Development of effective pedological methods to educate high school students about food irradiation and safe food handling practices

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Development of effective pedological methods to educate high school students about food irradiation and safe food handling practices

by

Sherrlyn S. Olsen

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

Major: Meat Science

Program of Study Committee:
Joseph G. Sebranek, Major Professor
Brad R. Skaar
M. Douglas Kenealy

Iowa State University
Ames, Iowa
2006

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Graduate College
Iowa State University

This is to certify that the master's thesis of

Sherrlyn S. Olsen

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
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CHAPTER 1. GENERAL INTRODUCTION

Introduction

All who have meditated on the art of governing mankind have been convinced that the fate of empires depends on the education of youth. Aristotle

Aristotle's quote, written during the establishment of civilizations, still provides the wisdom that is required for the successful function of today's society. Now, perhaps more than any other time in our history, this quote speaks to the importance of education and the role it plays in a country's attainment of wealth and world power. Without effective educational systems reaching all citizens, countries will continue to struggle both socially and economically with evidence of oppression and poverty remaining apparent.

In the United States, the basics of math, science, language and social sciences are emphasized in public and private schools from preschool through high school levels. At the high school levels courses are offered in vocational education, providing opportunities for students to learn skills that can be utilized throughout their lifetimes. Once effectively learned by this population, these skills will continue to be implemented as these young persons continue into adulthood and begin to raise families, enter the work force, and assume roles as public servants.

Educating consumers about topics such as irradiation and handwashing have proven beneficial in helping to reduce the numbers of foodborne disease outbreaks. With mobilization of men, movement of commodities and subsequent explosion of the earth's population, the implementation of new food technologies and proper food handling methods have been instrumental in improving the safety of the world's food supply. Mead et al. (1999) published the landmark paper estimating that annually foodborne diseases caused by known and unknown pathogens totaled approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States. It was concluded that by identifying new causes for enteric illnesses, and impressing upon the public how important it is to identify the sources of these illnesses, the prevention efforts of foodborne diseases could be improved.

Important information was made available in an issue of the Morbidity and Mortality Weekly Report (2006). Comparisons of the 2005 data to 1996-1998 data by the United States Department of Health and Human Services Centers for Disease Control and Prevention showed significant decreases in the incidences of Campylobacter, Listeria,
Salmonella, Shigella, E. coli O157, and Yersinia for 10 states within the United States. Attributing to these lower numbers was a concerted effort to meet the national health objectives which included educating consumers about safe food handling practices and increasing testing at slaughter and processing plants. However, the United States Department of Health and Human Services Centers for Disease Control and Prevention reiterated that challenges lie ahead in understanding and controlling pathogens in animals and plants; reducing and/or preventing contamination during food processing; and educating consumers about risk and prevention measures when handling food. The risk of developing foodborne illnesses can be decreased by following safe food handling practices and using proper cooking and storage temperatures. Technologies identified that could effectively improve food safety included the pasteurization of in-shell eggs and irradiation of ground meat and raw poultry. Most beneficial for at-risk populations, the uses of these technologies has not reached full potential.

Ellis et al. (2004) provided research concerning high school students’ perceptions of foodborne illnesses and general food safety. Students were found to be familiar with Salmonella, E. coli, and Hepatitis A, and were less familiar with Campylobacter, Listeria and Clostridium. They were more concerned about developing foodborne illnesses from consuming meats and eggs than from fruits and vegetables. Students suggested that food safety problems were initiated during food manufacturing and processing followed by: restaurants, transportation, supermarkets, homes and farms. Their confidence in the food eaten at home was higher than that served in restaurants. Ellis concluded that, similar to adult consumer research, education at the high school level was paramount for developing awareness about foodborne pathogens, as well as the need for food safety education at earlier ages. However, he was quick to report that education alone would not reduce problems associated with food safety. Learned behaviors about food safety and food technology must be modified or taught so as to develop habits that would be relied upon far into adulthood. These research results provided beneficial information for developing those types of food safety education and training programs.

**Research Objective and Hypothesis Statement**

The objective of this research was to assess effective pedological methods to educate high school students about irradiation as an effective food technology, as well as to introduce them to safe food handling practices. The hypothesis stated that if effectively
delivered, the information learned by the students would continue to be used by this population far into the future, thus making favorable impact in reducing the incidences of foodborne illnesses. By implementing the most effective educational tools to teach this material, successful results would be realized. Therefore a number of learning activities were developed and implemented to several participants in order to discover the most effective educational method to use in teaching food safety concepts to high school students.

Thesis Organization

This thesis was written in four chapters. The first chapter is a general introduction to food irradiation education and the objective and hypothesis for the research. The second chapter provides a literature review of pedological methods. Chapter three is entitled "Development of effective pedological methods to educate high school students about food irradiation and safe food handling practices". Contained within this chapter are the abstract, introduction, methods, results, discussion, conclusions, and references. Chapter four consists of general conclusions.

References


CHAPTER 2. LITERATURE REVIEW

Introduction

Much research, time, and money has been devoted to our nation’s food system to control the outbreaks of foodborne illnesses. In addition, considerable resources have been used to educate consumers concerning personal accountability for the foods they prepare and consume in the privacy of their own homes and to the industries who are responsible for feeding a hungry world. For years researchers have been studying the most effective methods for educating consumers about safe food handling practices. While much time has been spent teaching adult consumers and youth about food safety, little time has been devoted to developing the most effective classroom instructional methods necessary to teach high school students (Boutelle et al., 2001). This is especially true for a particularly safe and reliable technology used to ensure a safe food supply—namely irradiation. The objective of this literature review is to discuss consumers’ knowledge and understanding of irradiation, and to uncover educational methods that may be used to teach high school students about the effectiveness of irradiation and its important role in the world’s food supply. Information in this review will discuss the most valuable educational methods used to teach high school students. Programs developed to teach about food irradiation, and subsequently food safety, must be developed and assessed so as to implement the most valuable learning experiences for this population. It is hypothesized that if successfully accomplished, the information learned and practiced by this group will prove to be beneficial for not only the high school students, but also for future generations.

Population Growth Impacts the Incidences of Foodborne Illnesses

The incidences of foodborne illnesses can best be understood by identifying what is known and understood about food. Blaser (1996) summarized civilization’s progress throughout the development of the food chain. As domesticated societies evolved, households were individually responsible for their own food production and consumption. With the onset of cultural and technological developments, food production became industrialized and today wide varieties of foods are transported for global distribution. The food chain has evolved into convoluted relationships between growers, processors, distributors, retailers, and consumers. These changes have led to the possibilities of potentially hazardous situations, thus compromising food safety throughout the world.
Salmonellosis has been described as a "disease of civilization" (Blaser, 1996). According to the National Institute of Allergy and Infectious Diseases (2005), the episodes of this illness are becoming more numerous due to methods used to prepare food and the consumption choices made by the general population. *Salmonella* enteritidis is the most common strain found in humans. The second most common strain, *Salmonella* typhimurium, was first discovered in the United Kingdom, and eventually in the United States. Unfortunately this particular strain is resistant to several antibiotics, and therefore is recognized as a serious threat to the world's population. Salmonellosis may be implicated in both large and small outbreaks, and the sources of the disease can be found in both private households and public food establishments such as restaurants, hospitals, and facilities that prepare food for children or the elderly. Children, the elderly, and persons suffering from chronic conditions are the most severely afflicted with this disease. AIDS patients and others with compromised immune systems often have recurring bouts of salmonellosis. Poor food handling practices are common causes of this disease, and many outbreaks probably go unreported. Because food production is a global business, there are increased chances of outbreaks throughout the world. The most reported cases of salmonellosis have come from North America and Europe. Annually in the United States, the United States Department of Health and Human Services Centers for Disease Control and Prevention receive reports of 40,000 cases. It is estimated that each year 1.4 million persons are infected with the disease and 1,000 persons die due to salmonellosis.

Blaser (1996) suggested that, "Food is not sterile, and eating cannot be made risk-free." This statement drives home the importance of teaching food science and technology, and food safety in the nation's classrooms. Consumers need to be constantly reminded that they are each accountable for applying safe food handling practices. The United States food industry provides the world's safest food supply. However, as Blaser (1996) indicated, the consumer must also assure that the food coming from his kitchen has been properly prepared.

In 2000, the United States Department of Agriculture provided information in the PR/HACCP (Pathogen Reduction/Hazard Analysis and Critical Control Point) Rule Evaluation Report that stated many Americans still do not practice the 4 C's in food preparation- cook, clean, chill, and avoid cross contamination. A study of participants aged 20 through 60 years and older provided the following information. 83% of the participants washed cutting boards between using them for meats and vegetables and only 5% used a
different cutting board. 76% washed their hands after handling raw meat or poultry. 43% owned a food thermometer, and of those, most were a dial thermometer. Only 17% used a thermometer when preparing large cuts of meat such as roasts or turkeys. 22% refrigerated soups or stews containing meat or poultry immediately after serving.

Handwashing is another practice that is commonly compromised and affects food supplies. In 2003, the School Network for Absenteeism Prevention, through information provided by the United States Department of Health and Human Services Centers for Disease Control and Prevention, provided information on handwashing. They reported that research has shown only 48% of male and only 58% of female high school and middle school aged students wash their hands after using the bathroom. Only 8% of male students and 33% of female students use soap when washing their hands. Of the adult population using public restrooms, only about 33% wash their hands after using bathrooms.

Until irradiation becomes commonplace and every human being uses safe food handling practices, there will be the need for food safety education. Therefore researchers must continue to investigate educational methods that are the most effective at reaching those consumers.

