

PEER-REVIEWED ARTICLE

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Florida Master Gardeners' Knowledge and Adherence to Food Safety Guidelines

ABSTRACT

The Florida Master Gardener Volunteer (MG) program has provided science-based horticultural training for volunteers since 1979. Because little is known about the participants' food safety knowledge and practices, food safety risks may be present among the targeted servicing population. We surveyed 4005 active Florida MGs for their food safety knowledge and practice, using a 40-item instrument via Qualtrics, and analyzed 1012 completed responses. Most respondents were female (80%; 791/991), aged ≥ 60 years (80%; 786/986), and held college or post-graduate degrees (73%; 731/989). Respondents correctly identified the five most common foodborne illness risk factors, and 80% (661/842) of them knew the time/temperature control principles. Eighty-seven percent (87%; 643/738) of respondents knew the safe minimum internal temperature for whole poultry, but fewer knew the safe minimum temperature for ground beef (60%; 364/599), leftovers and/or casseroles (43%; 207/475), and fresh whole cut beef (42%; 273/640). The majority of participants reported

correct handwashing practices (68%; 671/980), fresh produce washing (77%; 741/967), cross-contamination prevention methods (86%; 549/635), and thawing methods (78%; 464/592). Fewer respondents reported safe leftover storage methods (51%; 478/926) and adhering to thermometer use during cooking of meat products (< 30%). Respondents were not knowledgeable about specific vulnerabilities of different populations to foodborne illness. The survey revealed certain gaps in food safety knowledge and practice.

INTRODUCTION

The Master Gardener volunteer (MG) program is one of the most well-known volunteer programs in the United States and Canada. Founded in 1973 by the Washington State University Cooperative Extension office, MG programs are typically offered through local Extension offices affiliated with land-grant universities, with statewide coordination (2). The Florida Master Gardener program, started in 1979, is affiliated with the Extension Service of the University of Florida (UF) Institute of Food and Agricultural Science

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(IFAS) (6). The typical curriculum of Florida's MG training includes a wide variety of topics related to horticulture, such as plant nutrition, plant pathology, cultivation methods, soil management, and pesticide management (6). After the participants complete their training courses, they volunteer to work with the County Extension Offices by serving in various capacities, e.g., in school or community gardens. Currently, 56 of the 67 counties in Florida have active training programs, with an average of 66 active volunteers in each county. Florida MG volunteers have contributed significantly to the agriculture and economy of the state of Florida (6).

Food safety is a complex discipline that scientifically guides appropriate food production, handling, processing and storage to minimize and/or eliminate contaminants (biological, chemical or physical) and prevent foodborne illness at each step from production to consumption (9, 21, 22). However, for the general consumer population of the U.S., one of the most well-known food safety sources is from FightBac!®, which focuses on the simple core principles of food safety guidelines: the Clean, Separate, Cook and Chill concepts (5). The principle of "clean" primarily refers to removing visible soil and debris on hands and kitchen utensils by washing with hot soapy water (an action that contributes to reducing the numbers of some harmful bacteria) (5). The principle of "separate" refers to preventing cross-contamination, which particularly occurs when one handles raw meat and then prepares vegetables or fruits, using the same cutting board and knife without cleaning (5, 9). Foods are not properly cooked until the internal temperature is high enough to kill or inactivate potentially dangerous bacteria; thus, a food thermometer is recommended to ensure that meat products are fully cooked. The principles of "chill" refer to the need to package hot leftovers first into shallow containers for quicker cooling and then refrigerate them within two hours. Refrigerating foods at or below 40°F is effective in slowing (but not stopping) the growth of microorganisms. The temperature danger zone can be avoided efficiently by keeping an appliance thermometer in the refrigerator to monitor actual temperatures. Frozen meat, poultry, and seafood should be defrosted and/or marinated in the refrigerator, instead of at room temperature. If immediate thawing is needed, one should defrost the meat in the microwave or seal the food in an airtight package and submerge it in cold water, which should be changed every 30 minutes (5, 9).

