

Development, Dissemination, and Assessment of a Food Safety Systems Management Curriculum for Agribusiness Students in Armenia

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Abstract: This study addresses the development, dissemination, and assessment of a Food Safety System Management (FSSM) curriculum offered to college-aged, agribusiness students in Yerevan, Armenia. Prior to beginning the program, demographic data were collected and a paper-based pretest was administered to assess the food safety knowledge, behavior, and attitude of participants ($n = 29$). For assessment of a skill, participants' handwashing techniques were videotaped and scored before the program commenced. Immediately after completion of the entire curriculum, a paper-based post-test with identical questions for food safety knowledge, behavior, and attitude was administered and handwashing skills were assessed. ANOVA with repeated measures was used to evaluate significant differences ($\alpha = 0.05$) for food safety knowledge using a pretest, post-test, and a 3-mo follow-up. A paired t -test was used to evaluate handwashing skills before and after the curriculum was presented. The pretest score (44.93%, ± 2.87) for food safety knowledge ($n = 29$) differed significantly ($P < 0.0001$) when compared with the post-test score (73.21%, ± 3.28) and the 3-mo follow-up ($n = 23$) score (67.76%, ± 3.93). Participants' ($n = 9$) handwashing skills prior to delivery of the FSSM curriculum differed significantly ($P < 0.0001$), when compared to handwashing skills after completion of the curriculum. Students' food safety attitudes and behavior assessed using a five-point Likert scale, also improved significantly as a result of the FSSM program. The 3-mo follow-up survey on food safety attitude and behavior was consistent with the post-test survey results. The information from this project may be of interest to education experts, Extension professionals, food industry personnel, or regulatory agencies, in the development and dissemination of an international food safety program.

Keywords: food safety, attitude, behavior, knowledge, skills

Introduction

According to the World Health Organization (WHO), an estimated 600 million—almost 1 in every 10 people in the world—get sick after eating contaminated food. As a result, 420,000 die every year from foodborne illness. The lack of general food safety knowledge and poor food handling practices may result in the deaths of *ca.* 125,000 children under the age of 5 every year (WHO 2015). Surveillance systems and surveys provide vital information about the burden of foodborne illness, but still fail to capture each and every illness (CDC 2016). This aspect becomes more important and less accurate when assessing food safety in developing countries. In such cases, the burden of foodborne illness is an estimated value because the illness is not reported or is diagnosed incorrectly (CDC 2016).

There is no doubt that scientific advances have played a key role in increasing the global food production, yet there is a need to address food safety deficiencies. Foodborne illness is a global health challenge, where some diseases are controlled and others evolve as new threats (WHO 2008). This challenge is especially important given that the elderly, infants, and immunocompromised individuals are more susceptible to foodborne diseases than the general population. In today's world, globalization of the food supply or even a traveler, who might have been exposed to a foodborne pathogen, may introduce that hazard inadvertently into a new geographical area (WHO 2008). Additionally, change in the environment and adaptation of the microorganism in a new geographical area may lead to the evolution of antibiotic-resistant pathogens or organisms with new virulence factors (WHO 2008; Davies and Davies 2010; Gaze and others 2013).

Production and export of unsafe food leads to a lack of trust between producers, processors, and consumers, as well as between importers and exporters. In such cases, a downgrade of international trade is inevitable, which results in economy and gross domestic product (GDP) losses. Therefore, food safety, if practiced by all sectors that are directly or indirectly related to food,

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may contribute to the overall sustainability and profitability of the food industry. If food safety is practiced properly by all parties, food will be much safer from biological, physical, and chemical agents that have the potential to cause illness or injury.

With the increase in international trade of food or food-related commodities, becoming familiar with internationalization of a state university Extension system is pertinent. A Food Safety System Management (FSSM) curriculum offered at the Agribusiness Teaching Center (ATC) of Natl. Agrarian Univ. in Yerevan, Armenia evolved from a state university's Extension program (Penn State Food Science Certificate; <http://foodscience.psu.edu/workshops/certificate>). Internationalization or globalization of Extension not only benefits the targeted audience, but also promotes the Extension mission and related international issues, while also providing Extension specialists and educators with opportunities to incorporate international perspectives into their programs (Ludwig and Barrick 1996). Increasingly diverse clientele would benefit from global Extension programs and help to promote a safer food supply (Ludwig and McGirr 2003).

Many studies have been conducted to assess food safety knowledge of consumers and food handlers (Bruhn and Schutz 1999; Rimal and others 2001; Unusan 2007; Sanlier 2009). However, studies related to perceived behavior, attitude, and skill of consumers or food handlers toward food safety are limited (Medeiros and others 2004; Wilcock and others 2004; Bas and others 2006; Tokuc and others 2009; Machado and others 2017). As the research suggests, many individuals are unaware of basic food handling and preparation methods, resulting in a substantial amount of foodborne illness (Redmond and Griffith 2003). While food safety is a very important issue globally, it is possible that governing bodies may not prioritize or forgo food safety training and emphasis, which may occur in developing countries.

This study was conducted at the Agribusiness Teaching Center (ATC) of the Natl. Agrarian Univ. of Armenia in Yerevan, Armenia to access the food safety knowledge, attitude, behavior, as well as a skill, of students who participated in a FSSM course developed by the Pennsylvania State Univ. and Virginia Tech Univ. The outcomes of this project may provide a template for other similar food safety training programs that can be offered globally/internationally.

Materials and Methods

The protocols for human subjects' research, including recruitment, consent forms, FSSM lecture modules, lesson plans, and surveys/questionnaires used to assess food safety knowledge, attitude, behavior, and skill of participants, were approved by the Institutional Review Board (IRB) at the Pennsylvania State Univ. (PSU; IRB #00005030). All surveys/questionnaires were reviewed by Penn State faculty members in Food Science for grammar and clarity. Students who were in their 4th year (seniors) in the Agribusiness program at the Agribusiness Teaching Center were recruited by the researchers via e-mail. In December, 2016, all consent forms were distributed, signed, and received from participants prior to the start of the FSSM program. This particular audience was chosen in response to food industry and food safety needs in Armenia (Vardan Urutyun, Director of ATC personal communication).