**Food Safety Education Targeting Youth is Critical**

Bruhn (1997) concluded that consumers still do not understand the importance of food safety. The author cited research by Abt Associates Incorporated (1996) that indicated consumers were willing to listen about information concerning bacterial hazards. Research from this study showed that from 1992 to 1996, consumers’ concerns increased from 36% to 49%. Overall concerns ranked as follows: bacterial contamination- 77%; pesticide residues- 66%; product tampering- 66%; and antibiotic residues- 42%. Alarmingly, basic safe food handling practices have not been taught to younger consumers. Bruhn stressed that this lack of education exposes the general public to increased opportunities of becoming ill due to foodborne diseases. More and more young people are entering the work force, particularly becoming employed in food service. These young workers are not being exposed to safe food handling practices in their homes or in the schools. In food service establishments, equipment for partially prepared foods as well as equipment used to complete food preparation is used. Improper use of this equipment and mishandling of the products can result in compromised food being served to the public.
Bruhn concluded that because of increased consumer concern about foodborne illnesses, the industry is obligated to utilize new technologies in order to protect the consumer. Medical and health communities must strengthen efforts to provide educational opportunities to the population, teaching about these technologies in order to provide a safer food supply. All educated consumers, companies, and the food industry must become actively engaged in dispelling any inaccurate information being publicized about new or non-traditional food handling technologies. Because food irradiation technology is so misunderstood, particular care must be taken in disseminating information about its use. Cooperating with representatives from mass media in broadcasting factual and up-to-date information is very important. Television, radio, and newsprint are the most common sources from where the public obtains their news; therefore care must be taken in developing the proper information that will be broadcast. Bruhn specifically stated that young consumers can be educated through school curriculum targeted to each age level. Examples of classroom instruction included teaching proper hygiene and life skills that would educate youth about food safety.

Ellis et al. (2004) studied Iowa high school students concerning their views of food safety and found that little research had been done to determine what they understood about safe food handling practices or foodborne illnesses. Their research indicated that high school students were familiar with Salmonella (90.7%), E. coli (88.9%), and Hepatitis A (83.7%); however their familiarity was much lower with Campylobacter (4.8%), Listeria (12.8%), or Clostridium (14.2%). Additionally, these students related meat and eggs to causes of foodborne illnesses as opposed to fruits and vegetables.

When questioned about sources of foodborne illnesses, these high school students provided the following rankings: food processors/manufacturers- 75.8%; restaurants- 64.4%; transportation- 58.1%; supermarkets- 47.1%; home- 40.5%; and farms- 38.4%. The students were more reliant on the safety of the food that was served in their own homes than that served in schools, and stated that they had the least amount of confidence in restaurant foods. Although 32.5% of these students worked in food service jobs, and 62.3% of them learned about food safety in school, they still had little knowledge of the sources of foodborne illnesses and how they could contract such illnesses.

Ellis concluded that their research would be helpful in the development of educational information for this age group. As high school students are tomorrow's consumers, the impact of this education would be invaluable for the future.
Tobin et al. (2005) studied Irish students aged 13-18 to determine how much they knew about food safety; how they actually handled food; how they thought that they should handle food; and what attitudes they demonstrated concerning food safety issues. An additional objective of the study was to determine if the financial well-being of the students paralleled their food safety handling skills.

Using questionnaires, both qualitative and quantitative methods were used to analyze different food safety issues. One-half of the respondents came from a higher socio-economic background, and the balance came from lower socio-economic backgrounds. Safe food handling skills were not considered very important by these Irish teenagers, but willingness to learn about these practices was demonstrated by the students. Both groups indicated that any food safety education they received was derived through schools, parents, and television. Students from both groups indicated that neither time nor temperature should be monitored when properly preparing a whole chicken for consumption. The majority of the students indicated that handwashing was very important when handling foods, but a large number of them did not wash their hands while at school. Teenagers from higher socio-economic backgrounds had better understandings of safe food handling practices than the group from the lower socio-economic background. The youth from disadvantaged areas did not understand the concept of cross contamination, nor did they know the proper temperature settings for refrigerators. It was concluded that food safety education must be taught in the schools as a basic life skill because safe food handling practices would be used throughout a lifetime. Educational methods implemented in the classrooms must be formed to best fit the needs of the students so that the knowledge can be successfully learned and practiced. Risk communication- teaching students that they are at risk for developing foodborne illnesses- was listed as one effective method used to teach this information.

The Principles of Successful Learning

Successful classroom instruction has evolved as studies in adolescent psychology and various teaching methods have been implemented. In 1956, Bloom et al. introduced the book Taxonomy of Educational Objectives- The Classification of Educational Goals. This classic instructional text classified educational goals and objectives, and researched the continued development of students’ acquired proficiencies and skills. Bloom and his associates organized this taxonomy into six major classes: knowledge, comprehension,
application, analysis, synthesis, and evaluation. As students progressed through the educational process, each class built upon their abilities to master the previous classes.

Newcomb and Trefz (1987) wrote that successful students acquired the following traits in the classroom: communication- the capability to convey knowledge effectively and efficiently; independence- the ability to think and perform on their own; ingenuity- the talent to develop novel thoughts, ideas, and products by evaluating existing conditions; and application- utilizing knowledge previously gained in relevant situations. Although college students could be prepared for successful professional careers by providing them with opportunities to hone these traits, high school students could also become proficient at these same skills. The authors suggested a revision of the six major classes of Bloom’s taxonomy into four levels- remembering, processing, creating, and evaluating. Every student was capable of successfully reaching each of these four levels when educators strategically planned and presented their instructional material. By mastering the traits of remembering, processing, creating, and evaluating, students could grow and evolve in the work force thereby experiencing more fulfilling professional careers.

Assessment of Effective Learning

The organization of classroom strategies allowed teachers to focus energies toward educational goals, effectively providing students with the tools to successfully achieve each classification as outlined by Bloom et al. (1956). Because the Institute of Food Technologists Education Standards for Food Science (Institute of Food Technologists, 2005) required learning outcomes to be written for each food science course, Hartel and Foegeding (2004) chose to highlight the following terms- learning outcomes, learning objectives, and competencies- because these terms are commonly misinterpreted in educational literature. By clearly defining these terms, clear assessments could be made of classroom activities. Competency detailed the knowledge and skills that each student should have gained upon graduating from the course or program. Objectives stated the larger goals of the course or program. Outcomes measured a student’s progress in the classroom. A competency could contain more than one outcome. This learning outcome was the tool used to measure each student’s achievement of satisfactorily completing the work in each course or program. Outcomes must be written utilizing verbiage indicating measurements of the learned activity. Using Bloom’s taxonomy, the authors composed the following chart to organize those verbs:
Table 1. Key verbs describing outcome measurements.

<table>
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<th>Outcome Measurements</th>
<th>Key Verbs</th>
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<tbody>
<tr>
<td>Knowledge: remembering information</td>
<td>define, identify, label, state, list, match</td>
</tr>
<tr>
<td>Comprehension: explaining the meaning of information</td>
<td>describe, paraphrase, summarize, estimate</td>
</tr>
<tr>
<td>Application: using abstracts in concrete situations</td>
<td>determine, chart, implement, prepare, solve, use, develop</td>
</tr>
<tr>
<td>Analysis: breaking down a whole into component parts</td>
<td>point out, differentiate, distinguish, discriminate, compare</td>
</tr>
<tr>
<td>Synthesis: putting parts together to form a new and integrated whole</td>
<td>create, design, plan, organize, generate, write</td>
</tr>
<tr>
<td>Evaluation: making judgments about the merits of ideas, materials or phenomena</td>
<td>appraise, critique, judge, weigh, evaluate, select</td>
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Distinguishing the difference between an assessable outcome and competency has become important for writing learning outcomes. Although the Institute of Food Technologists Educational Standards for Food Science refers to college and university food science coursework, the same requirements could be applied to high school students enrolled in science coursework.

Creative Educators Influence Students’ Attitudes in the Classroom

Whether using the taxonomy developed by Bloom et al. (1956) or the revision of that original work as described by Hartel and Foegeding (2004), detailed and effective strategies must be developed enabling students to graduate through each level. McKenzie (2003) wrote the article, “Pedagogy Does Matter!” where he cited the definition of pedagogy as defined by The National Board for Professional Teaching Standards. The board stated that “content pedagogy refers to the pedagogical (teaching) skills teachers use to impart the specialized knowledge/content of their subject area(s). Effective teachers display a wide range of skills and abilities that lead to creating a learning environment where all students feel comfortable and are sure that they can succeed both academically and personally. This complex combination of skills and abilities is integrated in the professional teaching standards that also include essential knowledge, dispositions, and commitments that allow educators to practice at a high level.” McKenzie (2003) stated that for several years new “quick-fix” technologies for student learning had been emphasized. He stressed that
educators should approach learning by addressing the following: 1) review needs assessment for each student; 2) improve teaching via professional growth; 3) improve classroom culture for learning; 4) strategize teaching methods to achieve the highest results; 5) review educational resources available in the classroom and utilize those resources to their fullest; 6) and develop problem solving skills. The combination of these six elements of effective pedagogy would provide classrooms with students transformed and eager to learn, and thus would implement the taxonomy that Bloom et al. described in 1956. Solid pedagogy that incorporated technological advancements available in the classrooms would provide effective and enthusiastic learning atmospheres.

Horng et al. (2005) reviewed effective teaching strategies by collecting data from three award winning teachers via individual interviews, focus group interviews, classroom observations and content analyses. Investigators found the following factors influenced creative teaching in classrooms: personality traits such as persistence, willingness to develop, acceptance of new experiences, self-confidence, sense of humor, curiosity, depth of ideas, and imagination; the support of families who reflected open and tolerant ways of teaching children, and the creativity performance of their parents; incorporation of experiences that encouraged growth and education by the use of self-created games and stories, and the encouragement of brainstorming between classmates; teaching beliefs that valued hard work and motivation; and the ability to organize the administrative business of school.

Integrated activities are closely connected to life experiences and help students instill creative thinking. Esquivel (1995) researched educational methods that incorporated teacher creativity and cited research performed by McGreevy (1990) that concluded students connected to lessons that incorporated stories of real-life events. Such events captured the interests of the students because they could relate to topics being discussed. Opportunities were provided for increased discussion with and amongst the students that concerned the lessons of the day and they began to develop problem-solving skills on higher levels. Horng et al. (2005) stated that in addition to connecting topics to real-life experiences, this method also taught management skills in the classroom, initiated open-ended questions to be asked of the students, and used technology and multi-media tools. By utilizing and emphasizing creative classroom instruction, students began to think independently, and were transformed into more creative and productive learners.
The authors concluded that the development of creative instructors began with effective teacher-training programs at colleges and universities. Potential educators on all levels could learn and practice creative teaching methods and obtain the knowledge necessary to instill these aspects in their students. Additionally, they determined that school systems should provide workshops and training activities to allow teachers to share their methods and classroom experiences with each other. This in-service training would urge teachers throughout the school system to use the creative teaching component in classrooms.