Foodborne illness refers to disease transmitted to people by food. The five most common risk factors for foodborne illness include poor personal health and hygiene, purchasing food from unsafe sources, using dirty or contaminated utensils and equipment, inadequate cooking, and improper holding/storage of foods (3, 5, 9). Certain populations are at higher risk of foodborne illness: infants and preschool-aged children, pregnant and

lactating women, seniors, and people with compromised immune systems (5, 9).

Certain MG training programs in the U.S. include food safety information in food safety fact sheets that focus on decreasing the risk of contamination during both the planting phase and the harvesting/handling phase (4, 10, 12, 13, 14, 15, 16, 17, 18). The fact sheets do not address critical food safety guidelines in meal preparation (e.g., utensil cleaning and safe minimum cooking temperatures), but MG volunteers often help with meal preparation. The Florida Master Gardener program does not include food safety training along with its horticultural training. Therefore, evidence-based research is needed to determine whether it is necessary to include food safety training in the Florida MG program, since Florida MG volunteers are occasionally involved in meal preparation for fundraising purposes, although they are more likely to offer help with gardens, plant sales, and landscaping. Lack of sufficient food safety training could raise the risk of foodborne illness among the targeted populations. Moreover, there is little data regarding MG volunteers' knowledge about and daily adherence to food safety guidelines, even among MG programs that have included food safety training.

Research objectives and hypothesis

The objective of this study was to evaluate Florida Master Gardener volunteers' food safety knowledge and practice. We hypothesized that less than 50% of Florida MG volunteers have accurate knowledge of the food safety guidelines and adhere strictly to food safety guidelines. Drawing upon methods used in the U.S. Food and Drug Administration (FDA) Food Safety Survey, the present study also evaluated the Florida MG volunteers' attitudes toward pesticide and antibiotic residues. Similarly, we hypothesized that Florida MG volunteers would not perceive pesticide or antibiotic residues as food safety problems. The study was approved by the University of Florida Internal Review Board (IRB201601233) on July 12, 2016 as exempt.

METHOD

Target population

The target population of the present study was all currently active Florida MG volunteers, not including MG trainees and gold-badged, retired MGs. As a result, 4005 MG volunteers were recruited for this study. A minimum sample size of 375 completed responses was required to obtain $\pm 5\%$ sampling error, 95% confidence level and variability of 0.5 (8).

Survey instrument development

The food safety question items for the survey instrument used were taken from three reliable and reputable sources: (1) the Consumer Knowledge of Home Food Safety Practice Survey, conducted by the Academy of Nutrition and Dietetics (AND) in 2011 (1); (2) the Food & Health

Survey, conducted by the International Food Information Council Foundation (IFICF) in 2015 (7); and (3) the Food Safety Survey, conducted by the FDA in 2010 (19). The questions were slightly modified in some cases to increase clarity for the target population. The survey instrument primarily consists of three domains: (1) food safety knowledge, (2) food safety practice, and (3) attitudes toward pesticide and antibiotic residues.

The subject of food safety knowledge covered key items such as safe minimum cooking temperature, safe time-temperature control, the most common risk factors for foodborne illness, and the most vulnerable populations for foodborne illness. The domain of food safety practice included handwashing, produce washing, cross-contamination prevention, food thermometer usage, safe thawing methods, and storage of leftover high-protein foods. In particular, cross-contamination prevention surveyed both hand and cutting board cleaning after handling of raw meat products. Last, the participants were surveyed about their perception of pesticide or antibiotic residues as a food safety problem.

Pilot test

The survey was initially pilot-tested among fifty MGs from Alachua County, Florida, using a University of Florida Qualtrics email invitation sent on September 13, 2016. Participants were encouraged to send any suggestions or comments to the study investigator by E-mail. After a week, 24 completed surveys had been recorded, with no feedback received. However, certain survey items were revised, either for question format or for more clarification.

Survey distribution

The revised survey was distributed to the statewide list of active MG volunteers ($n = 4005$) on October 25, 2016 via Qualtrics, and 3969 E-mail invitations were successfully sent. However, significant feedback was received regarding several questions' confusing statements and system errors. These comments had not been anticipated after pilot testing, so the survey was temporarily closed for further revision on October 26, 2016, after 455 completed surveys had been recorded.

