible vehicles for transmission of foodborne pathogens, and the emergence of foodborne pathogens with low infectious doses could contribute to the increase in produce-associated outbreaks (60). For example, *Cyclospora*

spp., *Escherichia coli* O157:H7, hepatitis A virus, and *Shigella* spp. are infectious at relatively low levels (44, 56). In response to the increased occurrence of foodborne outbreaks associated with fresh produce, recommendations for handling produce have begun to appear in literature and on the Internet (12, 31, 34, 59, 61).

Although most reported foodborne outbreaks occur from food prepared and consumed outside the home, an estimated 65 million to 81 million Americans have foodborne illness due to food prepared at home (2). However, most consumers believe that foodborne illness occurs least frequently in the home compared with other places (32, 37). The common misconception that foodborne illness does not occur frequently in the home may have an impact on the severity of unsafe food handling practices in the home (14). This study was performed to determine the prevalence of poor produce handling practices, including insufficient washing, poor hygiene, cross-contamination, temperature abuse, and inappropriate storage conditions. The results will then be used to create consumer education materials that will be targeted to correct unsafe practices.

## MATERIALS AND METHODS

A national mail survey was conducted in spring 2000 to assess consumers' attitudes toward safety and handling and washing practices associated with fresh fruits and vegetables. Before the survey, a focus group study was conducted in early 1999 to identify current methods of handling and washing fresh produce in California. Based on focus group findings, a series of questions

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TABLE 1. Demographic characteristics of respondents and the U.S. population

Demographic characteristics	No. (%) of respondents	% of U.S. population or households <sup>a</sup>
Sex ( <i>n</i> = 621)		
Female	435 (70)	—
Male	186 (30)	—
Ethnicity ( <i>n</i> = 615)		
Caucasian	532 (88)	71
Hispanic American	17 (3)	11
African American	23 (4)	13
Asian American	22 (4)	4
American Indian	4 (1)	1
Other	11 (2)	—
Age group ( <i>n</i> = 619) (y)		
≤24	9 (2)	—
25–34	57 (9)	—
35–44	113 (18)	—
45–54	148 (24)	—
55–64	100 (16)	—
≥65	192 (31)	—
Education level ( <i>n</i> = 620)		
Some high school	26 (4)	—
High school graduate	166 (27)	—
Some college	168 (27)	—
College graduate	171 (28)	—
Postcollege graduate	89 (14)	—
Household income level ( <i>n</i> = 624)		
<\$15,000	39 (6)	17
\$15,000–\$24,999	36 (6)	13
\$25,000–\$34,999	79 (13)	12
\$35,000–\$49,999	70 (11)	15
\$50,000–\$74,999	130 (21)	19
\$75,000–\$99,999	67 (11)	11
> \$99,999	39 (6)	13
Prefer not to answer	164 (26)	—

<sup>a</sup> County Level Aggregate Demographics Report from Survey Sampling, Inc. Annual estimates projected forward from the U.S. 1990 Census.

was asked in the survey to assess the respondents' practices and attitudes toward the purchase, transportation, storage, handling, and washing of fresh produce, prewashed salads, pre-cut fruits and vegetables, and six common fruits and vegetables. The fruits and vegetables selected (i.e., apples, broccoli, carrots, lettuce, melon, and strawberries) are commonly purchased and represent a variety of textures and growth environments. Consumers were also asked their preferred sources for receiving information on safe handling practices of fresh fruits and vegetables. Finally, demographic characteristics (i.e., sex, ethnicity, education, income, and age) were also collected.

The questionnaire was pilot tested (*n* = 12) for refinement. The coded questionnaires, each enclosed with a personally signed cover letter on university letterhead, which indicated voluntary participation and confidentiality, and a postage-paid return envelope were mailed to a sample of 2,000 households in the United States. Persons that mainly purchased and prepared fresh fruits and vegetables in the households were asked to complete the ques-

TABLE 2. Consumer preference for packing fresh produce in the grocery bag

Bagging of fresh produce ( <i>n</i> = 599)	% of respondents <sup>a</sup>
Separately from canned foods	16
Separately from meat, poultry, and fish	28
On the top or separately, so they will not be crushed	32
Heavy items on the bottom and light items on top	27
No special requirements	51

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

tionnaire. The names and mailing addresses of the sample, purchased from Survey Sampling, Inc. (Fairfield, Conn.), reflected demographic distribution of the United States (Table 1).