Ismail and Hayes (2005) identified positive and negative factors that influenced student motivation in a junior level dairy products elective course at a major Midwest university. Their findings paralleled previous research that concluded an enthusiastic instructor, the use of humor in the classroom, and positive attitude all significantly ($P=0.068$) influenced students’ goal-directed behavior. Positive factors included instructor enthusiasm and humor; positive feedback and attitude during the class discussions; and use of course objectives and outcomes. Negative remarks included the students’ attitudes towards the educational material being taught and its relevancy upon their careers; the discussion of equipment; and the instructor’s statement that the exams would be easy. Ismail and Hayes (2005) referred to a conclusion by made by Schunk in 1996. Schunk stated that some students perform better if told that achieving the ultimate goal is very difficult. Self-efficacy, as defined by Bandura in 1993, was defined as a method allowing students to see themselves as learners and the subsequent development of their abilities to become involved and proficient with learning new materials or skills. Students with higher levels of self-efficacy initiated goal-directed behavior quickly and continued working even though tasks became more difficult. Therefore, these students reached higher levels of achievement (Schunk and Zimmerman, 1997). The authors also quoted Bandura (1993) as stating, “Learning environments that construe ability as an acquirable skill, de-emphasize competitive social comparison, and highlight self-comparison of progress and personal accomplishment are well suited for building a sense of efficacy that promotes academic achievement.” Interpreted, this statement meant, “tell your students they can do it, don’t tell them the average exam_HW scores, and outline their progress toward defined objectives and you should elicit a positive influence on motivation.”
Established and Innovative Food Science Educational Methods

The constructivist learning theory had been implemented in food science education and it hypothesized that preconceived notions about life experiences served as the basis for individuals' ideas and decision making processes. Driver and Oldham (1986) concluded that educators using this method must measure students' comprehension about a particular subject before the new material should be taught. Students could then be stimulated to change their preconceived thoughts and opinions.

Trexler and Roeder (2003) researched the constructivist learning theory when determining elementary students' understanding about food spoilage. Qualitative research methods were used when seven students aged from 10 to 11 years were interviewed. Results showed that these students needed to understand bacteria and how the bacteria caused food spoilage before they could provide explanations of how to slow or prevent the spoilage. The researchers referred to The American Association for the Advancement of Science (1993) who stated that food preservation and spoilage could be taught in the earlier grades, but teaching about spoilage microorganisms should be delayed until the sixth grade. The Trexler and Roeder study implied that understanding microorganisms was part of a larger concept, thus building the foundation for ultimately understanding preservation methods. The researchers concluded that proper food preservation should be taught at an earlier age. By the use of proper educational methods, students would be able to understand the concepts of bacteria and eventually food spoilage.

Just-in-Time-Teaching (JiTT) emphasizes pedagogically successful methods for teaching and learning, specifically active learning, constructivism, and feedback. Marrs and Chism (2005) discussed this method developed by Indiana University-Purdue University Indianapolis in Indianapolis, Indiana (IUPUI) and the United States Air Force Academy (Novak et al., 1999). Currently this system is being used to teach physics, biology, geology, chemistry, psychology, math, nursing, history, economics and anthropology. More than 200 faculty members at 80 institutions around the world are using this instructional system. Using the internet in college courses, JiTT required students to complete assignments prior to class so that they were able to provide more feedback during classroom discussion. This system allowed instructors to review assignments before class so learning activities could be adjusted based upon students' indications of prior knowledge and misconceptions. Any misconceptions could then be addressed in class. Effectiveness had been measured, and results showed there were decreased drop-out rates, and improved student attitudes,
motivation, interactivity, study habits, and cognitive gains. Because the students were expected to complete assignments in order to prepare for class, this method promoted good study habits and impacted their capabilities to eventually learn the material more effectively.

JiTT identified five of the "Seven Principles for Good Practice in Undergraduate Education". These principles were: interaction between faculty and students; active learning techniques; increased feedback; students cooperating amongst themselves when completing projects; and prompt completion of projects. JiTT provided another effective educational method that has been proven effective because of affirmative results.

Just as JiTT relied on the internet, Tapia et al. (2005) developed a web site used to teach chemistry classes. Because some students performed better in the classroom when allowed to learn material visually, this paper discussed how to develop effective web sites. Results showed that students learned material more efficiently when allowed internet use because the visual situations provided hands-on learning applications with which they were more comfortable. The animations provided in the web sites motivated the students because they could make visual observations in lieu of using their imaginations.

Reitmeier (2002) researched an interactive learning environment designed for students studying dietetics, food science, and nutritional science. Named Project LEA/RN (Learning Enhancement Action/Resource Network), traditional 50-minute lectures were replaced by group activities and 15-minute lectures. Instead of written examinations, the students were given quizzes and out-of-class assignments. Group reports were assigned instead of individual reports. The average class scores with these non-traditional teaching methods improved from 81.5% to 85.6%. Because students were allowed more interaction, they improved upon their abilities to solve food science problems, while at the same time became more proficient at clearly discussing oral and written critiques of research results. Reitmeier cited Ewell (1997) who suggested that when people identified specific problems that they wanted to solve, and they were capable of doing so, they then learned at their highest levels. According to Reitmeier, this active learning was worth the necessary effort because increased student achievement was noted. Students increased their confidence levels and this imparted itself to improved professional speaking and writing skills. Both instructors and students found these techniques personally gratifying and empowering. However, LEA/RN must be a cooperative effort amongst all members of the teaching administration and staff in order to see significant improvement in students' progress.
Two educational models in the medical field were identified - the Health Belief Model and the Transtheoretical Model (Elder et al., 1999). The Health Belief Model could possibly be a useful tool for learning if an individual could affirmatively answer these four questions: 1) Am I susceptible to particular health problems? 2) Is the problem serious? 3) Am I convinced that the activities to prevent or cure the disease are not too costly? and 4) Can I be taught that I can take care of myself with proper care? Once again, an individual’s preconceived idea provided the instructor with a point at which education could begin. This method could be useful in food safety education. For example, the risks of not using safe food handling practices make an individual more susceptible to foodborne illnesses.

The Transtheoretical Model, also known as the Stages-of-Change Model (Prochaska & DiClemente, 1983) stated that an individual’s cognitive and behavioral change developed as he moved through pre-contemplation, contemplation, preparation, action, and maintenance.

Using these two models, Edwards et al. (2005) studied how students could learn the proper use of food thermometers in cuts of meat, and then the students taught their families how to use the thermometers during food preparation and why this was important. After the proper training, the students understood the reasons for using thermometers and they were more confident when using the instruments. It was concluded that more research should be performed among adolescents to identify the most significant methods and motivational factors that would encourage them to use meat thermometers. The researchers suggested using the Health Belief Model and the Transtheoretical Model to teach this food safety practice. Safe food handling practices could be implemented by stressing to the adolescents that risks were taken by not using meat thermometers when cooking cuts of meat.

Edwards et al. (2005) used the Health Belief Model and the Transtheoretical Model in the development of educational materials to teach the proper use of meat thermometers. Brochures, recipe cards, and videos were distributed to consumers who did not typically use these instruments in food preparation. There were noted changes in both knowledge and attitudes indicating that the objectives set by the researchers had been achieved. 80% to 90% of those surveyed rated the materials as beneficial for teaching the proper use of the thermometers. The researchers suggested that these educational materials and additional materials teaching about food safety would be useful if distributed by the following avenues: grocery and cooking store displays; community classes and public events such as fairs and
community events; 4-H and extension programs; and family and consumer science classrooms.

"Powersumers" Promoting Irradiation

McGregor (2005) suggested that consumer education should be revised with traditional consumers becoming "powersumers". This term, coined by McGregor, referred to consumers whose inner beliefs had been transformed so that they could change the existing attitude of a society. This opposed traditional consumer education where citizens were taught to benefit only themselves. Because this change was created through inner strength, the newly learned behavior could not be unlearned; consumer education would have stronger values; and true change throughout society could be realized. This same methodology could be used when teaching young adults about the benefits of irradiation, which is the crux of the proposed research. If these youth were taught about foodborne diseases and their causes; the emotional and economical disasters these diseases could inflict; and that irradiation's use in meats, fruits, and vegetables could eliminate and/or reduce the bacteria that caused foodborne illnesses, then acceptance of the technology would be more likely and growth of the irradiation industry could be achieved.

Consumer Knowledge and Perceptions about Food Irradiation

Irradiation has been studied as a food preservation method for over 50 years. Internationally, over 35 governments have approved its use for 40 foods (International Food Information Council, 2004). As of this date it is the most highly researched and tested food technology that has gained regulatory approval (American Medical Association, 1993). Even with evidence of extensive study and research, irradiation is still cursed and condemned by activists across the world, much like pasteurized milk was declared unfit for consumption when it was introduced in 1890.

Jack and Sanderson (1995) coined the term radiophobia- to describe the fear of irradiation- through the use of a questionnaire and evaluation of consumers' attitudes. They found that consumers were either unaware of irradiation or misinformed about the technology. Consumers felt as though the process had not been tested enough and they were not willing to purchase irradiated products, therefore proving that more consumer education was needed. Although this research suggested the need for more education, there was one area of optimism. When questionnaires were divided by ages, results
indicated that consumers less than 40 years of age were more accepting of irradiation than older consumers. This data provided promise for irradiation’s future use. Hashim et al. (1995) showed that effective educational sessions teaching consumers about the benefits of irradiated poultry were successful. The percentages of persons who purchased irradiated poultry breasts and thighs increased from 59.5% to 83.3% and from 61.9% to 85.7%, respectively. This fear of irradiation is likely to continue to be a major roadblock to irradiation around the globe. Education about the process and its safety will help to make this food safety tool more acceptable.

Wolfe et al. (2004) studied consumers’ spending habits on irradiated poultry products. Research indicated that women (in general), as well as women caring for children under 18 years of age, were both negative factors that affected whether or not irradiated poultry would be consumed in the household. These women received education concerning irradiation and their willingness to purchase irradiated products increased, even if there were children in the household less than 18 years of age. If high school students can be taught about irradiation and its benefits, will they in turn take this message home to teach their caretakers? This question suggests a need for further research to determine what these youth know and understand about irradiation.