The finalized survey was distributed again to the target population ($n = 4005$) on October 28, 2016, and 3,858 E-mail invitations were successfully sent. Within a week, 658 completed responses were recorded and included for data analysis. Although a grace period was given to provide extended time, no started or completed responses were recorded after day eight.

Statistical analysis

The two distributions were combined for final analysis, except for duplicate responses (duplicate responses were detected by comparing respondents' IP addresses; if found,

the initial survey responses were deleted). Survey items that had been revised after the first distribution (questions 8, 12, 16, 21, and 36) were analyzed based on the second responses only.

The data were analyzed with SPSS version 24.0. Pearson's chi-square test was conducted to examine the association between food safety knowledge/practices/attitudes and demographic factors. A significance level of $P \leq 0.05$ was selected.

To more easily interpret the results, food safety knowledge scales were described, mirroring the existing ServSafe® certification program. The ServSafe® Food Handler and Manager Certification Program is the leading food safety training program affiliated with the National Restaurant Association Educational Foundation. It certifies participants as ServSafe® practitioners only when they answer $\geq 75\%$ of exam questions correctly. Since food safety training is not incorporated into the Florida MG volunteers' curriculum, a cutoff of 70% was applied in the present study. The scale created in the present study was for the purpose of examining what the entire surveyed population knew about food safety guidelines. That is, Florida MG volunteers were considered well aware of a food safety guideline if $\geq 70\%$ of respondents correctly answered the survey question corresponding to that specific recommendation. If $\leq 70\%$ of respondents answered correctly, this would be considered a gap in food safety knowledge and practice.

RESULTS

There were 455 and 654 completed responses from the first and second distributions, respectively, 97 of which were duplicate responses. A total of 1,012 completed responses were therefore included in the statistical analysis. All participants were free to decline to answer any question, so the exact number (n) of responses for different questions could be different. All questions had recorded responses that met the minimum sample size.

Demographics

Eighty percent of all surveyed MG volunteers were female (791/991) and aged ≥ 60 years old (786/986). Nearly half (489/989) of the participants had 0–5 years of active volunteer experience, while the majority of the remaining participants had 6–10 years of active MG experience (27%; 263/989) or 11–20 years (16%; 154/989). The respondents' educational backgrounds, from most to least common, included post-graduate (40%; 399/989), college graduate (34%; 332/989), and some college (21%; 207/989).

The participants' occupations were re-categorized into nine main groups: education (e.g., teacher, college professor), economy/business (e.g., sales, finance, advertising, office management, landlord), healthcare (e.g., nurse, physician, and therapist), agriculture/farming (e.g., farmer, lawn maintenance, horticulture), engineer/industry (e.g., aircraft

mechanical engineer, information technology, network engineer), laws/military/ government (e.g., circuit judge, lawyer, attorney, parole officer, military stenographer, U.S. air force), news/arts (e.g., journalism, reporter, costume designer, interior designer), natural science (e.g., chemist, botanist, biologist, geologist), and others (e.g., retired, NA). The reported top three occupations were economy/business, education, and healthcare.

The top three reported volunteer activities were gardening activities (70%; 424/618) (e.g., school garden, community garden, botanical garden, retirement home garden), extension office work (64%; 393/618), and plant sale volunteering (54%; 331/618). Other frequently recorded volunteer activities included Florida-Friendly Landscaping™ work, plant clinic work, horticulture program volunteering, and farmers' market volunteering. The top four choices listed as "go-to" sources for food safety information were government (47%; 440/944), TV/radio (13%; 125/944), university extension programs (14%; 129/944), and WebMD/health Internet (10%; 95/944).

Food safety knowledge

With regard to the four concepts of basic consumer food safety knowledge (i.e., clean, separate, cook, and chill), the participants were asked about the importance of food safety in each produce-handling step. Nearly 43% (412/949) of respondents viewed meal preparation as the step in which food safety is most important. Meal preparation includes washing hands with soap and warm water, washing produce before consuming, using clean and sanitized utensils, and cooking produce to the proper temperature. Growing produce (24%; 228/949) and storing it at the proper temperature (18%; 172/949) were next most frequently rated as most important as steps in produce handling.