A subsequent mailing procedure was used to enhance return rates (26). One week after the initial mailing, a thank you/please return questionnaire postcard was mailed to all households. Three weeks after the postcards were mailed, another copy of the questionnaire, letter, and postage-paid return envelope were mailed to nonresponders.

Of the 2,000 questionnaires mailed, 624 were returned and analyzed, and 110 were undeliverable, resulting in a return rate of 33% ( $624/[2,000 - 110] = 33\%$ ). Frequencies of safe handling and washing behaviors were calculated and chi-square tests, using the SPSS (10.0 for Windows) statistical program, were performed to determine if the handling behavior was related to demographic characteristics.

## RESULTS

Of the 624 respondents, 70% were women. The respondents represented a high percentage of Caucasians (88%), persons with at least some college education (69%), and persons 65 years and older (31%) (Table 1). Medium income was \$50,000 to \$74,000. Compared with the demographics projected forward from the 1990 U.S. Census (57), Caucasians were overrepresented in the sample, whereas Hispanic Americans (3% sample versus 11% nationwide) and African Americans (4% sample versus 13% nationwide) were underrepresented. Compared with the 1990 U.S. Census, households with incomes of less than \$25,000 and households with incomes of more than \$99,999 were underrepresented.

To see if demographic characteristics were related to food handling practices, chi-square tests were performed; sex, age, income, and education were shown to be related to some safety-related food handling practices at a significance level of 0.05 and lower ( $P \leq 0.05$ ).

**Produce handling practices at the market.** When asked if they specified how fresh produce should be bagged to take home, less than 30% of respondents indicated separating fresh produce from meat, poultry, and fish (Table 2). More than 50% of respondents indicated "no special requirements" for packing fresh produce. More college and postcollege graduates reported that they bag produce without special requirements ( $P = 0.050$ ) than those who were not college graduates.

TABLE 3. Consumer washing of fresh produce in the home after returning from the market

Washing practices (n = 607)	% of respondents who replied yes <sup>a</sup>
Just before preparing or cooking	81
Before placing in the refrigerator	21
Before leaving out on a counter or in a bowl	19
Seldom or never wash	6
Other	<1

<sup>a</sup> Percentages can be greater than 100% because respondents may check “yes” to more than one category.

**Produce washing in the home.** Although 81% of the respondents indicated that they wash fresh produce just before preparation and cooking, approximately 20% practiced more risky washing methods; 21% indicated washing their produce before storing in the refrigerator, and 19% washed produce just before storing at room temperature on the counter or in a bowl (Table 3). Results from the chi-square tests showed that more women indicated washing fresh produce right before preparation and cooking compared with male consumers ( $P = 0.010$ ). Consumers 65 years and older were more likely to wash produce just before refrigeration ( $P = 0.041$ ) and less likely to wash just before preparation and cooking than the younger age groups ( $P = 0.004$ ). Many respondents with a household income level of less than \$35,000 reported washing produce before refrigeration compared with those with higher incomes ( $P = 0.033$ ).

When asked in a general question, 6% of the consumers responded that they seldom or never wash fresh produce (Table 3); failure to wash specific produce items, however, was higher, with melons washed less frequently than other items. More men compared with women ( $P = 0.007$ ) and more postcollege graduates compared with those with lower education levels ( $P = 0.031$ ) seldom or never washed fresh fruits and vegetables. Specifically, more than 35% indicated that they do not wash melons before preparation (Table 4).