Development and delivery of the FSSM program

The course curriculum was developed and based on course requirements for the PSU Food Science Certificate program (<http://foodscience.psu.edu/workshops/certificate>), an Outreach program of the Dept. of Food Science. As part of the Food Safety

Certificate, participants must complete a minimum of 12 continuing education units (CEU's) (Cutter and Bucknavage 2017). To fulfill the CEU requirements for the Food Safety Certificate, the following modules were developed and delivered in person to students of the ATC: Introduction to Food Science (Food Science; 2.5 CEU's), Principles of Sanitation (Sanitation; 2.5 CEU's); Principles of Food Microbiology (Food Microbiology; 2.5 CEU's); thermal processing and acidification of foods via Better Process Control School (BPCS; 3 CEU's), Hazard Analysis and Critical Control Point systems (HACCP; 1.5 CEU's), and Food Defense (0.5 CEU's), for a total of 12.5 CEU's. Modules consisted of lectures and hands-on laboratory exercises or group activities as described below. Each module was supplemented with onsite tours to local food processing facilities (for example, winery, meat processor, dairy processor, cannery, juice processor) to see how food safety systems were implemented and operated under real-world conditions.

The Food Science module incorporated lectures on food science principles, refrigeration, freezing, heating, microwaving, canning, pasteurization, food components, and sensory, with hands-on laboratory exercises, including cheese and jerky making, sensory analyses, Maillard reactions in foods and enzymatic browning of fruits, principles of fermentation (for example, pizza making), and groups activities around the hurdle concept for food safety.

The Sanitation module incorporated information on the microbiology of biofilms, cleaning, sanitizing, chemical safety, plant and equipment design, and included laboratories and hands-on activities around personal hygiene (including handwashing), cross contamination, cleaning, and sanitizing of food contact surfaces, use of adenosine triphosphate (ATP) bioluminescence assays, pest management, and rapid methods for allergen detection.

The topics for the Food Microbiology module included an introduction to food microbiology, spoilage and indicator microorganisms, sampling procedures for foods, dilutions and bacterial enumeration, an overview of parasites, viruses, molds, mycotoxins, and pathogens, immunological and molecular methods of pathogen detection, as well as use of outside food microbiology labs for environmental testing and sampling of foods. Hands-on laboratory exercises addressed aseptic techniques, food sample preparation, dilutions, standard culture methods (for example, plate count/pour plates/Petrifilm), Gram staining and microscopy, and antibody-based detection methods.

The BPCS module was lecture-based with opportunities for class discussions and participant interactions. Participants of the BPCS module gained a broad knowledge of low-acid and acidified canned foods, including how to pack and thermally process low-acid foods or acidified foods in hermetically sealed containers, plant sanitation, food container handling, records, and record keeping.

For HACCP, participants were trained using an accredited program (Intl. HACCP Alliance; Texas A&M Univ., College Station, Tex., U.S.A.) that incorporated lectures (for example, prerequisites for HACCP, 7 principles of HACCP, hazards, critical control points, critical limits, monitoring, verification and validation, record keeping, managing a HACCP plan, training of employees, and recalls), along with breakout sessions. During the breakout sessions, participants were divided into groups and assigned to a food category. As part of the breakout sessions, individual groups developed product descriptions, flow diagrams, and identified processes and ingredients for their food product. Groups also conducted a hazard analysis of the process, identified

critical control points, critical limits, and monitoring activities for employees. Finally, participants identified verification activities and record keeping processes for their individual HACCP plans, progressing to the development of a draft HACCP plan. Participants took turns presenting their plans to the class, garnering input and discussion with others, but gaining an understanding of HACCP across other food products.

The Food Defense module was made available to participants of the FSSM using an online, FDA-based curriculum (Food Defense 101; access at: goo.gl/obRxB). Modules included FDA and USDA regulations, food defense awareness for food industry professionals/front line employees (including ALERT), broad/focused mitigation strategies, vulnerability assessments, and development of a food defense plan. Total time for completion of this module was 6 to 8 h, which largely depends upon how long one can sit and focus in front of a computer. This online module also was used to gauge the participants' interest in online courses for future iterations of the FSSM program.

All modules were delivered in English and onsite at the ATC. After completion of each module, participants completed a quiz, where a passing grade was 60% or above. Participants were allowed to retake the quiz if they were unable to pass on their 1st attempt. Participants of the BPCS module were quizzed after every section. Participants received a certificate only after successfully completing each module and passing the quiz. If participants completed all 6 modules satisfactorily, they received a Penn State Food Science/Food Safety Certificate.

Demographics, food safety knowledge, attitude, behavior, and handwashing skills

Senior-level students and 1 staff member from the ATC enrolled in/employed by the Agribusiness program, agreed to participate in the month-long FSSM program, beginning January 9, 2017 and completing on February 3, 2017. One student dropped out of the FSSM program after the BPCS module, for a total of 29 participants who completed the entire curriculum. Prior to beginning the program, participants' demographic information and an assessment of their food safety knowledge, behavior, and attitude were obtained.

Twenty-two demographic questions were administered to assess age, sex, education level, English proficiency, marital status, employment, prior food safety training, and household characteristics. Participants also were surveyed (pretest) about their food safety knowledge, attitude, and behavior before the FSSM training began. Attitude and behavior questions were developed using the methodology described by Witkin and Altschuld (1995). A total of 30 true/false and multiple choice questions were developed to assess food safety knowledge; 18, six-point Likert-scale questions were developed for the attitude assessment; and 15, six-point Likert-scale questions were used to assess food safety behavior. With the exception of the demographic questions, the same food safety knowledge, attitude, and behavior questions were used after the training was completed (post-test). The tests were graded with scores and percentages.

Additionally, 9 participants were assessed for their handwashing technique prior to the Sanitation module and also at the end of the entire FSSM course. The group of volunteers who agreed to participate in the handwashing skill, both before and after the end of the course, were not the same individuals. To assess handwashing techniques, volunteers were asked to wash their hands and the activity was videotaped. The resulting handwashing videos were downloaded onto an iPhone 5 smartphone (Apple Inc. Cupertino,

Table 1—Steps evaluated during handwashing and assigned points.