Sapp (2003) studied persons in the Midwest and how they perceived food irradiation by research of their cognitive, emotional, and social reasoning. The objective was to understand how consumers made risk decisions. Sapp found that it was very important to teach consumers about the scientific processes involved in food safety technologies. To earn the trust of the consumer, the facts about food irradiation must have been communicated very effectively and factually. Proper communication to peer groups would also influence how the general public perceived irradiation.

**Food Irradiation Educational Strategies**

Millar et al. (1990) studied the teaching of radioactivity and irradiation at the secondary school level. Researchers suggested that clear justifications for teaching the subject must have been developed when writing the curriculum, and in this study those justifications were twofold. Children might be subjected to the technologies in their lifetimes and must understand the benefits of its use. These children must become educated about the technologies so as to debunk any misconceptions that the media may publicize. Educators must know what the students understand about radioactivity and irradiation.
before they can begin teaching the subjects, and this ability to understand radioactivity and irradiation differs from student to student. Utilizing the classification method devised by Bloom et al. (1956), the curriculum development for irradiation education must be a progression of learning from one level to another.

Thompson et al. (2004) researched the most optimum method to teach food irradiation to adults. Expert presentations, an irradiation facility tour, group activities, and a computer model were all provided for the participants. These adults were the most receptive to training that allowed them to visualize the irradiation procedure. Therefore, to provide the most educational benefit about irradiation, care must be used when developing these lessons. As with the study where students were taught about the importance and proper use of food thermometers, consumers who accepted and understood the irradiation process could continue to teach others about the benefits of irradiated meat products.

Conclusion

Researching effective methods to educate high school students about irradiation is an important area of food safety education, as irradiation is a valuable tool to insure a safe food supply. Although adult consumers have been targeted with educational sessions, emphasis has not been placed on teaching young persons about irradiation. A growing population with an increasing number of elderly persons, and those with compromised immune systems, will especially benefit from accessible irradiated foods. By teaching students about the benefits of this technology, growth within the irradiation industry can occur.

Educational methods must be studied in order to achieve the most effective procedure to teach about this technology. Different systems have been discussed; however, applying these instructional procedures in the classroom will determine the most appropriate techniques to implement. Educators must be exhaustive in their efforts- the students must gain thorough understandings about irradiation so as to change their preconceived ideas about the process, and make decisions that will change the ways that they purchase products for themselves, and eventually their families. With proper education, they will also become advocates for irradiation, insuring that consumers will become as accustomed to purchasing irradiated meats, fruits, and vegetables as pasteurized products.
References


CHAPTER 3. DEVELOPMENT OF EFFECTIVE PEDOLOGICAL METHODS TO EDUCATE HIGH SCHOOL STUDENTS ABOUT FOOD IRRADIATION AND SAFE FOOD HANDLING PRACTICES

A paper to be submitted to the Journal of Food Science Education

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Abstract

Significant gaps have developed in the education of high school students about food technologies and safe food handling practices. The objective of this research was to develop effective pedological methods for educating this population about food irradiation and safe food handling practices. By implementing the most effective delivery method, successful results would be realized. The students would continue to use this information into the future, thus making favorable impact in reducing the incidences of foodborne illnesses. Utilizing jigsaw reading as a cooperative learning activity, 72 Iowa high school students participated in irradiation workshops. Pre and post workshop survey questions were administered and a coding scheme was used to track answers. Dramatic improvement in attitudes concerning the purpose of irradiating food, the process, and irradiation's impact on the health of people was observed (P-values \leq 0.05). The percentages of students who could specifically implicate pathogenic bacteria as the cause of foodborne illnesses also improved (P-value \leq 0.056). No significant P-values were attained when students were asked about packages with or without a Radura symbol; the prevention of foodborne illnesses; good versus bad bacteria; and re-contamination. The jigsaw reading activity was determined to be an effective pedological method and does not require a food safety expert to teach high school students about food irradiation and safe food handling. This approach will allow a larger audience to learn about food irradiation and safe food handling practices.

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Introduction

It is evident that significant gaps have developed in the education that high school students receive about technologies designed to provide safe food supplies, as well as safe food handling practices (Bruhn, 1997). Bruhn cited the Institute of Food Technologists’ Expert Panel on Food Safety and Nutrition (1995), as well as Dumagan and Hackett (1995). This research stated that more young people are entering the work force specializing in food service and they are not receiving proper instruction about safe food handling practices, either at their jobs or in their homes. At their jobs young workers may not become properly trained with the equipment that is used to complete the preparation of partially cooked foods, thus potentially placing their customers at risk for foodborne illnesses. Additional concerns arise when considering that many schools do not offer or require students to enroll in courses that teach this important information. It has become essential that food processing technologies and safe food handling practices must be taught to these young people. Their increasing roles in the food service industries, as well as augmented responsibilities for their own, and their families, food purchasing and preparation decisions mandates this education. Mead et al. (1999) provided research estimating that annually foodborne diseases caused by known and unknown pathogens totaled approximately 76 million illnesses, 325,000 hospitalizations and 5,000 deaths in the United States. The National Institute of Allergy and Infectious Diseases (2005) stated that aging populations, as well as children and persons experiencing chronic conditions, are especially susceptible to foodborne illnesses. Educating high school students about food technologies, particularly food irradiation, and safe food handling, has never been more important to our society.

It is hypothesized that educating high school students about food irradiation and its capability to eliminate and/or reduce bacteria in meats, fruits, and vegetables will prove beneficial for both themselves and future generations. Incorporating education about safe food handling practices while teaching them about food irradiation will also teach them valuable life skills. These skills, once effectively learned, will continue to be utilized throughout adulthood. Stringent efforts must be made to provide this audience with the most accurate and up-to-date food irradiation and food safety information that is available. This will enable them to make well-informed decisions for not only themselves, but also for their families and the general public. By becoming knowledgeable about these topics, they become equipped with the information to provide education to individuals misinformed about these subjects. However, this information cannot be taught haphazardly, that is, made
available to the students in hopes that they will absorb the information and begin practicing the learned material. Research is necessary to identify preferred learning methods for this age group. Through the assessment of educational methods, learning activities can be identified that provide the most beneficial delivery methods for teaching this information. Not every educator, youth leader, or group facilitator is an expert in food irradiation and food safety; therefore activities must be structured so that these persons can conduct successful courses and workshops that will allow their audiences to learn the material and subsequently put the education into practice.

An investigation into effective educational methods was completed by Kolb (1984). His research on experiential learning deduced that learning is a four stage process referred to as the helix of learning. He identified four modes in this learning style: 1) concrete experience- students immerse themselves into the new experience with no preconceived notions or biases about the subject; 2) reflective observation- students reflect upon the information they have learned in the concrete experience; 3) abstract conceptualization- students use newly learned information to process new observations; and 4) active experimentation- previous experiences, observations and theories are used to solve new problems and make appropriate decisions. Kolb believed that all learning was a process of relearning and was continually being updated through new experiences. Once the active experimentation was engaged the entire learning process began again with the concrete experience.

Ricketts et al. (2005) researched the differences of learning styles for students at a junior college, and found that the strongest learning method amongst this research group was active experimentation. His suggested that faculty should incorporate this style of education into their classrooms, thereby utilizing projects, homework, and small group discussions as learning tools. Reflective observation was ranked second to active experimentation. Reflective observation used lectures (passive learning experiences) so the students were provided time to process the information. Abstract conceptualization did not rank highly amongst the preferred learning methods used with this research group. This learning style required the development of curiosity, thinking and analyzing ideas- such as would be found in undergraduate research projects. Ricketts found that the least preferred method of learning was the concrete experience. Students who did not enjoy group learning activities and working together in team concepts preferred this learning style. Feelings and
human interaction were not important to this group, as they preferred to work alone in completing problem solving activities.

Felder and Brent (1994) concluded that regardless of the course objective, a form of active learning, referred to as cooperative learning, has been repeatedly proven to be more effective than the customary approaches to education. When cooperative learning is used in the classroom, students work together in order to learn the educational materials. They concluded that benefits of cooperative learning include: team members learn to rely upon each other; individual accountability is developed; they teach and encourage each other; they develop collaborative skills; and they learn to work together as a group to reach a designated goal. Matheson (1998) used jigsaw reading (a form of cooperative learning) for his research and subsequently encouraged its use for groups of students in any size classroom. Several important aspects for successful education were identified by the use of jigsaw reading, and those included improved reading comprehension, writing, and small group work. The versatility of jigsaw reading is particularly beneficial. Any size class can participate in the activity, and educators of all teaching abilities are capable of delivering the materials. As an effective teaching tool, this method can be formatted to teach any number of subjects. This fact drew particular interest for this research project, as not every educator, youth leader, or group facilitator is an expert in food irradiation and food safety; therefore this structure allows leaders or teachers to conduct successful activities allowing participants to learn the material and subsequently put the education into place.

In jigsaw reading, students are divided into small groups, and each member is responsible for reading a designated assignment. When each student is completed with his reading, then he is responsible for teaching the rest of the group about what he has learned and helping them answer questions about the material. In this manner, learning can be improved because with the student teaching the material to others, he also learns it more effectively. However, care must be taken that the student correctly comprehends his assignment or he will be disseminating incorrect information. Because this could become a problem, Matheson suggested reviewing the answers to questions to ensure that the material was correctly learned by all of the students. He also suggested that the educator monitor groups during the activity to help contravene this possible situation. Obviously, classroom attendance is very important when incorporating jigsaw reading into a teaching program so that all students learn the material. He also stated that overuse of this method may allow students to think that they are only responsible for the material that they learned
in their particular group; therefore, jigsaw reading needs to intertwined with other active learning methods so that course materials can be effectively learned.

Active learning has been shown to be a very valuable educational method. By effectively incorporating this method into courses teaching about food irradiation and safe food handling, correct information can be provided to these high school students at an earlier age. They can then immediately put this information to use as they move into adulthood.