TABLE 4. Consumer preparation of fresh fruits and vegetables<sup>a</sup>

Fruit or vegetable	Do not wash	Peel	Rub with hands	Scrub with brush	Soak in container or sink	Wash under running water	Use vinegar	Use dish detergent	Use chlorine solution	Use commercial solution
Apple (n = 622)	4	28	22	6	2	86	1	4	<1	2
Whole carrot (n = 623)	2	57	8	17	3	74	<1	1	<1	1
Whole broccoli (n = 619)	2	3	5	1	15	79	1	1	<1	1
Baby carrots, not bagged (n = 618)	6	NA	7	7	5	48	<1	<1	1	1
Head or leaf lettuce (n = 622)	4	NA	6	<1	15	88	1	1	1	1
Whole melon (n = 619)	36	28	5	4	2	35	<1	1	1	<1
Strawberry (n = 622)	2	NA	6	1	20	88	0	1	<1	1

<sup>a</sup> Data are percentages of respondents. Percentages can be greater than 100% because respondents may check “yes” to more than one category. NA, not applicable.

Respondents 65 years and older ( $P = 0.000$ ), those with higher income levels ( $P = 0.000$ ), and those with more formal education levels ( $P = 0.032$ ) were more likely to report not washing whole melons compared with younger respondents, those with lower income, and those with less formal education.

**Methods of produce washing.** Respondents were asked to identify their washing methods for each of the six produce items. Relatively effective methods (peeling, rubbing with hands, scrubbing with a brush, and washing under running water, chlorine solution, and commercial solution) and potentially unsafe or ineffective methods (highly diluted vinegar, soaking in a container or sink, and dish detergent) were listed for consumers to select (Table 4). The most common method of handling was washing fresh produce under running water.

**Home storage.** Most respondents stored fresh produce either in the refrigerator produce drawer or on a shelf; however, 6% stored strawberries at room temperature, and a large percentage stored apples (42%) and melons (24%) at room temperature (Table 5). Almost half indicated storing meat, poultry, and fish in the recommended locations, with 47% citing the refrigerator’s meat-poultry drawer and 20% using the bottom shelf (Table 6). Almost one quarter stored meat, poultry, and fish on a shelf above other foods, and 9% placed these items wherever there was room. More people younger than 65 years indicated storing meat, poultry, or fish at no specific location in the refrigerator than those who were 65 years and older ( $P = 0.011$ ).

**Hand washing.** Almost half of the respondents indicated that they did not always wash their hands before handling fresh produce; 34% wash most of the time, 9% wash some of the time, 3% rarely wash, and 1% never wash (Table 7).

**Refrigerator cleaning.** More than 50% of the respondents indicated cleaning their refrigerators at least once a month (Table 8). More women and noncollege graduates reported cleaning at least once a month, whereas more men and college or postcollege graduates indicated cleaning two

TABLE 5. Percentage of consumers who store fruits and vegetables in the refrigerator and at room temperature

Fresh produce	Respondents' storage locations of fresh fruits and vegetables <sup>a</sup>			
	Room temperature (%)	Refrigerator fruit or vegetable drawer (%)	Refrigerator shelf (%)	Do not buy (%)
Apples ( <i>n</i> = 609)	42	63	12	1
Strawberries ( <i>n</i> = 604)	6	45	53	5
Whole carrots ( <i>n</i> = 607)	1	88	13	3
Preprepared fresh vegetables ( <i>n</i> = 601)	<1	73	17	14
Whole broccoli ( <i>n</i> = 600)	1	70	24	12
Whole melons ( <i>n</i> = 597)	24	27	56	5
Preprepared fresh fruits ( <i>n</i> = 607)	1	19	35	49
Lettuce, leaf or head ( <i>n</i> = 607)	1	82	23	3
Prewashed lettuce or spinach ( <i>n</i> = 602)	<1	63	21	23

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

to three times a year or less ( $P = 0.000$ ). Likewise, more people with an income level of \$34,999 and lower claimed to clean weekly than those with an income level of \$35,000 and higher ( $P = 0.001$ ).

Respondents were asked to indicate their methods of cleaning the refrigerator; a list of possible cleaning agents (bleach, cleanser or cleaning solution, dishwashing liquid, antibacterial soap, vinegar, and baking soda) or water only were provided as possible choices for respondents to select. Dishwashing liquid (46%) was used most frequently to clean the refrigerator, followed by baking soda (35%) and cleanser or cleaning solution (32%) (Table 9). More than 10% of respondents indicated using water as the only method of cleaning the refrigerator. This practice was more common among respondents 44 years and younger compared with older age groups ( $P = 0.037$ ) and college and post-college graduates compared with noncollege graduates ( $P = 0.008$ ).