Steps	Action (points awarded)
1. Wet hands	No (0); Partial (1); All (2)
2. Soap application	No (0); Yes (2)
3. (i) Lather (ii) Lather time	i. No vigor (0); Minimal vigor (1); Vigorous (2) ii. 5 s or less (0); 6 to 10 s (1); more than 10 s (2)
4. Rinse	No (0); Partial (1); All (2)
5. Dry	No (0); Partial (1); All (2)

Calif., U.S.A.). The videos focused on the movement and sounds produced by hands when washing (Machado and others 2017). A timer, imbedded in the video, was used to calculate the time spent by each volunteer to wash their hands. The captured videos were later downloaded from the researcher's smartphone to a password-protected computer. After making sure that the videos were saved on the computer, videos were deleted from the researcher's smartphone. A scoring system was developed to evaluate the handwashing skill. The system was adopted from a Consensus Measurement in Hand Hygiene project (Anonymous 2009; Machado and others 2017). The questions asked in the scoring system were used to judge the effective handwashing techniques, with both exploratory and points assigned (Anonymous 2009; Machado and others 2017). In the scoring tool, 5 steps were evaluated for each participant and points were awarded on the basis of action performed. As presented in Table 1, lather was the only step evaluated via 2 separate parameters: vigor and time, which have a maximum combined score of 4 points. Except for lathering, all other steps were awarded a maximum of 2 points, allowing for a maximum total score of 12 points (Machado and others 2017).

Data Analysis

Microsoft Office-Excel 2013 (Microsoft Corp., Redmond, Wash., U.S.A.) was used for compilation, storage, to summarize, and to calculate data points and basic descriptive statistics (for example, mean, standard deviation, standard error of the mean, percentage of responses, and observations). ANOVA (SAS Inst. Inc. software 9.4 Cary, N.C., U.S.A.) with repeated measures was used to evaluate significant differences ($\alpha = 0.05$) for food safety knowledge with a pretest, post-test, and a 3-mo follow-up. Food safety knowledge was treated as a dependent variable, whereas the 3 different time frames (pretest, post-test, and 3-mo follow-up) were considered independent variables. Initially, a paired *t*-test (Microsoft Corp.) also was used to evaluate significant difference at the level of $\alpha = 0.05$ for food safety knowledge and handwashing skills demonstrated by participants before and after the administration of FSSM program. Food safety attitudes and behaviors were compared using the scores and percentages feature of Excel 2013 and were compiled before and after the program, as well as after 3 mo.

Results

Demographics

Demographic data are presented in Table 2 to 5. The average age of participants in the FSSM program was 22, with a range from 20 to 23 y. Out of 29 participants, 8 (28%) were male and 21 (72%) were female, and 2 (2/29; 7%) of the female participants were married. All of the participants, except for one (ATC staff), were college seniors. Most participants (26/29; 90%) planned to continue their education in the fields of agribusiness and/or business, with 6 (21%) choosing agribusiness and 8 (28%) choosing

Table 2—Participants' characteristics-age, gender, and marital status (n = 29).

Participant characteristics	Responses	Total %
Average age	22 (range: 20 to 23)	
Gender		
Male	8/29	28
Female	21/29	72
Marital status		
Single	27/29	93
Married	2/29	7

Table 3—Participants' level of education, employment status, and living situation (n = 29).

Participant characteristics	Responses	Total %
Year in school (college):		
Junior	1/29	4
Senior	28/29	96
Highest level of education received:		
Master's degree	1/29	4
Expectation of enrollment in an advanced degree:		
No	1/29	4
Yes	26/29	90
Unknown	2/29	7
Majoring in the area of:		
Agribusiness	6/29	21
Business only	8/29	28
Both	15/29	52
Enrollment status:		
Full time	19/29	66
Part time	7/29	24
Unknown	3/29	10
Working on or off campus while enrolled:		
No	18/29	62
If yes, is work related to foods?	8/29	28
No	2/8	25
Yes	6/8	75
Unknown (no response)	3/29	10
Living situation:		
Off campus, living with family	28/29	96
Off campus, living independently	1/29	4
On average, the grades received at this institution		
A	3/29	10
B	22/29	76
C	4/29	14

Table 4—Participants' understanding of English language (n = 29).

Participant characteristics	Responses	Total %			
Spoken languages:					
Armenian	29/29	100			
Russian	27/29	93			
English	29/29	100			
Portuguese	1/29	4			
Polish	1/29	4			
Started learning to speak English language in:					
Elementary or middle school	26/29	90			
High school	1/29	4			
College	2/29	7			
Took "English as a Secondary Language" classes in the past:					
No	13/29	45			
Yes	15/29	52			
No response	1/29	4			
Household members speaking English as a secondary language:					
No	14/29	48			
Yes	15/29	52			
	Very poor (%)	Poor (%)	Fair (%)	Good (%)	Very good (%)
English language proficiency:					
Reading	0	0	0	8/29 (28)	21/29 (72)
Speaking	0	0	6/29 (21)	15/29 (52)	8/29 (28)
Writing	0	0	3/29 (10)	19/29 (66)	6/29 (21)
Listening	0	1/29 (4)	1/29 (4)	15/29 (52)	13/29 (45)

Table 5—Participants' food safety courses/training (n = 29) prior to the FSSM program.

Participant characteristics	Responses	Total %
Taken food science/food safety related courses in the past:		
No	24/29	83
Yes (which of the following?)	5/29	17
Food microbiology	0	
Food sanitation	0	
Food defense	0	
Food chemistry	0	
Animal product technology	5/5	100
Dairy science	4/5	80
Participated in food safety training courses:		
No	29/29	100
Interested in working in the food sector after graduation:		
Strongly agree	7/29	24
Agree	7/29	24
Neutral	12/29	41
Disagree	3/29	10
Strongly disagree	0	0

business as their major. The majority (19/29; 66%) of the participants were full-time students, while 7 (24%) were part-time students.

The majority of the participants (18/29; 62%) were not employed. However, of the 8 participants who were employed, 6/8 (75%) indicated that their employment was related to the food sector. Almost all of the participants (28/29; 97%) were living with their families. Most participants (22/29; 76%) acknowledged getting "B" grades for their coursework, with very few (3/29; 10%) getting "A" or "C" grades (4; 14%) for their coursework.