**Methods**

As a part of this educational research, a manual titled the “Iowa State University Beef Irradiation Education Manual” (2006) was written and appears in the appendix of this publication. A website has also been developed that contains information from this manual. This manual was developed through the cooperation of the following departments at Iowa State University: the Department of Animal Science; the Department of Agricultural Education & Studies; and the Department of Hotel, Restaurant, and Institution Management. Based upon information found in the materials entitled “Science and Our Food Supply” (developed by the National Science Teachers Association in 2001), the Iowa State University Beef Irradiation Education Manual was developed with a stronger emphasis on food irradiation technology and safe food handling practices. Five sections of this manual teach the following information: Section I: The Food Chain and Food Safety Responsibility; Section II: Introduction to Bacteria and Food Safety; Section III: Investigating Irradiation; Section IV: Food Preparation in Retail Food Service and Home; and Section V: Foodborne Illness Outbreaks and Future Technology. This manual is comprised of numerous activities to teach about food irradiation and food safety, and thus was very useful in the development of the learning activities for this research.

A scholarly progression of ideas occurred throughout the development and delivery of each preliminary workshop by studying the results of the pre and post surveys from the preceding workshops. With the implementation of the passive learning experience just once, it became evident that the students enjoyed the active learning experiences and learned the materials just as effectively. Realizing this fact, emphasis was paced upon how to achieve similar results by providing an activity that could be facilitated by a non-expert in food irradiation and food safety. The cooperative learning method incorporating jigsaw reading
was chosen as the method that could provide the most successful activity and still be facilitated by a non-expert.

It is important to note that code names and/or code numbers were used on all pre and post workshop surveys to assure the anonymity of the participants. Copies of surveys used for this research appear in the appendix of this publication. The proper human subject forms were filed with the Iowa State University Human Subjects Research Office prior to the onset of the learning activities. The preliminary workshops were: Iowa State University Science in Agriculture Day Irradiation Workshop; Iowa State University State 4-H Roundup Irradiation Workshop; Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (December 2005); and the Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (February 2006). The learning activities for the Science in Agriculture Day Irradiation Workshop, the State 4-H Roundup Irradiation Workshop, and the Working with Animals Irradiation Workshop (December 2005) incorporated activities found in the Iowa State University Beef Irradiation Education Manual. Those activities were “Sensory Evaluation of Ground Meat Products”, “Chain of Food”, and “Irradiation Webquest”, respectively. Incorporated into the first two workshops were visits to the Iowa State University Linear Accelerator Facility. The Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (December 2005) reviewed both the active and passive teaching methods, and although both procedures were successful, the active method engaged the students into learning, and provided just as much educational value for the students.

The cooperative learning activity using the jigsaw reading method was selected as the delivery method in the Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (February 2006), and subsequently with the Iowa High School Vocational Agriculture Students Irradiation Workshop.

Iowa State University Science in Agriculture Day Irradiation Workshop

Twelve high school students and one teacher visiting Iowa State University, Ames, IA, participated in a fifty minute irradiation education workshop hosted in the university’s meat laboratory. The objective of the workshop was to teach the group about food irradiation and the benefits of the technology while also incorporating lessons surrounding safe food handling practices.
First each participant answered questions on a pre workshop survey, and those questions were: 1) What are some words/ideas that come to your mind when I say irradiation? 2) Do you know how irradiation is used in the preparation of food for humans? If so, how is it used? If not, how do you guess it might be used (in other words for what purpose)? 3) Have you ever been sick from eating “contaminated food”? 4) How do you think food might become “contaminated”? 5) Knowing this, do you have any concerns at this point about eating irradiated meat? What might those concerns be? 6) How often do you typically eat meat? 7) Are you male or female? 8) How big is your school district?

Secondly, participants donned meat laboratory frocks and hairnets. Two electric skillets were made available, and volunteers were asked to wash their hands and prepare two packages of ground beef. This activity referred to the laboratory activity “Sensory Evaluation of Ground Meat Products” selected from the Iowa State University Beef Irradiation Education Manual (2006). Without divulging the identity of the packages, the volunteers cooked two packages of ground beef- an irradiated product and a non-irradiated product. As the volunteers cooked the ground meat products, discussion was initiated concerning the role that food irradiation plays in helping to ensure a safe food supply, as well as lessons concerning safe food handling practices.

Participants then visited the Iowa State University Linear Accelerator Facility where they learned about the facility; its operation and uses at the university; and the benefits of irradiation. An animation of the linear accelerator in operation (found at the Iowa State University Food Safety Project website) was viewed so that clear mental images of irradiation could be developed and understood by the participants. This website may be accessed at http://www.extension.iastate.edu/foodsafety/irradiation/index.cfm?parent=3.

After visiting the linear accelerator, and viewing the animation showing the facility in action, the participants returned to the meat laboratory where they were provided opportunities to taste both ground beef examples to determine if they could differentiate between the two samples. Once again, discussion revolved around irradiation and its uses in industry.

At the close of the workshop, all participants completed a post workshop survey. Those questions were: 1) What are some words/ideas that come to your mind when I say irradiation? 2) Do you know how irradiation is used in the preparation of food for humans? If so, how is it used? If not, how do you guess it might be used (in other words for what purpose)? 3) How do you think food might become “contaminated”? 4) Do you have any
concerns at this point about eating irradiated meat? If yes, what might those concerns be? 6) Do you think that the irradiated hamburger today tasted differently than the non-irradiated hamburger today? Looked differently than the non-irradiated hamburger today? 7) Based on our discussion, do you think that families would be willing to pay more money for irradiated hamburger than non-irradiated hamburger? If yes, then why do you think they would? If no, then why do you think they would not?

Iowa State University State 4-H Roundup Irradiation Workshop

Sixty-three Iowa 4-H members, including their adult leaders, participated in a food irradiation workshop held at the university’s meat lab. The objective was to teach about food irradiation and the benefits of the technology while also incorporating lessons about safe food handling practices.

First each participant answered questions on a pre-workshop survey, and those questions were: 1) What are some words/ideas that come to your mind when I say irradiation? 2) Do you know how irradiation is used in the preparation of food for humans? If so, how is it used? If not, how do you guess it might be used (in other words for what purpose)? 3) Have you ever been sick from eating “contaminated food”? 4) How do you think food might become “contaminated”? 5) Knowing this, do you have any concerns at this point about eating irradiated meat? What might those concerns be? 6) How often do you typically eat meat? 7) Are you male or female? 8) How big is your school district?

The activity, “Chain of Food”, from the Iowa State University Beef Irradiation Education Manual (2006), had been earlier chosen as the workshop activity. The participants were divided into smaller groups. Each group was provided with large sheets of paper and marking pens, and assigned a particular food. Working cooperatively they discussed the movement of food along the farm-to-table production chain. Foods used as props for the discussion included: a cheeseburger, French fries, strawberry milk, and an apple. At the end of this segment, a representative of each group was asked to make a brief presentation to the rest of the participants and initiate discussion about the farm-to-table movement of their assigned product. The workshop coordinator also provided information about safe food handling practices, and incorporated information about food irradiation’s use in the industry.
The participants donned meat laboratory frocks, hairnets, and plastic gloves. The discussion of the food chain was continued as they moved into the meat laboratory cooler and viewed lamb carcasses on display.

Irradiation was discussed with the participants as they visited the Iowa State University Linear Accelerator Facility where the process was explained and the benefits of the technology were reviewed. Emphasis was placed upon the previous exercise of the farm-to-table production chain and irradiation’s usefulness in circumventing any contamination problems along that path. Participants were reminded of the consumer’s responsibility for applying safe food handling practices both at home and when dealing with the public’s food supply.

Before the conclusion of the workshop, each participant completed a post workshop survey. Those questions were: 1) What are some words/ideas that come to your mind when I say irradiation? 2) Do you know how irradiation is used in the preparation of food for humans? If so, how is it used? If not, how do you guess it might be used (in other words for what purpose)? 3) How do you think food might become “contaminated”? 4) Do you have any concerns at this point about eating irradiated meat? If yes, what might those concerns be? 5) Based upon our discussion, do you think that families would be willing to pay more money for irradiated hamburger than non-irradiated hamburger? If yes, then why do you think they would? If no, then why do you think they would not? 6) If you purchased irradiated ground meat at the store, should you handle it any differently than non-irradiated ground meat?

*Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (December 2005)*

181 Iowa State University students enrolled in Animal Science 101 Working with Animals participated in a food irradiation and food safety workshop which was included as a section of their course syllabus. The objective of this workshop was to teach the students about food irradiation, its purpose, and uses in the food industry. Basic safe food handling practices were also taught. However, as opposed to earlier workshops, two learning methods were researched in the delivery of materials for this workshop. An active learning experience was delivered where students worked in small groups at a computer and cooperatively answered 18 questions; and a passive learning experience was provided where students listened to a power point presentation and viewed two videos.
All students completed the same pre and post workshop surveys regardless of the learning method in which they participated. The pre workshop survey questions were as follows: 1) Are you male or female? 2) How old are you? 3) In one week, how often do you eat meat? 4) In one week, how often do you eat raw fruits and vegetables? 5) In one week, how often do you purchase/prepare food for yourself? 6) In one week, how often do you purchase/prepare food for friends, family members, or customers? 7) In one week, how often do you eat out, either at someone else’s home, or in a location other than your home? 8) Have you ever gotten sick because of the food you ate? 9) What do you know or believe about irradiation? 10) Describe how you prefer your hamburgers cooked. 11) When shopping in a grocery store, how do you make sure that the foods you are buying are safe to eat? 12) How can you tell the difference between the stomach flu and a foodborne illness? 13) What do you know or believe about bacteria found in foods? 14) How would you characterize the safety of irradiation facilities? 15) What do you think that this (Radura) symbol represents?

Two laboratory sections (ninety-five participants) were provided the passive learning experience. First, the participants completed the pre workshop survey. At the completion of the survey, the lecture portion of the activity was delivered, focusing on irradiation as an effective method used to combat bacterial contamination of our food supply. Basic safe food handling was also taught and discussed. The three minute video from the Chicago Meat Authority, Chicago, IL (http://www.chicagomeat.com/CorporateProfile.htm) showed how ground beef is prepared and packaged; a twenty-two minute video provided a tour of the irradiation facility at the National Center for Electron Beam Research located in College Station, TX (http://ebeam.tamu.edu/multimedia/index.htm).