**Sink cleaning.** About 56% reported that they always wash the sink before handling fresh produce, and about 49% always wash the sink after handling (Table 10). Although most indicated using a cleanser or cleaning solution (69%), dishwashing liquid (48%), bleach (27%), antibacterial soap (19%), or baking soda (9%) to clean the sink, 11% indicated water as their only means of cleaning the sink (Table 9).

More noncollege graduates indicated they always clean

TABLE 6. Consumer storage of meat, poultry, and fish in the refrigerator

Storage locations in refrigerator ( <i>n</i> = 611)	% of respondents <sup>a</sup>
In the freezer	66
In the meat-poultry drawer	47
No special location, wherever there is room	23
On the bottom shelf	20
On the shelf above the other foods	9
Do not buy meat, poultry, or fish	2

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

the sink before and after washing fresh produce compared with college or postcollege graduates ( $P = 0.000$ ). Likewise, more consumers 65 years and older and those with a lower income levels reported that they always washed the sink before and after washing produce compared with consumers 64 years and younger ( $P = 0.000$ ) and those with an income level of \$75,000 and higher ( $P = 0.003$ ;  $P = 0.048$ ). Postcollege graduates were more likely to wash the sink with water as the only cleaning agent than those with a lower education level ( $P = 0.001$ ).

**Washing cutting surfaces and knives.** Most respondents (97%) reported that they always washed their cutting surfaces after contact with meat, poultry, or fish; nine respondents (2%) reported that they sometimes washed after cutting meat and sometimes or seldom or never washed before cutting vegetables (Table 10). Most respondents indicated always cleaning after cutting meat products and before and after cutting produce (60% and 86%, respectively) and making sandwiches (65% and 80%, respectively). More than 20% of consumers indicated using water and 5% simply dry wipe their food cutting and preparation surfaces (Table 9).

More women indicated always washing their food cutting surface before and after making sandwiches ( $P = 0.031$ ;  $P = 0.038$ ) and cutting fresh produce ( $P = 0.006$ ;  $P = 0.010$ ) than men. More people with an income level of \$34,999 and lower indicated always washing their cutting or preparation surface before cutting meat ( $P = 0.010$ ) and produce ( $P = 0.017$ ) than those with a higher income level. College or postcollege graduates were less likely to

TABLE 7. Consumer frequency of hand washing before handling fresh produce

How often do you wash your hands? ( <i>n</i> = 619)	% of respondents
Every time	53
Most of the time	34
Some of the time	9
Rarely	3
Never	1

TABLE 8. Consumer frequency of refrigerator cleaning

How often do you clean your refrigerator? (n = 609)	% of respondents
Weekly	14
Once a month	40
2-3 times a year	34
Yearly	7
Less than once a year	5

always wash their food preparation surface before cutting produce ( $P = 0.001$ ); before cutting meat, poultry, and fish ( $P = 0.006$ ); and before making sandwiches ( $P = 0.000$ ) than noncollege graduates. In addition, more people 65 years and older indicated always washing their food cutting surface before cutting produce ( $P = 0.001$ ) and making sandwiches ( $P = 0.000$ ) than the younger age groups. Men and college or postcollege graduates were also more likely to wash their cutting surfaces with water only than women and noncollege graduates ( $P = 0.000$ ).

Some consumers did not adequately clean kitchen utensils. Almost 20% indicated that sometimes they just rinsed their knife with water and 8% just wiped with a paper towel after cutting raw meat, poultry, or fish and before cutting produce (Table 11). Men were more likely to wipe their knives with a paper towel than women ( $P = 0.003$ ), whereas women were more likely to use a different knife when switching from meat to produce ( $P = 0.000$ ).