Participants also were asked for their language proficiency. All (29/29; 100%) of the participants acknowledged that they speak Armenian and English. Additionally, some participants (27/29; 93%) were fluent in Russian, Portuguese (1/29; 4%), and Polish (1/29; 4%). The majority of the participants (26/29; 90%) started learning English as a secondary language when they were in elementary or middle school. More than half (15/29; 52%) of the participants also took "English as a Secondary Language" classes in the past. Many (15/29; 52%) of the participants' family members also spoke English.

Since the FSSM program was delivered in English, it also was important to assess English language proficiency of the participants in the areas of reading, speaking, writing, and listening, using a five-point Likert scale. Most of the participants' rated their reading level for English as "very good" (21/29; 72%), while the remainder (8/29; 28) rated themselves as "good." More than half (15/29; 52%) of the participants felt they spoke "good" English, while only 28% (8/29) participants rated themselves as "very good." For English writing, most of the participants (19/29; 66%) rated themselves as "good," while few (6/29; 21%) felt they are "very good." Likewise, for listening, more than half of the participants (15/29; 52%) felt "good," while almost half (13/29; 45%) of them felt "very good."

When asked about food science or food safety-related courses that participants had taken in the past, most (24/29; 83%) replied "no." Only a few (5/29; 17%) of the participants indicated that they had taken animal product technology and dairy science courses. None of the participants (29/29; 100%) indicated they had participated in a food safety course. When asked if the participants were interested in working in the food sector after their graduation, almost half of them "agreed" or "strongly agreed" (14/29; 48%).

Table 6—Food safety knowledge of participants before and after the FSSM training.

Participants (n = 29)	Pretest		Post-test		Change in score	Percent (%) change in score
	Score (max = 30)	Percent score	Score (Max = 30)	Percent score		
1	15	50	24	80	9	30
2	12	40	23	77	11	37
3	15	50	24	80	9	30
4	16	53	11	37	-5	-16
5	7	23	24	80	17	57
6	12	40	24	80	12	40
7	15	50	22	73	7	23
8	13	43	22	73	9	30
9	14	47	22	73	8	26
10	17	57	25	83	8	26
11	15	50	19	63	4	13
12	7	23	25	83	18	60
13	14	47	24	80	10	33
14	16	53	21	70	5	17
15	15	50	26	87	11	37
16	13	43	22	73	9	30
17	17	57	24	80	7	23
18	16	53	25	83	9	30
19	11	37	18	60	7	23
20	13	43	25	83	12	40
21	15	50	16	53	1	3
22	11	37	24	80	13	43
23	12	40	19	63	7	23
24	10	33	21	70	11	37
25	16	53	19	63	3	10
26	17	57	23	77	6	20
27	11	37	22	73	11	36
28	17	57	19	63	2	6
29	9	30	25	83	16	53
Average	13.48	44.93	22	73.21	8.52	28.28
Knowledge test		Mean score	Standard deviation	SEM		Paired <i>t</i> -test
Pre		13.48 ^b	± 2.87	0.53		
Post		22.00 ^a	± 3.28	0.61		<0.0001

^{a, b}means within a column lacking a common superscript letter differ (*P* <0.05).

Table 7—Food safety knowledge of participants using a pretest, post-test, and 3-mo follow-up^c.

	Mean score	Mean score (%)	Standard deviation	SEM	<i>P</i> value
Pretest	13.48 ^b	44.93	± 2.87	0.53	<0.0001
Post-test	22.00 ^a	73.21	± 3.28	0.61	
3-mo follow-up	20.33 ^a	67.76	± 3.93	0.80	

^{a, b}means within a column lacking a common superscript letter differ (*P* <0.05).

^cnumber of participants present during pretest and post-test evaluations were *n* = 29 and during 3-mo follow-up evaluation were *n* = 23.

Knowledge

Respondents were evaluated for food safety knowledge before, immediately after, and again 3 mo after the delivery of the FSSM course. The questionnaire consisted of 30 multiple choice and true/false questions, which remained identical in the structure and content. Questions covered all aspects of the FSSM course modules: food science, food microbiology, sanitation, BPCS, HACCP, and food defense. For all participating students, the pre-test score mean (44.93 %) differed significantly (*P* <0.0001) when compared to the post-test score mean (73.21%), which is a clear indication of knowledge gained over the time period (Table 6). The standard deviation around the mean for pretest and post-test scores was ± 2.87 and ± 3.28, respectively. ANOVA also was used to evaluate significant differences at the level of $\alpha = 0.05$ for food safety knowledge from the pretest, post-test, and the 3-mo follow-up. It was evident that the knowledge gained differed significantly with time (Table 7). There was no significant difference (*P* >0.05) between post-test (73.21%, ± 3.28) and the 3-mo follow-up for food safety

Table 8—Average quiz grade for participants after completion of each module (*n* = 29).

Modules	Average grade (%)	Standard deviation
Food Science	79	± 9
Food Microbiology	79	± 7
Sanitation	85	± 8
Better Process Control School	88	± 5
HACCP	88	± 8
Food Defense	73	± 5

knowledge (67.76%, ± 3.93); however, both of these parameters differed significantly (*P* <0.0001) when compared with pretest knowledge (44.93%, ± 2.87).

In addition to the food safety knowledge assessments, students were quizzed after each module. The grades of participating students for each FSSM module is presented in Table 8. The average grade for food science and food microbiology modules was 79%, whereas, in the BPCS and HACCP modules, students got the highest grades (88%) when compared with other modules. On average, participating students received an average grade of 85% and 73% on sanitation and food defense modules, respectively.