As for safe minimum cooking temperature, the percentages of participants knowing the safe minimum cooking temperature for whole chicken/turkey, ground beef, leftovers and/or casseroles, and fresh beef were 87% (643/738), 61% (364/599), 44% (207/475), and 32% (206/640), respectively. Pearson's chi-square test showed that female MGs were more familiar than male MGs with safe minimum cooking temperatures for whole chicken/turkey ($P = 0.000$) and ground beef ($P = 0.013$).

With respect to safe time-temperature control, nearly 80% (661/842) of surveyed MGs knew the safe temperature for refrigerators, which is at or below 40°F. No significant association with demographic characteristics was detected by Pearson's chi-square test.

In terms of personal vulnerability, 58% (237/408) of participants had the correct perception that certain groups of people are at higher risk for foodborne illness. No significant association between such perceptions and demographic characteristics was detected. The top four subpopulations perceived by participants as being at greatest risk for

foodborne illness were people with poor food-handling behaviors (69%; 283/408), people with compromised immune systems (67%; 275/408), the elderly (65%; 267/408), and people with certain illnesses (55%; 224/408). However, according to FDA epidemiological reports, the four populations that are actually most vulnerable to foodborne illness include infants (< 1 year), the elderly, pregnant women, and immune-compromised individuals. In this study, 50% (208/408) and 34% (137/408) of respondents perceived infants and pregnant women, respectively, as the populations most vulnerable to foodborne illness.

The top five risk factors for foodborne illness reported by participants were cross-contamination (81%; 777/955), undercooking (77%; 739/955), leaving food out of the refrigerator too long (70%; 665/955), not washing hands properly before cooking (69%; 662/955), and purchasing food from unsafe sources (62.93%; 601/955) (Fig. 1). These listed factors are essentially the same as the five most common causes for foodborne illness identified by the CDC, which are poor personal hygiene, inadequate cooking, improper storage temperatures, cross-contamination, and consuming food from an unsafe source.

Overall, the surveyed MGs were well aware of safe time-temperature control and the top risk factors for foodborne illness. They were also generally aware of foodborne illness risks among different populations. However, the participants were only somewhat aware of safe minimum cooking temperatures and the foodborne illness rate each year in the U.S.

Food safety practices

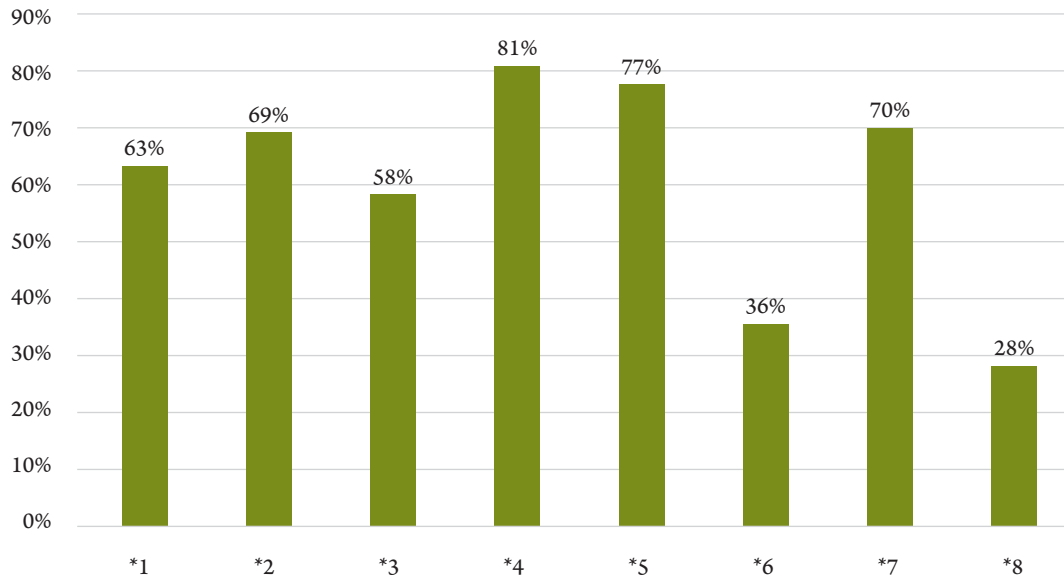
Sixty-eight percent (671/980) of the surveyed MGs stated that they wash their hands thoroughly with soap and warm water every time before cooking. Pearson's chi-square test showed that female MGs had better handwashing practices than male MGs ($P = 0.012$).