**Consumer attitudes toward safe handling.** Respondents reported that the most common reason to wash fresh produce is to remove dirt (93%), followed by removal of pesticides (79%) and bacteria or germs (60%) (Table 12). Consumers responded that when they did not wash produce, it was because they did not serve or eat the produce with the skin on (16%).

More than 30% of the respondents were not interested in obtaining information on safe produce handling (Table 13). When asked what information sources on safe produce handling were most convenient, more than 50% indicated a supermarket brochure (Table 13).

Consumer attitudes toward information differed by sex, income, education, and age. More women indicated an interest in obtaining information on safe handling of fresh produce compared with men ( $P = 0.038$ ). More women reported that recommendations listed on a supermarket bag ( $P = 0.029$ ) and on a produce container ( $P = 0.003$ ) were convenient ways to obtain safe handling information, whereas men preferred Internet Web sites ( $P = 0.001$ ). Likewise, college or postcollege graduates ( $P = 0.001$ ) and people with an income level of \$75,000 and higher ( $P = 0.012$ ) preferred a Web site as a source of receiving information, whereas those with no college experience and those with an income level of \$34,999 and lower did not consider the Web convenient. Likewise, people 65 years and older do not prefer to use the Web compared with the younger age groups ( $P = 0.000$ ). Results also showed that people 65 years and older were less likely to prefer supermarket brochures, whereas people between the ages of 55 and 64

TABLE 9. Consumer methods of cleaning areas in the kitchen

Source	% of respondents <sup>a</sup>
What do you usually use to clean your refrigerator? (n = 612)	
Dishwashing liquid	46
Baking soda	35
Cleanser or cleaning solution	32
Antibacterial soap	15
Water only	14
Bleach	13
Vinegar	10
Other	1
What do you usually use to clean your kitchen sink? (n = 614)	
Cleanser or cleaning solution	69
Dishwashing liquid	48
Bleach	27
Antibacterial soap	19
Water only	11
Baking soda	9
Vinegar	4
Other	2
Which do you use to wash your food-cutting or preparation surface? (n = 610)	
Dishwashing liquid	70
Cleanser or cleaning solution	36
Antibacterial soap	24
Water only	24
Bleach	22
Baking soda	8
Dry wipe (no water or solution)	5
Other	5
Vinegar	4

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

years and those 44 years and younger preferred brochures ( $P = 0.018$ ). More people 44 years and younger preferred a magnet with food handling information to place on the refrigerator compared with older age groups ( $P = 0.000$ ). People 65 years and older were more likely to report a preference for a newspaper article compared with those 44 years and younger ( $P = 0.000$ ). People 65 years and older were also more likely to prefer information on a produce container than those between the ages of 55 and 64 years and those 44 years and younger ( $P = 0.043$ ). Consumers between the ages of 45 and 54 years were more likely to prefer a cooking show than those 44 years and younger ( $P = 0.021$ ).

**DISCUSSION**

Results suggest that consumers need to improve handling of produce even before the produce is prepared in the home. About one third or more of consumers reported that they do not bag their produce in a way to separate it from potential juices from raw meat, poultry, or fish during transportation from the market to the home. To prevent potential cross-contamination, consumers should place fresh produce and raw meat, poultry, and fish products in different shop-

TABLE 10. Consumer frequency of washing kitchen preparation areas

Washing area	% of respondents				
	Always	Sometimes	Rarely	Seldom/ never	Don't use this product
<b>Washing food cutting or preparation surface</b>					
Before cutting meat, poultry, and fish ( <i>n</i> = 534)	71	21	—	7	1
After cutting meat, poultry, and fish ( <i>n</i> = 580)	97	2	—	<1	1
Before cutting fruits and vegetables ( <i>n</i> = 526)	60	31	—	9	0
After cutting fruits and vegetables ( <i>n</i> = 567)	86	12	—	2	0
Before making sandwiches ( <i>n</i> = 536)	65	22	—	9	4
After making sandwiches ( <i>n</i> = 557)	80	14	—	3	3
<b>Washing kitchen sink</b>					
Before washing or preparing fresh produce ( <i>n</i> = 609)	56	32	6	6	—
After washing or preparing fresh produce ( <i>n</i> = 609)	49	36	6	9	—

ping bags or instruct the supermarket bagging clerks to do so.