Attitude

Food safety attitude of respondents toward general food safety practices, buying and preparation of food, regulations, and training is presented in Table 9. This table covers respondents' attitudinal responses before and after the delivery of the FSSM course. The questions asked before, after, and during the 3-mo follow-up were identical and kept in the similar format. Questions were asked on

Table 9—Attitude of participants toward general food safety practices, buying and preparation of food, regulations and training (*n* = 29) before, after, and during a 3-mo follow-up (*n* = 23).^a

General food safety practices (Survey questions)	Before training					After training					3-mo follow-up						
	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)
1. Food safety is an important issue to me.	1/29 (4)	1/29 (4)	16/29 (55)	12/29 (41)	2/29 (7)	1/29 (4)	6/29 (21)	4/29 (14)	7/29 (24)	22/29 (76)	1/29 (4)	1/29 (4)	1/29 (4)	7/23 (30)	10/23 (44)	13/23 (57)	7/23 (30)
2. I believe that foodborne illness is common.	1/29 (4)	11/29 (38)	11/29 (38)	4/29 (14)	2/29 (7)	1/29 (4)	4/29 (14)	13/29 (45)	12/29 (41)	10/29 (35)	1/29 (4)	1/29 (4)	1/29 (4)	1/23 (4)	11/23 (48)	5/23 (22)	5/23 (22)
3. I would like to learn more about personal hygiene on how it relates to food safety.		4/29 (14)	11/29 (38)	14/29 (48)			1/29 (4)										
4. I believe that washing hands before and after food preparation is important to keep food safe.		8/29 (28)	21/29 (72)				4/29 (14)	25/29 (86)							4/23 (17)	19/23 (83)	
5. There is always a chance of getting sick from food contaminated with pathogens/toxins.	2/29 (7)	11/29 (38)	15/29 (52)	1/29 (4)	1/29 (4)	1/29 (4)	9/29 (31)	20/29 (69)						1/23 (4)	14/23 (61)	8/23 (35)	
Buying and preparation of food																	
6. I am concerned about buying safe food.	1/29 (4)	14/29 (48)	14/29 (48)				1/29 (4)	11/29 (38)	17/29 (59)					1/23 (4)	11/23 (48)	11/23 (48)	
7. I always check the expiration/best buy date on food I buy.	1/29 (4)	2/29 (7)	11/29 (38)	5/29 (17)	2/29 (7)	1/29 (4)	1/29 (4)	9/29 (31)	19/29 (66)					7/23 (30)	7/23 (30)	16/23 (70)	
8. I always wash fruits and vegetables before I eat them.	6/29 (21)	6/29 (21)	5/29 (17)	12/29 (41)	1/29 (4)	3/29 (10)	4/29 (14)	6/29 (21)	16/29 (55)					2/23 (9)	9/23 (39)	12/23 (52)	
9. I never eat raw meat products.	7/29 (24)	8/29 (28)	4/29 (14)	7/29 (24)	2/29 (7)	5/29 (17)	3/29 (10)	9/29 (31)	12/29 (41)					4/23 (17)	8/23 (35)	8/23 (35)	
10. I use 2 different cutting boards when preparing vegetables and raw meat.	1/29 (4)	11/29 (38)	17/29 (59)	1/29 (4)	1/29 (4)	1/29 (4)	8/29 (28)	5/29 (17)	4/29 (14)					7/23 (30)	10/23 (44)	1/23 (4)	
11. It has been always easy to understand the labels on food items.	1/29 (4)	3/29 (10)	6/29 (21)	3/29 (10)	3/29 (10)	1/29 (4)	5/29 (17)	7/29 (24)	17/29 (59)					2/23 (9)	13/23 (57)	8/23 (35)	
12. Using a properly calibrated thermometer to measure the internal temperature of meat is important to keep it safe.																	
Regulations and training																	
13. I am responsible for the safety of the food that I eat.	2/29 (7)	8/29 (28)	9/29 (31)	10/29 (35)		2/29 (7)	4/29 (14)	9/29 (31)	14/29 (48)					4/23 (17)	10/23 (44)	8/23 (35)	
14. We should have local/regional/state regulations to ensure safe food.	1/29 (4)	9/29 (31)	14/29 (48)	10/29 (35)		1/29 (4)	4/29 (14)	10/29 (35)	19/29 (66)					8/23 (35)	15/23 (65)	6/23 (26)	
15. I am interested in taking more food safety-related training, if provided.	1/29 (4)	8/29 (28)	14/29 (48)	10/29 (35)		1/29 (4)	4/29 (14)	10/29 (35)	14/29 (48)					1/23 (4)	16/23 (70)	9/23 (39)	
16. More classes/seminars/training regarding food safety should be available for consumers.	6/29 (21)	6/29 (21)	8/29 (28)	9/29 (31)	9/29 (31)	1/29 (4)	6/29 (21)	13/29 (45)	9/29 (31)					2/23 (9)	5/23 (22)	11/23 (48)	
17. It is the government's responsibility to ensure that the food we eat is safe.	3/29 (10)	5/29 (17)	10/29 (35)	11/29 (38)		1/29 (4)	3/29 (10)	10/29 (35)	15/29 (52)					2/23 (9)	15/23 (65)	6/23 (26)	
18. I want to gain additional knowledge about food safety.	10/29 (35)	17/29 (59)	38/52 (73)			10/29 (35)	17/29 (59)	38/52 (73)						9/23 (39)	65/92 (71)	26/35 (74)	

SD, Strongly Disagree; D, Disagree; N, Neutral; A, Agree; SA, Strongly Agree; IDNK, I Do Not Know.
^anumber of participants present during pretest and post-test; evaluations were *n* = 29 and during 3-mo follow-up evaluation were *n* = 23.

five-point Likert scale plus a “I do not know” column. The “I do not know” section gave respondents a place to express their feeling if they are unaware of the presented scenario.

Attitude of respondents on general food safety practices was observed. Questions asked were related to food safety issues, foodborne illness, personal hygiene and hand washing, and foods contaminated with pathogens. Before the FSSM course, less than half (12/29; 41%) “strongly agreed” on food safety being an important issue. In contrast, after the administration of the course, most of the respondents (22/29; 76%) “strongly agreed” upon the same statement, which decreased after the 3-mo follow-up (13/23; 57%). Likewise, when compared with the pretest (4/29; 14%), more respondents (10/29; 35%) believed that foodborne illness is common. However, after the training and during the 3-mo follow-up, few respondents (6/29; 21%) were still “neutral” about foodborne illness being common. Similarly, the number of respondents “agreeing” or “strongly agreeing” about washing hands before and after food preparation were increased after the FSSM training.