At the conclusion of the presentation the participants all completed the post workshop survey. This survey contained questions nine through fifteen that were on the pre workshop survey.

The remaining two laboratory sections (eighty-six students) participated in the active learning experience that focused on cooperative learning where they were required to work together in small groups comprised of three persons. This activity was based upon “Irradiation Webquest” found in the Iowa State University Beef Irradiation Education Manual (2006). Utilizing computers, they were directed to the United States Food and Drug Administration website (found at http://www.cfsan.fda.gov/~dms/fdirrad.html) that focused on irradiation- what it is, how it works, and its uses to help combat the incidences of foodborne
illnesses. Eighteen questions were collectively answered by members of each group based upon information found in that reading material. Those eighteen questions were: 1) What is one of the U.S. food industry's hottest sellers? 2) What makes ground beef one of the implicated foods in causing foodborne illness? 3) How many deaths and cases of illness are associated with *E. coli* O157:H7 each year in the United States? 4) List 5 foods that FDA has approved for irradiation. 5) List 3 different kinds of organisms that are reduced or eliminated by irradiation. 6) Does irradiation make food radioactive? Explain. 7) Do you think you could tell if a food had been irradiated by eating or tasting the food? Explain. 8) What is *Salmonella*? Where is it found? 9) What is *Campylobacter*? Where is it found? 10) How many Americans are stricken by foodborne illness each year? Approximately how many die? 11) In a Louis Harris poll, what percent of Americans considered irradiated food to be a hazard? 12) What process was used to convince 60 percent of people in another survey to buy irradiated food? 13) Explain the connection between luggage and milk. 14) What famous groups of high-flying individuals have routinely eaten irradiated foods? 15) Explain the connection between "strawberry hairs" and freshness. 16) List the significance of each point of view of the four organizations that have endorsed using irradiation to decrease cases of foodborne illness. 17) List the significance of each point of view of two organizations that have given food irradiation a thumbs-down. 18) Why does irradiation generate so much controversy, compared to other technologies, such as pasteurization, for example?

Upon the completion of the activity the workshop coordinator facilitated discussion as the answers were reviewed by the participants, and then the answers were collected for review by the coordinator. A review showed that the students provided correct answers. As with the participants in the passive learning experience, the post workshop survey questions containing questions nine through fifteen on the pre workshop survey were answered.

*Iowa State University Animal Science 101 Working with Animals* Irradiation Workshop *(February 2006)*

Ninety-four Iowa State University students enrolled in Animal Science 101 Working with Animals participated in a food irradiation and food safety workshop which was included on the course syllabus. As with the preceding workshops, the objective of the activity was to teach these students about food irradiation, its uses, and benefits, as well as teach them about safe food handling practices.
Before the educational activity began, all students completed a pre workshop survey that contained the following questions: 1) What is the purpose of irradiating food? 2) How does irradiation work? 3) How do you feel irradiation might impact the health of people (by placing a mark on a Likert scale numbered -3, -2, -1, 0, +1, +2, +3)? Give me the top reason why you chose to put your X where you did. 4) Which package would you likely buy: A- the one with the symbol; B- either one (makes no difference to me); C- the one without the symbol? Why did you choose this answer? 5) Why do some people get ill from meat? 6) What can people do to help prevent these foodborne illnesses? 7) What causes foodborne illness? 8) Are all bacteria bad? 9) Can I get sick from foodborne illness after it has been “cooked”? If yes, how so? If no, why not? 10) Have you ever studied biology in school? 11) Do you often help prepare meals at home? 12) Do you/have you worked at a restaurant? and 13) Have you ever studied food safety practices in school or other programs (e.g. 4-H, FFA, etc.)? The use of the Likert scale by the students for answering question number three allowed the researcher to detect attitudinal changes from the pre to post workshop surveys. In this instance, by providing a scale that ranged from negative to positive numbers, the researcher was able to determine how the students felt that irradiation impacted the health of people. Negative numbers indicated that the students felt irradiation had a bad impact on health; however, a positive number indicated that they felt irradiation impacted persons in a positive manner by being beneficial to their health.

Upon completion of the pre workshop survey, students were asked to randomly divide into groups numbering three members each by numbering off "1, 2, 3", "1, 2, 3", etc. This system helped to keep students from working closely with their friends and increase attentiveness throughout course of the activity.

The educational activity developed for this research was a cooperative learning experience that used the jigsaw reading method. This method was chosen because active learning methods have been shown to be preferred by audiences of this age group; the jigsaw reading activity implements cooperative learning; and it does not require an expert to facilitate the learning activity. Each student referred to an activity booklet titled "Iowa State University Food Science and Technology Spring 2006" (available in the appendix of this publication) that was comprised of two fictional scenarios and the jigsaw reading exercise that was comprised of one article about food irradiation, and one article teaching about safe food handling. The four-color booklet contained instructions, along with the reading material and the questions. The booklet was comprised of the following information:
Page 1: Instructions for the activity along with color photos depicting animal science and meat science. Students were asked to move into groups of no more than three people, study the material in the booklet, and answer the questions following Scenario 1; Food Safety from Farm to Table; and Scenario 2.

Page 2: Scenario 1. This story depicted two girls, Sally and Jessica, who were faced with purchasing decisions surrounding irradiated and non-irradiated ground beef, and ultimately foodborne illnesses. Colored pictures of ground beef (one with a Radura symbol on the label and one without a Radura symbol on the label) were shown. After group members individually read the scenario, they were asked to answer the following questions: 1) Obviously Sally prepared her meal and no one got sick. However, Jessica was not so fortunate and both she and her roommate became ill. What do you think could have happened that caused such a difference between the two cases? Briefly explain. 2) Compare the two packages- do you notice any differences between them? If you make any observations, jot them down. 3) Now’s not the time to be shy- have you ever gotten sick because of something you ate? We don’t want the gory details- just name the circumstance and the food that you think made you sick.

Pages 3-6: Food Safety from Farm to Table. This article, provided by the Food Safety Project at Iowa State University, was separated into three reading sections. Group member one was responsible for reading the following: Food Irradiation- What Is It?; Irradiation Compared to Pasteurization; Regulation of Food Irradiation; and The Food Irradiation Process. Group member two read the following: Approved Uses for Food Irradiation; Applications for Food Irradiation; Irradiation is Most Useful in Four Areas- Preservation, Sterilization, Control Sprouting, Ripening, and Insect Damage, Control Foodborne Illness; and Nutritional Quality of Irradiated Foods. Group member three read the following material compiled by the United States Food and Drug Administration: Proper Food Handling Still Needed- Clean, Separate, Cook, Chill. The following questions were cooperatively answered: 4) What is irradiation, how does it work, and what uses does it provide for the food industry? 5) How can we tell if products have been irradiated? Name some foods that utilize the technology. 6) Based upon the reading, is irradiation a safe process? Why or why not? 7) Can irradiated foods become re-contaminated? What can be done to prevent this problem?

Page 7: Scenario 2. This story again featured Sally and Jessica who each prepared meals using irradiated ground beef. However, in these situations they were faced with
implementing safe food handling methods. After group members each read the story they were asked to cooperatively answer the following: 8) So what happened that caused Sally and her family to get sick? What could she have done differently? 9) Okay, you’re almost done- and if you miss this question then you haven’t been paying attention. What were the good handling practices that Jessica used to make sure that she and her roommate didn’t get sick?

At the conclusion of the workshop, participants once again completed post workshop surveys that were comprised of questions one through nine from the pre workshop surveys. The answers to the jigsaw reading activity were collected by the workshop facilitator and reviewed for correct/incorrect answers. A review showed that the students answered the questions correctly.

**Iowa High School Vocational Agriculture Students Irradiation Workshops**

Based upon results from these four workshops, educational materials for the “Iowa High School Vocational Agriculture Students Irradiation Workshops” were finalized. Forty-four Iowa vocational agriculture educators were invited to participate in this activity. Educators from four high schools representing 72 students accepted the invitation. The following materials were sent to each instructor (along with self-addressed envelopes for returning the consent forms and pre and post workshop surveys): school administrator, parent/guardian, and student consent forms; pre and post workshop surveys; and the educational activities. Each of these items are provided in the appendix of this publication.

The consent forms were developed under the auspices of the Iowa State University Human Subjects Research Office. Educators were required to obtain the approval from each of the four high school administrators before administering the surveys and the activity in their classrooms. In addition, the parent or guardian of each student was notified about the subject matter and provided the option of disapproving his student for the activity. Each student was also provided the opportunity to decline involvement in the activity. There were no instances where the administrators, parents or guardians, or students declined the opportunities to participate in the food irradiation/food safety educational workshop.

The pre workshop survey, administered before the onset of the activity, was the same pre workshop survey that had been used in the Iowa State University Animal Science 101 Working with Animals Irradiation Workshop (February 2006). The educational activity used the same activity booklet titled “Iowa State University Food Science and Technology
Spring 2006” that was utilized in the February 2006 workshop and the activity was managed in the same manner. The same post workshop survey administered to the students in the February 2006 workshop was administered to these students. In these cases, the vocational agricultural instructor retained the answers to the questions asked in the jigsaw reading activity for his own review.

Results

Qualitative data from both the pre and post workshop surveys was collected from 72 Iowa high school vocational agriculture students and values were assessed to each student’s answers. The use of open-ended answers to the questions asked in the surveys provided more information as to the students’ thoughts and ultimate perceptions of irradiation, foodborne illnesses, and safe food handling practices. For the workshops, the following questions were asked on the pre workshop surveys: 1) What is the purpose of irradiating food? 2) How does irradiation work? 3) How do you feel irradiation might impact the health of people (by placing a mark on a Likert scale numbered -3, -2, -1, 0, +1, +2, +3)? Give me the top reason why you chose to put your X where you did. 4) Which package would you likely buy: A- the one with the symbol; B- either one (makes no difference to me); C- the one without the symbol? Why did you choose this answer? 5) Why do some people get ill from meat? 6) What can people do to help prevent these foodborne illnesses? 7) What causes foodborne illness? 8) Are all bacteria bad? 9) Can I get sick from foodborne illness after it has been “cooked”? If yes, how so? If no, why not? 10) Have you ever studied biology in school? 11) Do you often help prepare meals at home? 12) Do you/have you worked at a restaurant? and 13) Have you ever studied food safety practices in school or other programs (e.g. 4-H, FFA, etc.). Post workshop surveys included questions one through nine.