Once fresh produce is in the home, consumers may mishandle it as they prepare it for storage. About 20% of consumers washed their produce before storing in the refrigerator, a practice that may facilitate mold or bacterial growth (4). A similar percentage store produce at room temperature, thus not benefiting from the protective effect of refrigeration.

Educational messages should focus on storage of raw meat, poultry, and seafood in the refrigerator to avoid cross-contamination of fresh produce. Raw meat, poultry, and fish must be kept separate and stored below ready-to-eat foods, such as fresh produce (28, 44). Correctly storing meat, poultry, and seafood on the refrigerator's bottom shelf or in the meat-poultry drawer was reported by less than half of the consumers in this study. These findings are comparable to studies in the United States (50) and Australia (41). Jones and Weimer (42) reported that many homemakers underrate their responsibility for safe food handling and did not recognize the potential hazards of handling meat and seafood in association with other foods. This indicates that educational messages about storage of produce should also include advice on raw meat, poultry, and seafood storage.

Lack of consistent hand washing before handling fresh produce was noted among nearly half of the respondents. These findings are comparable to other studies, where 33% to 66% of consumers did not wash their hands after han-

TABLE 11. Consumer methods of handling knife after handling meat and before cutting fresh produce

Method of handling used knife ( <i>n</i> = 609)	% of respondents <sup>a</sup>
Use a different knife	64
Wash knife with dishwashing liquid	49
Rinse knife with water	19
Wipe knife with paper towel	8
Never use meat, poultry, or fish	2
Use knife directly as is	<1

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

dling raw meat (3, 6, 24, 66). Some consumers are not aware that hand washing is important (7, 41), and others may not be aware of recommended washing techniques (33). The American Society for Microbiology (5) conducted a telephone and observational survey in five major U.S. cities; 94% of respondents in the telephone survey claimed to wash their hands after using the restroom, yet the observational survey found that only 68% washed their hands. This suggests that actual washing before meal preparation may be even less than reported. Although there is evidence that more consumers recognize the importance of hand washing today than in the past (7), this continues to be a necessary component in consumer education.

Although almost all respondents reported that they always washed their food preparation surfaces and knives after contact with raw meat, poultry, or fish, 20% or more did not identify effective clean methods. Others have shown that consumers fail to properly clean food preparation sur-

TABLE 12. Consumer beliefs about washing fresh fruits and vegetables

Beliefs	% of respondents <sup>a</sup>
<b>Reasons for washing fresh fruits and vegetables (<i>n</i> = 617)</b>	
Remove dirt	93
Remove pesticides	79
Remove germs and bacteria	60
Remove wax	31
Other	2
<b>Reasons for not washing some fruits and vegetables (<i>n</i> = 582)</b>	
I wash fruits and vegetables	69
I don't eat or serve the fruit with the skin on	16
The fruit or vegetable is already clean	9
The fruit or vegetable is safe without washing	6
The fruit or vegetable is too delicate to wash	3
It is too time-consuming to wash this fruit or vegetable	2
Other	1

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

TABLE 13. Convenient sources of information on safe handling of fresh produce

Information source	% of respondents <sup>a</sup>
Interest in getting information on safe handling of fresh produce ( <i>n</i> = 589)	
Yes	69
No	31
Preferred sources of information ( <i>n</i> = 574)	
Brochure at supermarket	54
Information with individual produce container	46
Article in newspaper	34
Information on supermarket bag	32
Television program (eg, news or "60 Minutes")	31
Article in magazine	30
Magnet for refrigerator	28
Sign or poster in produce section	24
Cooking show on television	20
Web site	17
Advice on radio	11
Other	4

<sup>a</sup> Percentages can be greater than 100% because respondents may check "yes" to more than one category.

faces and knives (3, 5, 16, 17, 40, 41, 66, 68). The kitchen sink drain area and faucet handle can be heavily contaminated with bacteria (54). Fresh vegetables can become contaminated with a large bacterial population when cutting boards have not been properly cleaned after use with raw poultry and before slicing vegetables (70). Contaminated cutting boards and spigots transfer bacteria to lettuce and hands (21, 25, 55).