Respondents were surveyed on their attitude for buying and preparation of food items. Before the FSSM course, almost half of the participants (14/29; 48%) “agreed” or “strongly agreed” that they were concerned about buying safe food, but very few (1/29; 4%) were “neutral.” In contrast, after the FSSM course and during the 3-mo follow-up, more than half of the participants “agreed” or “strongly agreed” on the same topics. The attitude of respondents toward checking the expiration or best-buy date, washing fruits and vegetables before eating, and using separate cutting boards for preparing raw meat and vegetables changed after the delivery of the course. Few respondents (5/29; 17%) “disagreed” when asked about using separate cutting boards for raw meat and vegetable after the course delivery and again (3/23; 13%) during the 3-mo follow-up. More than half of the respondents (16/29; 55%) “strongly agreed” about never eating raw meat products, yet some of the respondents (3/29; 10%) “disagreed” and (4/29; 14%) remained “neutral” toward the end. Likewise, the respondents improved their attitude on using a properly calibrated thermometer to measure the internal temperature of meat to keep it safe. In the beginning, 1/5 (6/29; 21%) of the participants “strongly agreed” with using calibrated thermometer to keep meat safe. In contrast, almost 2/3 (17/29; 59%) of them “strongly agreed” on the same topic after the course delivery. During the 3-mo follow-up, most of the participating students “agreed” (13/23; 57%) or “strongly agreed” (8/23; 35%) that using a calibrated thermometer was important.

Respondents were surveyed on their attitude for food safety regulations and training as well. Survey questions asked their responsibility for the safety of the food that they eat. While 8 (28%) of the respondents were “neutral” at the beginning of the training, 4/29 (14%) were “neutral” after complete delivery of the course and again after the 3-mo follow-up. After delivery of the course (post-test) and after the 3-mo follow-up, more than half (19/29; 66%) of the respondents “strongly agreed” on having local/regional/state level regulations to ensure safe food supply. Interest of respondents toward taking more food safety-related training/classes/seminars, and/or gaining additional knowledge about food safety increased (21/23; 91%) after the completion of the FSSM course.

Behavior

Perceived behavior of respondents toward food safety practices and food safety training is presented in Table 10. This table covers respondents’ behavioral response on food safety practices and

training before and after the delivery of FSSM course, as well as the 3-mo follow-up. Similar to attitudinal response, behavioral questions were identical and kept in the similar format. Questions were asked on five-point Likert scale plus a “I do not know” column.

Respondents were asked about their basic understanding of food safety before and after the training. Almost all participants (25/29; 86%) “strongly agreed” that it was important to have a basic understanding of food safety, especially for those working in the food industry. By the end of the training, and again after the 3-mo follow-up (20/23; 87%), the “strongly agreed” responses were almost twice (14/29; 48%) that of those associated with the initial assessment. Before the beginning of the FSSM course, few respondents (3/29; 10%) were not aware of foodborne illness symptoms. However, the importance of this topic became clear after the course delivery. Likewise, when asked about contamination of food by microorganisms that can cause a serious food safety issues, before the beginning of the course, few of the respondents (3/29; 10%) “did not know” or were “neutral” (5/29; 17%). After the delivery of the course and after the 3-mo follow-up, all of the respondents “agreed” or “strongly agreed” that microorganisms can cause serious food safety issues. When asked about the importance of refrigerating food, the respondents (3/29; 10%) did not change their response over time. When asked about washing and sanitation of a cutting board, if used for raw meat and vegetables, only 11 respondents (38%) “strongly agreed” with the importance before the course, whereas after the course delivery and after the 3-mo follow-up, almost all participants “agreed” or “strongly agreed” about the importance of washing and sanitizing before using cutting boards for different food products. Similarly, the behavior of respondents about washing hands before preparing food at home, removing jewelry before entering the food processing facility, wearing hairnet while working in the food plant, and so on. changed to a higher level, such that most of the respondents “strongly agreed” that personal hygiene was an integral part of food safety after the delivery of the course.

Respondents were asked about the importance of good manufacturing practices (GMPs), both before and after the delivery of the course. At the beginning, 2/3 of the respondents either “agreed” (13/29; 45%) or “strongly agreed” (7/29; 24%) that GMPs were necessary; in contrast, after the delivery of the course and after the 3-mo follow-up, all of the respondents either “agreed” or “strongly agreed” on the same topic. Likewise, respondents’ behavior toward finding a job in a food industry after the training increased. Finally, after the course delivery, respondents were confident enough to train their families in basic safe food handling practices. Also, according to the obtained survey, participants were capable of preparing the safest food for their friends and families.

Skill

Participating student volunteers ($n = 9$) were asked to wash their hands, as a means of measuring their skill, before and after the delivery of FSSM course. The results are shown in Table 11. Before the training (pretest), students were asked to wash their hands as they do normally. For the post-test handwashing skill, students were asked to wash their hands according to what they learned throughout the FSSM course. The pretest score mean (5.44) differed significantly ($P < 0.0001$) when compared to the post-test score mean (11.44). The result signifies the importance of a hands-on exercise to improve handwashing skills of participants. The standard deviation around the mean for pretest and post-test score was ± 1.89 and ± 1.01 , respectively.

Table 10—Behavior of participants toward food safety practices and food safety training (n = 29) before, after, and during a 3-mo follow-up (n = 23).^a