Information obtained from Trexler and Roeder (2003) provided the coding scheme used to evaluate each answer. In their research they used “goal conceptions”. “Goal conceptions” were described as the scientific accuracy of the answers provided by their research subjects (elementary students). They then utilized a coding scheme that had been developed by Hogan and Fisherkeller (1996) that categorized responses according to the students’ capabilities to answer questions according to the expert “goal conceptions”; and then how elaborate the students were with their answers. This coding scheme was used when appropriate in this research. Using the coding scheme devised by Hogan and
Fisherkeller (1996), and used by Trexler and Roeder (2003), the following coding schemes were used (refer to Table 2 below):

**Table 2. Coding scheme for comparing student responses to expert conceptions.**

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE- Compatible Elaborate</td>
<td>Statements concur with the expert proposition and have sufficient detail to show the thinking behind them and/or recur throughout the transcript in the same form.</td>
</tr>
<tr>
<td>CS- Compatible Sketchy</td>
<td>Statements concur with expert proposition, but essential details are missing. Often represent a correct guess among choices provided, but no ability to explain why choice was made.</td>
</tr>
<tr>
<td>CI- Compatible/Incompatible</td>
<td>Makes sketchy statements that concur with proposition, but which are not elaborated, and also makes sketchy statements that disagree. Contradictory statements are often found in two parts of the transcript in response to different questions or tasks on the same topic.</td>
</tr>
<tr>
<td>IS- Incompatible Sketchy</td>
<td>Statements disagree with proposition, but very few details or logic given, and do not recur throughout transcript. Often seem to be responses given just to say something, a guess.</td>
</tr>
<tr>
<td>IE- Incompatible Elaborate</td>
<td>Statements disagree with proposition and students provide details or coherent, personal logic backing them up. Same or similar statements/explanations recur throughout transcript.</td>
</tr>
<tr>
<td>N- Nonexistent</td>
<td>Used when students respond “I don’t know” or do not mention the topic when asked a question calling for its use.</td>
</tr>
<tr>
<td>NE- No Evidence</td>
<td>Used when a topic was not directly addressed by a question and students did not mention it within the context of response to any question.</td>
</tr>
</tbody>
</table>

Once categorized, the data was analyzed using SPSS 14.0 Graduate Student Version, 2005, to obtain P-values (using a paired value T-test) and to determine the incidence of interaction between the students and the questions asked of them.

For informational purposes, demographic information was obtained from each student (refer to Table 3 below). That information is based upon information provided from questions ten through thirteen on the pre workshop surveys. Just over one-half of these students had studied biology in school, and more than half of them were either responsible for preparing meals at home, or employed/had been employed in the food service industry. Over one-half of them had received some training in safe food handling practices.
Table 3. Demographics of study sample.

<table>
<thead>
<tr>
<th>Have you ever studied biology in school</th>
<th>Do you often help prepare meals at home?</th>
<th>Do you/have you worked at a restaurant?</th>
<th>Have you ever studied food safety practices in school or other programs (e.g. 4-H, FFA, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes 51.4</td>
<td>Yes 57.0</td>
<td>Yes 66.7</td>
<td>Yes 65.3</td>
</tr>
<tr>
<td>No 48.6</td>
<td>No 22.2</td>
<td>No 33.3</td>
<td>No 30.5</td>
</tr>
<tr>
<td>Sometimes 20.8</td>
<td></td>
<td></td>
<td>Did not know 4.2</td>
</tr>
</tbody>
</table>

Statistical data was captured from answers provided from questions one through nine. The students were most successful in learning about irradiation and its uses. Significant P-values \( \leq 0.05 \) were achieved when students were asked the following questions: 1) What is the purpose of irradiating food? 2) How does irradiation work? and 3) How do you feel that irradiation might impact the health of people? A P-value \( \leq 0.056 \) suggested a close significance when question number five was asked, “Why do some people get ill from meat?” Specific results about each of these questions appears below.

The first two questions were directed at the students' knowledge of irradiation and how the process worked. Based upon pre and post workshop surveys, marked improvement was noted in the percentages of students that, once they completed the activity, were able to provide answers to both questions. When asked what the purpose of irradiating food was (Figure 1), 76.4% were able to explain that the process killed bacteria, compared to 12.5% from the pre workshop surveys (P-value \( \leq 0.05 \)). When asked how irradiation worked (Figure 2), the percentages of students categorized as “Compatibile Sketchy” improved substantially from the pre workshop survey results (69.4% compared to 4.2%), especially when compared to the percentages of students who did not know (83.3% compared to 11.1%) (P-value \( \leq 0.05 \)). However, the P-value \( \leq 0.083 \) indicates that there was interaction between the students and this question.
Because the students had addressed questions concerning pathogenic bacteria's role in health they were questioned about how they felt that irradiation could impact the health of people (Figure 3). Positive responses improved a total of 48.7% when comparing pre to post workshop surveys (P-value ≤ 0.05).
The remainder of the survey questions focused on students’ perceptions of safe food handling practices, their perceptions of how pathogenic bacteria can make people develop foodborne illnesses, and the measures that can be taken to circumvent those situations. Based upon the answers provided by the students on the pre and post workshop surveys, their understanding of the material improved. The percentages of students who were able to specifically implicate pathogenic bacteria as the root of the problem increased from 20.8% to 26.4% (Figure 4). This percentage increase was attributed to a shift from those whose answers were coded “Compatible Sketchy” with their answers (compare pre to post workshop survey results); however, the numbers of students who did not provide answers notably increased from 2.8% up to 11.1%. The students whose answers fell into the “Compatible Sketchy” category implicated poor food handling in the majority of their answers. Although the P-value for this question was ≤ 0.056, this value was close enough to significance (within 0.06) that the value should not be ignored.
In comparison, no significant values (P-value ≤ 0.05) were attained when the students were asked these questions: 4) Which package would you likely buy- A- the one with the symbol; B- either one (makes no difference to me); C- the one without the symbol? Why did you choose this answer? 6) What can people do to help prevent these foodborne illnesses? 7) What causes foodborne illnesses? 8) Are all bacteria bad? and 9) Can I get sick from foodborne illness after it has been "cooked"? Because an increasing number of students chose not to answer these questions on the post workshop surveys, the P-values were calculated as not being significant.

Students had been questioned about bacteria’s role in health, so they were then asked a more specific question about their choices as consumers. Students were questioned as to the package of ground beef they would purchase- choice A (the Radura symbol is posted on the package label); choice B (the student would chose either package because it did not matter to him); and choice C (the Radura symbol is not posted on the package label) (Figure 5). In the pre workshop survey, selections of packages A and B were nearly equal (30.6% and 33.3%, respectively). The percentage of persons that would not buy the irradiated product was 12.5%. Results of the post workshop survey showed that the percentage of students that would purchase package A increased from 43.0%, up to 73.6%. Students who would purchase package B decreased from 33.3% to 9.7%; and students who would purchase package C decreased from 12.5% to 1.4%. The P-value, however, for this response was not significant (P-value ≤ 0.279) because several students chose not to answer all of the post workshop survey questions.

Figure 5. Percentage of students’ responses answering the question “Which package would you likely buy- A- the one with the symbol; B- either one (makes no difference to me); C- the one without the symbol? Why did you choose this answer?” A= The package with the symbol; B= Either package; C= The package without the symbol; N= Nonexistent; NE= No Evidence
To further obtain information from the students concerning food handling, they were asked what they felt that people could do to help prevent these illnesses. Results of the post workshop survey showed that only 2.8% of them (Compatible Elaborate) were able to respond by answering with the 4 C's- cook, clean, chill, and avoid cross contamination (Figure 6). However, a large percentage of the students (66.6% answered “Compatible Sketchy”) were able to recite at least one, and many times three, of the 4 C's. Note that in the pre workshop survey 84.7% of the students provided answers in the “Compatible Sketchy” category, however, nearly 6% of them did not provide an answer to the question or complete the survey. The responses to this question resulted in a P-value ≤ 0.231.

Students were again asked to reiterate the role that bacteria plays in causing foodborne illnesses. After the educational activity, 58.3% (up from 44.4%) were able to name bacteria as the cause of foodborne illness (Figure 7). In the “Compatible Sketchy” category, those who continued to implicate poor food handling stayed virtually the same (26.4% compared to 25%). However, those students who had provided contradictory statements or incorrect answers in the pre workshop survey fell to 2.8% and 2.8%, respectively. Note that the numbers of students who did not answer the question at all rose to 11.1% in the post workshop survey. Again, there was no significance indicated with the answers to this question (P-value ≤ 0.122).
Because the educational activity had been implicating pathogenic bacteria, students needed to learn or be reminded that not all bacteria are considered pathogenic. With reference to the demographic portion of the survey where 51.4% of those surveyed had studied biology in high school, these percentages reflected that fact. 91.6% and 84.7% (pre and post workshop survey percentages) recognized that not all bacteria are bad and that some are beneficial in food processing (Figure 8). Note that in the post workshop survey 11.1% of the students did not provide answers to the question. The P-value calculated for these responses was \( \leq 0.230 \).

Re-contamination of food after it had been “cooked” was reviewed, and the students who responded with favorable responses to this question increased from 8.3% to 29.1% (a 20.8% increase) (Figure 9). The increase can be attributed from those who earlier had answered “Compatible Sketchy” when asked about the subject, or had earlier provided...
obviously incorrect answers ("Incompatible Elaborate" responses). However, even with these responses, the P-value was \( \leq 0.230 \).

**Figure 9. Percentage of students answering the question “Can I get sick from foodborne illness after it has been “cooked”?"**

CE = Compatible Elaborate; CS = Compatible Sketchy; CI = Compatible/Incompatible; IS = Incompatible Sketchy; IE = Incompatible Elaborate; N = Nonexistent; NE = No Evidence

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**Discussion**

As each of the preliminary workshops were delivered and the survey results researched, a trend of constructivism amongst the workshop participants became evident. According to Funderstanding.com, Incorporated, this learning philosophy relies upon the following guiding principles: learning involves searching for meaning; meaning requires that the wholes as well as the parts must be understood; effective teaching involves understanding the students’ perceptions and assumptions; and the learner must construct his own meaning of the new material. As the participants progressed throughout the learning activities, they began to put pull together the lessons on bacteria, irradiation, and food safety into a larger picture that showed how each of these subjects impacted overall food safety and personal health.