About three quarters (77%; 741/967) of the surveyed participants stated that they wash or rinse fresh vegetables (not bagged or pre-cut) every time before consuming, and 92.42% (914/989) of the respondents used safe washing methods. No significant association with demographics was detected by Pearson's chi-square test.

In terms of pre-cut, bagged produce, 36% (226/636) of respondents stated that they wash these every time, while 22% (137/636) wash them rarely. However, pre-cut, bagged produce actually should not be washed before consuming. Washing increases the risk of introducing harmful bacteria, since the produce pulp is exposed. With that in mind, only 20% of participants followed safe-handling practices with regard to pre-cut, bagged produce. No significant association with demographic factors was detected by Pearson's chi-square test.

As for cross-contamination prevention, 86% (549/635) of the surveyed MGs stated they would wash their hands

Risk Factors for Foodborne Illness



*Figure 1. Participants' perceptions of the most common risk factors of foodborne illness (n = 955). *1. Purchasing foods from unsafe sources. *2. Not washing hands properly before cooking. *3. Not washing utensils and/or dishes. *4. Cross-contamination. *5. Undercooking or not cooking to proper internal temperature. *6. Consuming expired foods. *7. Leaving foods out of the refrigerator too long. *8. Using dented cans. The top five reported risk factors were cross-contamination (81%), undercooking (77%), leaving foods out of refrigerator too long (70%), not washing hands properly before cooking (69%), and purchasing foods from unsafe sources (63%). These were the same as the five most common causes of foodborne illness identified by CDC.*

thoroughly with soap and warm water before the next food-handling step after handling raw meat/fish/chicken. No significant association with demographic factors was detected by Pearson's chi-square test. As expected, MGs with occupations in the natural science field (e.g., biologist, chemist, microbiologist) were most likely to follow safe handwashing practices (100%; 14/14 reported always washing their hands with soap and warm water) after handling raw meat/fish/poultry, while MGs with occupations in the agriculture/farming fields (e.g., farming, lawn maintenance, horticulture) were less likely to do so (73%; 25/34 reported always washing their hands with soap and warm water after handling raw meat/fish/poultry).

Regarding cleaning of cutting boards after use for cutting raw meat products, 89% (865/975) of surveyed MGs followed safe cleaning practices, such as washing boards thoroughly with soap and warm water (44%; 423/975), using a different cutting board for other foods (29%; 282/975), washing them with bleach or disinfectant (14%; 134/975), and putting them in the dishwasher (3%; 25/975) (Fig. 2). Pearson's chi-square test showed that female MGs (86%; 668/780) had safer cutting board cleaning practices than male MGs (83%; 84/191) ($P = 0.048$).

Ninety percent (879/977) of surveyed MGs had a food thermometer available at home. Excluding those

who said they don't cook the specific meat products, the percentage of participants saying they would frequently use a food thermometer was 48% (314/654), 45% (294/654), 54% (353/654), and 50% (327/654) for whole cuts of poultry, beef, pork and lamb, respectively. The percentage further decreased to 22% (144/654), 16% (105/654), and 19% (124/654) for ground poultry, ground beef and ground pork, respectively. No significant association between thermometer usage and demographic factors was detected by Pearson's chi-square test.

Seventy-eight percent (464/592) of participants followed safe thawing behavior when cooking frozen meat products, including thawing in the refrigerator (61%; 361/592), in cold water (10%; 57/592), and using the microwave (8%; 46/592) (again excluding those who don't cook meat products or don't use frozen meat products). No significant association between thawing methods and demographic factors was detected by Pearson's chi-square test. As for storage of leftover hot foods, 52% (478/926) of surveyed participants stated that they would first let these foods cool to room temperature for less than 2 h, then store them in the refrigerator.