Food safety practices (Survey questions)	Before Training					After Training					3-mo follow-up								
	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	
1. In order to insure the safety of all those working in a food laboratory/industry, everyone must have a basic understanding of food safety.	3/29 (10)	10/29 (35)	11/29 (38)	2/29 (7)	3/29 (10)	3/29 (10)	4/29 (14)	9/29 (31)	13/29 (45)	3/29 (10)	10/29 (35)	19/29 (66)	1/23 (4)	2/23 (9)	3/23 (13)	15/23 (65)	3/23 (13)	1/23 (4)	1/23 (4)
2. Food poisoning (vomiting, diarrhea, headache, mild fever) is common in Armenia.	5/29 (17)	15/29 (52)	6/29 (21)	3/29 (10)	3/29 (10)	3/29 (10)	3/29 (10)	5/29 (17)	10/29 (35)	7/29 (24)	14/29 (48)	7/29 (24)	1/23 (4)	2/23 (9)	3/23 (13)	6/23 (26)	15/23 (65)	1/23 (4)	1/23 (4)
3. How much do you agree that contamination of food by microorganisms can cause a serious food safety issue?	3/29 (10)	9/29 (31)	11/29 (38)	5/29 (17)	1/29 (4)	1/29 (4)	3/29 (10)	5/29 (17)	2/29 (7)	2/29 (7)	5/29 (17)	7/29 (24)	1/23 (4)	2/23 (9)	3/23 (13)	11/23 (48)	6/23 (26)	1/23 (4)	1/23 (4)
4. Keeping food refrigerated makes it safer.	3/29 (10)	3/29 (10)	10/29 (35)	11/29 (38)	2/29 (7)	2/29 (7)	3/29 (10)	2/29 (7)	2/29 (7)	2/29 (7)	12/29 (41)	15/29 (52)	1/23 (4)	2/23 (9)	3/23 (13)	11/23 (48)	6/23 (26)	1/23 (4)	1/23 (4)
5. I always rinse, wash, and sanitize the cutting board that is used for raw meat and poultry before using it with other ready-to-eat food(s).	1/29 (4)	10/29 (35)	18/29 (62)	5/29 (17)	5/29 (17)	5/29 (17)	3/29 (10)	5/29 (17)	7/29 (24)	9/29 (31)	20/29 (69)	20/29 (69)	1/23 (4)	2/23 (9)	3/23 (13)	4/23 (17)	19/23 (83)	1/23 (4)	1/23 (4)
6. I always wash my hands before preparing food at home.	1/29 (4)	4/29 (14)	9/29 (31)	10/29 (35)	5/29 (17)	5/29 (17)	1/29 (4)	2/29 (7)	2/29 (7)	5/29 (17)	24/29 (83)	24/29 (83)	20/23 (87)	1/23 (4)	1/23 (4)	2/23 (9)	4/23 (17)	1/23 (4)	1/23 (4)
7. Anyone entering the food processing facility must remove all jewelry.	1/29 (4)	2/29 (7)	6/29 (21)	21/29 (72)	1/29 (4)	1/29 (4)	2/29 (7)	2/29 (7)	2/29 (7)	3/29 (10)	26/29 (90)	26/29 (90)	1/23 (4)	2/23 (9)	3/23 (13)	1/23 (4)	22/23 (96)	1/23 (4)	1/23 (4)
8. Food plant workers should wear hairnets that contain and cover all the hair and ears.	16/29 (55)	7/29 (24)	3/29 (10)	3/29 (10)	1/29 (4)	1/29 (4)	24/29 (83)	2/29 (7)	1/29 (4)	2/29 (7)	2/29 (7)	2/29 (7)	20/23 (87)	1/23 (4)	1/23 (4)	1/23 (4)	1/23 (4)	1/23 (4)	1/23 (4)
9. It is okay for food processing employees to eat and drink on the production line.	1/29 (4)	10/29 (35)	17/29 (59)	1/29 (4)	1/29 (4)	1/29 (4)	1/29 (4)	1/29 (4)	1/29 (4)	5/29 (17)	24/29 (83)	24/29 (83)	1/23 (4)	2/23 (9)	3/23 (13)	2/23 (9)	20/23 (87)	1/23 (4)	1/23 (4)
10. Personal hygiene should be an integral part of food quality and safety for each and every food processor and/or employee(s).	1/29 (4)	6/29 (21)	13/29 (45)	7/29 (24)	2/29 (7)	2/29 (7)	1/29 (4)	4/29 (14)	1/29 (4)	9/29 (31)	20/29 (69)	20/29 (69)	1/23 (4)	1/23 (4)	1/23 (4)	11/23 (48)	10/23 (44)	1/23 (4)	1/23 (4)
Training	1/29 (4)	6/29 (21)	13/29 (45)	7/29 (24)	2/29 (7)	2/29 (7)	1/29 (4)	4/29 (14)	1/29 (4)	9/29 (31)	20/29 (69)	20/29 (69)	1/23 (4)	1/23 (4)	1/23 (4)	11/23 (48)	10/23 (44)	1/23 (4)	1/23 (4)
11. I understand the importance of Good Manufacturing Practices (GMPs).	1/29 (4)	6/29 (21)	12/29 (41)	10/29 (35)	1/29 (4)	1/29 (4)	1/29 (4)	1/29 (4)	1/29 (4)	11/29 (38)	13/29 (45)	13/29 (45)	1/23 (4)	1/23 (4)	3/23 (13)	10/23 (44)	8/23 (35)	1/23 (4)	1/23 (4)
12. Training related to safe food handling will help me to find a job in the food industry.	1/29 (4)	1/29 (4)	9/29 (31)	7/29 (24)	2/29 (7)	2/29 (7)	1/29 (4)	4/29 (14)	1/29 (4)	12/29 (41)	13/29 (45)	13/29 (45)	1/23 (4)	1/23 (4)	6/23 (26)	12/23 (52)	5/23 (22)	1/23 (4)	1/23 (4)
13. I would like to receive more training in food safety/food microbiology in the near future.	3/29 (10)	6/29 (21)	16/29 (55)	4/29 (14)	1/29 (4)	1/29 (4)	3/29 (10)	17/29 (59)	17/29 (59)	17/29 (59)	12/29 (41)	12/29 (41)	2/23 (9)	2/23 (9)	2/23 (9)	17/23 (74)	4/23 (17)	1/23 (4)	1/23 (4)
14. I am confident enough to train my family on basic safe food handling practices.	1/29 (4)	2/29 (7)	10/29 (35)	3/29 (10)	1/29 (4)	1/29 (4)	1/29 (4)	2/29 (7)	1/29 (4)	20/29 (69)	7/29 (24)	7/29 (24)	1/23 (4)	1/23 (4)	2/23 (9)	16/23 (70)	4/23 (17)	1/23 (4)	1/23 (4)
15. I am confident in my ability to prepare the safest food for my friends and families.	1/29 (4)	7/29 (24)	10/29 (35)	3/29 (10)	1/29 (4)	1/29 (4)	1/29 (4)	2/29 (7)	1/29 (4)	20/29 (69)	7/29 (24)	7/29 (24)	1/23 (4)	1/23 (4)	2/23 (9)	16/23 (70)	4/23 (17)	1/23 (4)	1/23 (4)

SD, Strongly Disagree; D, Disagree; N, Neutral; A, Agree; SA, Strongly Agree; IDNK, I Do Not Know.
^aNumber of participants present during pretest and post-test evaluations were n = 29 and during 3-mo follow-up evaluation were n = 23.