Lack of consumer knowledge and motivation may partially explain the failure to clean food preparation areas and utensils before and after food handling (43). Audits International (7) revealed that among consumers who had committed a cross-contamination hazard on camera, 65% were unaware of doing it and 16% did not think that cross-contamination was very important. The Research International USA (53) indicated that only 6% of shoppers mentioned keeping counters, utensils, and dishes clean to keep food safe. Therefore, the importance of cleaning food preparation surfaces and utensils is not ingrained in the consumer's mind.

Some consumers believed that melons need not be washed because the rinds are not consumed. However, the unwashed rind can contaminate the melon flesh during slicing (19, 20). Over the years, several melon-associated outbreaks have been reported (62), the most recent (April 2001) of which was traced to consumption of *Salmonella*-infected cantaloupes (18). To reduce the risk of foodborne outbreaks associated with melons, the outer surface of whole melons should be washed thoroughly with running tap water to remove dirt and bacteria before cutting with a sanitized knife (59).

Consumers need information as to safe and effective cleaning solutions. Although most consumers washed fresh

fruits and vegetables under running water, a small percentage used vinegar, chlorine solution, dish detergent, and commercial cleaning solution. Others have found similar trends (50, 51). Consumers did not recognize that detergent and all other soap products are not recommended for cleaning fresh produce since residues can remain even after rinsing (31, 34).

Vinegar (5% acetic acid) has been shown to have antimicrobial activity on parsley (39, 67) and laboratory media (38). Additionally, *E. coli* was effectively inhibited by 1% acetic acid from vinegar; however, lower concentrations were ineffective (29) unless food was soaked for 15 minutes (39). In focus groups (15), consumers added a small amount of vinegar to a large container of water, thus producing a solution too diluted to be effective in reducing foodborne pathogens.

Several studies have reported the ineffectiveness of chlorine to eliminate or remove foodborne pathogens on contaminated fresh produce, especially on interior structures and tissues (1, 10, 13, 58, 64). However, chlorine (or hypochlorites) is an effective antimicrobial agent of foodborne microorganisms on fresh fruits and vegetables (8, 30, 47, 52, 63, 67).

Commercial cleaning solutions (or produce washes) designed to wash fresh fruits and vegetables are being marketed as effective cleaning agents. One such solution, called Fit (produced by Procter and Gamble Co., Cincinnati, Ohio), can reduce foodborne bacteria on produce (11, 35, 36).

Baking soda or sodium bicarbonate, primarily used to absorb odors, is mistaken as an antimicrobial agent. Although some studies have suggested some antimicrobial activity (22, 23) and reduction of aflatoxin production (46), one study found only marginal antibacterial effects against *Yersinia enterocolitica* (38). Consequently, baking soda cannot be considered an effective antimicrobial agent for fresh fruits and vegetables, refrigerators, kitchen sinks, and food preparation areas, even though it may be an effective cleaning agent.

Although many consumers in this survey cleaned food surface areas and knives, few individuals sanitized. Consumers may not know that cleaning and sanitizing are two different food safety activities.

Results indicate that some population groups are more likely to practice unsafe produce handling practices than others. Women, non-college graduates, lower-income households, and people 65 years and older were more likely to practice safe food handling methods than men, college or postcollege graduates, higher-income households, and people 64 years and younger. For example, women were more likely to use bleach to clean the sink and cutting surfaces than men, and college graduates were more likely to wash the refrigerator and sink with water only compared with those with other educational levels. However, it should be noted that no demographic group consistently outperformed another in every safe handling practices. For example, although a high percentage of people older than 65 years demonstrated several safe practices, they were more

likely to rely on an ineffective antimicrobial agent to clean the refrigerator, sink, and cutting surfaces.

In previous studies, men and younger adults performed more risk-related food handling practices than did women and older consumers (2, 3, 40, 41, 65). Studies completed in the last decade found that people in their thirties and younger are more likely to use unsafe practices. This study indicates that consumers in their early forties are also more likely to perform risky practices. This suggests that people who practiced unsafe food or produce handling in their thirties may continue to perform those risky practices into their forties.