Overall, the surveyed participants were well aware of the necessity for fresh produce washing, of effective

Cutting Board Cleaning After Cutting Raw Meat Products

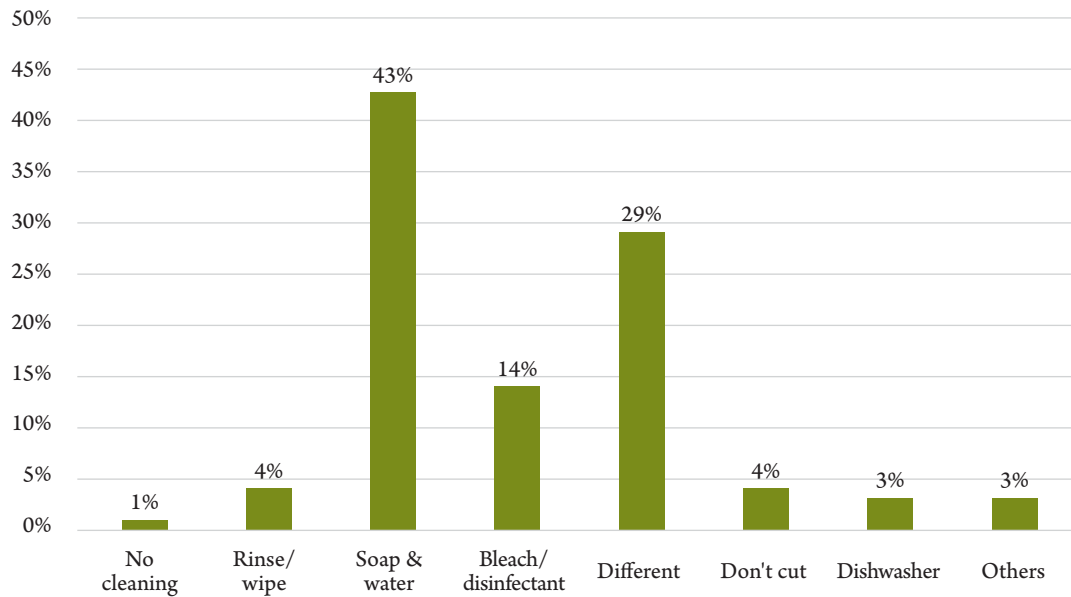
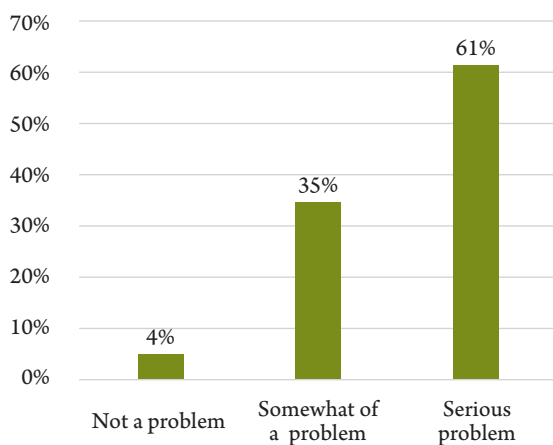


Figure 2. Methods of cutting board cleaning after using them for cutting raw meat products (n = 975). Nearly 90% of participants stated that they use safe cutting board cleaning practice for effective cross-contamination prevention. Methods included washing the cutting board with soap and warm water (43%), using a different cutting board (29%), applying bleach or disinfectant (14%), and putting it in the dishwasher (3%).

Perception of Pesticide Residues as a Food Safety Problem



Perception of Antibiotic Residues as a Food Safety Problem

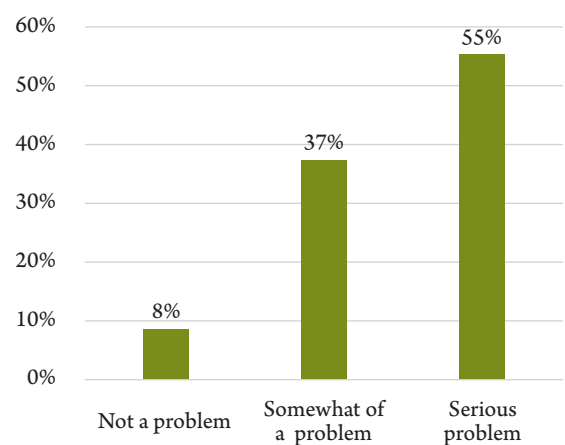


FIGURE 3. Participants' perception of pesticide (n = 924) and antibiotic (n = 882) residues as a food safety problem. About 61% and 55% of respondents stated that they perceive pesticide and antibiotic residues as a serious food safety problem, respectively.