Table 11—Average and percent of the handwashing skill of participants.

Respondents (n = 9)	Pretest		Post-test		Change in score	Percent change in score
	Score (Max = 12)	Percent score	Score (Max = 12)	Percent score		
1	7	58.33	11	91.67	4	33.33
2	3	25.00	12	100.00	9	75.00
3	3	25.00	12	100.00	9	75.00
4	7	58.33	12	100.00	5	41.67
5	7	58.33	9	75.00	2	16.67
6	7	58.33	12	100.00	5	41.67
7	7	58.33	12	100.00	5	41.67
8	4	33.33	11	91.67	7	58.33
9	4	33.33	12	100.00	8	66.67
Average	5.44	45.37	11.44	95.37	6.00	50.00
Skill test		Mean	Standard deviation	SEM		Paired <i>t</i> test
Pre		5.44 ^b	± 1.89	0.63		<0.0001
Post		11.44 ^a	± 1.01	0.34		

^{a, b}Means within a column lacking a common superscript letter differ ($P < 0.05$).

Discussion

In the developing world, the role of regulatory agencies to address safe food handling training for food service establishments is minimal (Grace 2015). Therefore, the number of well-controlled studies, addressing the effect of training on individuals' food safety knowledge, attitude, behavior, and skills appears to be limited (Grace 2015). In this study, responses obtained from participating students who participated in food safety training were encouraging. Continuous training or education of students and/or consumers has the potential to minimize hazards associated with improper food handling (Finch and Daniel 2005; Karabudak and others 2008). Therefore, questions in this study were asked to identify the social cognitive factors including knowledge, attitudes, behavior, and skill.

Participating students in this research study with an agribusiness background had no prior food safety training or courses. The food safety knowledge of the participating students was accessed at the beginning of the course. Pretest scores were significantly lower ($P < 0.05$) on the accessed food safety knowledge of the students, when compared with the post-test and 3-mo follow up score. The questions covered all FSSM course modules: food science, food microbiology, sanitation, BPCS, HACCP, and food defense. The results suggest that a comprehensive food safety training had a significant impact on students' knowledge and understanding of basic food safety practices. The findings are consistent with other studies (Costello and others 1997; Finch and Daniel 2005; McIntyre and others 2013) that showed individuals with food safety-related training scored higher than individuals without training.

According to Kraus (1995), attitudes, in one way or the other, guide, influence, direct, shape, or predict actual behavior. Cognitive responses related to attitude can affect food safety behavior of a person (Redmond and Griffith 2002). In addition, the attitude towards food safety may differ on the basis of socioeconomic factors such as gender, age, and educational level (Altekruse and others 1999; Verbeke and Viaene 1999; Wilcock and others 2004). To access the attitude of an individual toward general food safety practices, buying and preparation of food, related regulations and training, a number of questions were asked before and after the FSSM course. It was observed that, by the end of the course, respondents were very likely to change their food safety attitude, which may predict their actual behavior. Some of the scenarios where respondents appeared to change their attitude toward food safety included, but were not limited to: checking the expiration date before buying foods, not eating raw meat products,

using different cutting boards for different food commodities, the importance of food safety related trainings, and their interest in future trainings. Changes that were observed in the respondents' food safety attitude appear to be reflected in their behavior. One student noted: "In my opinion, the first step should be to increase the awareness in the society to food safety issues. As a student from the marketing department, I can use some digital marketing techniques to draw people's attention in social media. The fact that Food Safety Systems Management can make them and their products competitive not only in Armenian market but also abroad, which will increase their motivation to employ food safety techniques." Another student remarked: "I dream to set up my own farm, then in the future processing of raw materials. I would be glad to share my knowledge and experience with Armenian farmers and processors, and especially with those who are not following the requirements of food safety."

Respondents' perceived behavior toward food safety practice was accessed before and after the FSSM course. As the course progressed, there seemed to be change in behavior pattern of the participants. However, food safety knowledge, training, and education level do not always correspond with the implementation of appropriate food safety behavior (McIntosh and others 1994; Meer and Misner 2000). In addition, the change in behavior can be obtained by focusing on those who are at high risk for foodborne illness, followed by those who have demonstrated the greatest need (Meer and Misner 2000). In this study, young adults demonstrated some progress in their behavior with regards to food safety practices, GMP's and personal hygiene by the end of the course.

In addition to educating themselves, FSSM participants shared their gained knowledge on food safety, as evidenced by one student's comment: "My new knowledge is already helping me. During our FSSM classes I was telling how cool it is to one of my friends, who is a 40-y-old woman with a family and child. She was very interested and once she asked me to tell what we are learning during these classes. I showed my books and also our pictures on Facebook. All that was interesting for her and she asked to give my materials to her explaining that she wants to learn everything. I gave all the books I had and now she is using most of the principles that we were covering during our course. I think we need to make it interesting and attractive for involving many people and then it needs to show the whole seriousness of the issue."

Skill of the participants was accessed through observing their handwashing technique before and after the FSSM course. To avoid possible cross-contamination by pathogenic microorganisms,

consumers should be aware of multiple food safety skills, which are required from purchasing of food products through processing and consumption (Redmond and Griffith 2003; Grunert 2005). By the end of the FSSM course, significantly higher ($P < 0.05$) handwashing skill performance scores were achieved by the participating students. This finding is a result of clear demonstration by the researchers, thereby enhancing the skill development (Bloomfield and others 2010). An effective handwashing skill has proven to control the contamination or cross-contamination of pathogenic microorganisms (Monsma and others 1992; Lillquist and others 2005; Bloomfield and others 2010; Machado and others 2017). Inclusion of such training, while focusing on a vulnerable group, has the potential to help reduce the potential risk of cross-contamination.

Conclusion

It was concluded that the cognitive responses related to knowledge, attitude, behavior, and skill toward food safety practices were demonstrated by participating students. However, to maintain the food safety knowledge, improved behavior and attitude, as well as the attained skills by participating students, such programs should be conducted periodically. Additionally, practical knowledge with hands-on laboratory exercises, aided by an industrial tour to observe the food safety practices in action, is recommended.

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