Consistent with other studies (40, 65), this study found that higher-income households and people with at least a college degree are more likely to practice risky produce handling behavior compared with those with lower incomes and less formal education. People tracked into a college preparatory program in high school may not have been exposed to safe handling guidelines through home economics classes.

Convincing consumers to change their unsafe practices may be especially difficult since fruits and vegetables are not commonly associated with foodborne illness. In fact, one third of the respondents were not interested in receiving free education material on safe produce handling. Consistent with earlier work (49), this survey found that more women consumers are interested in receiving information on safe produce handling than men. In our study, some individuals not interested in receiving safe produce handling information are currently following some unsafe practices. For example, 37% of respondents not interested in receiving safe handling information failed to wash their whole melons, more than half (51%) indicated not washing hands before handling produce, and 27% stored meat, poultry, or fish randomly in the refrigerator. Either these consumers were unaware that they are following unsafe practices or they may not believe that safe handling is important. Awareness and motivation, therefore, must be key components in an effective educational program.

Consumer education materials should be presented through convenient sources. Consistent with other work (41), most consumers prefer a brochure available at the supermarket followed by information provided on an individual produce container. About 30% of respondents preferred newspaper articles, information on supermarket bags, television programs, magazine articles, and refrigerator magnets. Multiple sources should be used to reach different demographic groups. Material available on Web sites should focus on the risk groups who use this source: men, high-income households, college or postcollege graduates, and people 44 years and younger. Newspaper articles and instructions on produce containers may be targeted toward people 65 years and older, whereas refrigerator magnets and supermarket brochures are most preferred by people 44 years and younger. Safety information on cooking shows responds to the interests of consumers between the ages of 45 and 54 years. All materials should be simple to read and easy to follow. Consumers may be unwilling to adapt new,

safer practices if instructions are too time-consuming, uneconomical, or inappropriate.

Supermarkets should also be encouraged to train those who bag groceries to separate meat, fish, and poultry from foods eaten without cooking. The market could also more visibly promote safe handling and storage techniques in the meat and produce department. For example, many supermarkets offer plastic bags in the meat department, but none use pictures or a video to demonstrate how to use the bag as a glove so the hand does not become contaminated with wet packaging. Neither do they advise that raw meats be stored separately from produce.

This study has limitations typical of mail surveys and therefore the findings do not necessarily represent the average consumer in the United States. In general, mail surveys include disproportionately higher response rates from Caucasians, older persons, and those with higher incomes and more formal education (16). The relationships between ethnicity and unsafe handling practices could not be analyzed due to the low response rates from Asian Americans, African Americans, Native Americans, and Hispanic/Latino Americans. Income level did not reflect U.S. households, since relatively higher response rates were obtained from households that had income levels of less than \$25,000 and lower response rates from those with income levels greater than \$99,999. The findings therefore should be acknowledged as being from respondents with those demographic characteristics.

Furthermore, most responses could have been from people who have a particular interest in and/or previous knowledge about safe handling of fruits and vegetables. Responses were also inconsistent among some respondents. For example, some respondents indicated that they did not wash produce such as apples and melons and yet, in response to another question, indicated that they wash all fruits and vegetables. In addition, questions with an option for multiple answers made analysis difficult. For example, 258 respondents indicated both peeling whole carrots and washing carrots under running water; since it is unclear whether they do these practices together or as alternative preparation approaches, we cannot precisely describe these consumer handling behaviors.

In summary, consumers can benefit by safe handling recommendations that address purchase, transportation, storage, and preparation. Many do not separate fresh produce from raw meat, poultry, and fish. Information on personal and kitchen hygiene should include how to clean effectively. A variety of information sources should be used, with information targeted to the handling errors most likely to occur among the users of that source. People are more likely to follow a recommendation when they know why it is important. Since some are not interested in safe handling information and a comparison of previous with current research indicates that handling errors persist, research is needed on effective motivational strategies.

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