cross-contamination prevention, and of safe thawing practices. They were generally aware of the importance of handwashing before cooking and of how to store leftovers safely. Notably, the surveyed MGs were only somewhat aware of how to safely handle pre-cut, bagged lettuce and of the necessity of thermometer monitoring of internal temperature when cooking meat products, especially when cooking ground meats.

Attitudes toward pesticide and antibiotic residues

Sixty-one percent (61%; 562/924) and 55% (455/822) of respondents stated that they view pesticide and antibiotic residues, respectively, as a serious food safety problem (Fig. 3). Pearson's chi-square test showed that female MGs viewed pesticide ($P = 0.002$) and antibiotic ($P = 0.001$) residues as food safety problems more often than male MGs do. Three hundred eighty-eight participants identified both pesticide and antibiotic residues as serious food safety problems.

DISCUSSION

The present survey indicated that Florida Master Gardener volunteers have a good understanding of and good adherence to food safety guidelines in terms of time-temperature control, risk factors for foodborne illness, the necessity of washing fresh produce, cross-contamination prevention, and safe thawing methods. However, the survey also revealed certain gaps that need to be addressed along with MG volunteers' horticulture training. These topics include safe minimum cooking temperature, safe handwashing before cooking, personal vulnerability to foodborne illness, safe handling of pre-cut, bagged produce, food thermometer usage, storage of leftovers, and attitudes toward pesticide and antibiotic residues. Female Florida Master Gardeners tend to have better food safety knowledge and adherence to food safety guidelines than male Master Gardeners do. The data in present study may indicate the necessity of including food safety instruction along with Florida Master Gardeners' horticulture training.

To the researchers' knowledge, this is the first study that evaluates food safety knowledge and practices among Master Gardeners. Additionally, the significant sample size of the population contributes to the rigor of the data and results. Moreover, the present survey covers the four core principles of food safety: clean, cook, separate, and chill.

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There remains the potential for improvement for future research. Although the present survey covered all four core principles of food safety guidelines, it could be further developed and more comprehensive. Additional food safety topics include consumer awareness of harmful germs in specific food items (e.g., *Salmonella* in raw eggs), consumer understanding of the question of whether or not to wash chicken parts or whole chicken before preparation, consumer knowledge of safety issues about device use during cooking (e.g., smartphones, tablets), consumer knowledge about safety practices regarding washing and cutting of whole fruits (e.g., cantaloupe, watermelon), level of consumer attention to food recalls and consumer practices after hearing of food recalls, and consumer habits regarding consumption of raw foods (e.g., sushi, seafood).

None of the data in the present study is available to Florida Master Gardener volunteers. The 2015 Food and Health Survey and the 2016 FDA Food Safety Survey reported on the general public's food safety practices and attitudes in these areas. For example, the 2016 FDA Food Safety Survey reported that U.S. adults are more aware of *Salmonella* (93%) and *E. coli* (89%) as a threat to food safety than of *Listeria* (58%) or *Campylobacter* (16%) (20). It also showed that most consumers wash chicken parts (67%) and whole chicken or turkey (68%) before cooking them, and that 48% of consumers use devices while preparing foods (20). However, washing chicken before cooking is not recommended because washing does not help to remove potential pathogens; instead, it may contaminate other foods or surfaces. Touching personal devices during cooking may cause or worsen cross-contamination; therefore, device use should be kept to a minimum (11).

Last, it is worthwhile to track trends in Florida Master Gardeners' food safety knowledge and practice. The FDA Food Safety Survey has revealed certain trends in U.S. adults' food handling habits; thus, it is reasonable that Florida MG volunteers' food safety knowledge and food-handling behaviors will also change over time, because of changes in cooking frequency or access to food safety training.

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