At the conclusion of the Science in Agriculture Day Workshop, students were asked about their opinions concerning irradiation. One hundred percent of them were able to attribute irradiation with the elimination of bacteria, its use on meat, and that a form of energy was involved in the process. When asked if they knew how irradiation was used in the preparation of food for humans, just over 90% of the students recognized that it involved the use of energy, an improvement of nearly 30% from the answers provided on the pre workshop surveys. 8% of the students answered that the process killed bacteria in food. A myriad of answers were provided when the contamination of food was questioned, including the improper handling and storage of food and unsanitary conditions. In a sensory
evaluation of the irradiated and the non-irradiated ground beef, well over one half of the students detected a difference in the flavor of the irradiated ground beef, but 90% did not detect a difference in the appearance of the product. At the end of the workshop just over 90% stated that they did not have any concerns about eating irradiated meat, and well over one-half of them would be willing to pay more for the product because it would be safer and healthier.

Participants in the 4-H Roundup Workshops provided similar information at the close of the activity. Over 90% were able to provide information about irradiation, such as the use of energy, its use in food processing, and the elimination of bacteria in order to make food safer. When questioned about irradiation’s use in the preparation of food for humans, nearly 90% were able to use valid terms describing the process. Contamination of food was addressed, and once again a wide range of answers were provided (nearly 100%), all addressing the improper handling and storage of foods and unsanitary conditions. 80% of them would not have any concerns about consuming irradiated products, and nearly 80% of them stated that consumers would be willing to pay more for the irradiated products because those products would be healthier and safer. In particular, one student stated that the consumption of such products would be cheaper in the long run. Participants were questioned if the irradiated products should be handled differently than the non-irradiated products. 80% stated that they still needed to be handled using safe food handling practices (cook, clean, chill, avoid cross contamination).

A different approach to teaching about food irradiation technology and safe food handling practices was used with students in the Animal Science 101 Working with Animals class in December 2005. Both a passive (power point presentation and videos) and an active learning experience (cooperative learning activity) was administered to the students and once again, regardless of the method used and demographic profile of the students, there was substantial change in the perception of food irradiation and safe food handling practices. The most prominent change occurred in the percentages of the “I don’t know/ did not answer” responses to key questions on the surveys. Students were initially asked of their knowledge about irradiation, and on the pre workshop surveys for the passive group, well over one-half of them said that they either knew nothing or very little; on the active group similar responses were received with well over one-half of them providing a “nothing” response. However on the post workshop surveys for both groups, 100% of the students could provide plausible answers which included killing bacteria, as well as recognizing that
energy was used which made the meat safer. Students were also asked about their knowledge of bacteria. On the pre workshop surveys for both groups, over three-quarters of them recognized that bacteria could be harmful and cause illnesses. When both groups were asked the same question on the post workshop surveys, almost 100% were able to state that some bacteria was harmful, must be monitored when considering food safety, and that irradiation was beneficial in destroying them. Students were asked to consider the safety of irradiation facilities. For both groups on the pre workshop surveys over three-quarters of them did not know how safe they were. However at the close of the activity almost 100% of the students stated that they thought that the facilities were safe. The Radura symbol had been introduced to the students and on the pre workshop surveys for both groups, one-half of the students did not recognize the symbol. On the post workshop surveys for both groups, 90% were able to indicate what the symbol represented.

Based upon the successes of the three previously administered workshops (based upon the results previously discussed), the final pre and post workshop surveys were written, and the final active learning experience was developed. Because active learning was shown to be the most valuable learning method for students, a cooperative learning activity was developed that incorporated jigsaw reading. This method could be very beneficial because with this educational method information about irradiation and food safety could be more easily disseminated to a larger population. A workshop coordinator, not considered an expert in food irradiation and food safety, could facilitate this activity. Educators and facilitators would be more apt to utilize this information as little preparation time is required. They would only need to review the information, provide instruction to the class, and the students or participants could actually teach themselves and each other the lesson. Discussion could be initiated by the facilitator at the end of the activity.

Results of the research done with the Animal Science 101 students in February 2006 proved that this activity was very successful. The facilitator did not participate in the workshop other than to provide instruction at the beginning of the class. In order to mimic a regular high school lecture period, the workshop was limited to fifty minutes. Once again, regardless of the demographics of the participants, the students learned the material. When asked the purpose of irradiating food, 100% of the participants were able to answer the question. Nearly 100% of the students knew how irradiation worked, admittedly some better than others, but nearly all recognized that the process destroyed bacteria. Participants were asked how they felt that irradiation might impact the health of people through the use of a
Likert scale. A review of the post workshop survey results showed that the large majority of the participants had developed positive responses to the question for a variety of reasons, mainly because the process made the food safer, thus decreasing the incidences of foodborne illnesses. The Radura symbol was introduced and the post workshop surveys showed that the percentages of persons who would select a product with a Radura symbol improved to over 80%. Participants were asked why some people got sick from eating meat and several answers were provided on the post workshop surveys which included bacteria, and references were also made to the different ways that food could become contaminated. When participants were asked what people could do to help prevent those illnesses, nearly 100% of the participants answered that consumers should improve their food handling and storage methods and purchase irradiated foods. Almost 100% of the participants in the post workshop surveys were able to recognize different ways that food could be compromised, thus causing foodborne illnesses. Nearly 100% of the participants recognized that not all bacteria are bad, but pathogenic bacteria could re-contaminate the irradiated food products, thus allowing foodborne illnesses to develop.

Results of the research completed with the Iowa high school students reflected much of the same information. Nearly one-half of the students had not studied biology in their required coursework, but 77.8% of them were responsible for food preparation at home and two-thirds of the participants had experience working in the food service industry. The educational material provided information for the students to improve their knowledge of irradiation, as the numbers of students that could answer the question improved to 90.3%, and those answers generally stated that the process improved the safety of food. Initially, 88.9% either did not know or did not answer the question when asked about the irradiation process. However when asked this question at the completion of the session, 50.0% were able to recognize irradiation, and were able to provide explanations in general terms. Students were asked about the impact of irradiation on people’s health, and the positive answered improved to 75%, compared to 54.2% who had earlier started that they did not know and the 34.7% who provided positive responses. The Radura symbol was recognized and those participants who would purchase irradiated products improved by 37.5%. Students indicated that the safety of irradiated products would have been improved. Improper storage and handling, and contamination were the main reasons provided when asked about meat serving as the source of foodborne illnesses. In both surveys students were able to provide credible answers, and in the post survey 16.7% referred to the
consumption of irradiated meats as a strategy that could help prevent these foodborne illnesses. Students learned about the consequences of implementing poor food handling practices and the roles that bacterial contamination could play in the development of foodborne illnesses. They also recognized that the re-contamination of food was a problem as the affirmative answers increased from 62.5 to 73.6%.

In summary, the students were most successful in learning about irradiation and its uses. Significant P-values < 0.05 were calculated when students were asked the following questions: 1) What is the purpose of irradiating food? 2) How does irradiation work? and 3) How do you feel that irradiation might impact the health of people? A P-value ≤ 0.056 suggested a close significance when the question number five was asked, "Why do some people get ill from meat?"

In comparison, no significant values (P-values ≤ 0.05) were attained when the students were asked these questions: 4) Which package would you likely buy- A- the one with the symbol; B- either one (makes no difference to me); C- the one without the symbol? Why did you choose this answer? 6) What can people do to help prevent foodborne illnesses? 7) What causes foodborne illnesses? 8) Are all bacteria bad? and 9) Can I get sick from foodborne illness after it has been "cooked"?

These results indicate that this educational program would be more effective if the food irradiation material was delivered separately from the food handling material. A possible scenario would be to teach about food irradiation on Day 1, and then teach about safe food handling practices on Day 2. On Day 3, the two previously delivered educational activities could be discussed together, allowing constructivism to occur.

In addition to these changes in the delivery of the educational material, a larger survey population should also be used in future research to more accurately track progress of this educational activity. Diligence must also be implemented to ensure that participants complete all of the questions on both the pre and post workshop surveys. This allows the calculation of significant P-values for all questions.

Conclusions

With the development of this final educational activity, results prove that it does not require an expert in food irradiation and safe food handling practices to achieve an attitudinal improvement concerning food irradiation and food safety when providing the cooperative learning activity that utilized the jigsaw reading method. With jigsaw reading,
the students taught each other and themselves the information. Particular care had to be taken by each group member to ensure that he was providing the correct information to the rest of the group. Any misinterpretation on his part directly affected the answers provided by the others. By implementing this style of learning, the scope of teaching about food irradiation and safe food handling practices could be widened even further, directly impacting a decrease in the numbers of foodborne illnesses as a larger population could be taught the material. Because a (reusable) booklet was the source of information for the students, classrooms did not require any technological equipment, and the educator or facilitator could expand the activity to extend past a fifty-minute class period. Discussion would also be beneficial as the educator or facilitator could initiate discussion, and the participants could participate by offering their answers to the questions, initiate discussion themselves, ask additional questions, and provide insight and personal experiences to complement the material being taught.

Cooperative learning activities provide the active learning that has been shown to be most advantageous in teaching circles. This particular research investigated the success of cooperative learning (jigsaw reading, in particular) with a high school aged population. Future research could include using the same approach by developing jigsaw reading materials specifically developed for teaching food safety and delivering the information to elementary aged students. However, the topic of food irradiation should not be introduced until the junior high levels. The American Association of the Advancement of Science (1993) had previously suggested that the topic of pathogenic bacteria should not be introduced until the sixth grade. The students would be capable of understanding these bacteria and ultimately food spoilage at that age level. Developing assessments of this material at this age would not only provide valuable information as to the capabilities of this age group to learn and implement the safe food practices, but also begin making inroads to the prevention of foodborne illnesses, in addition to common colds, flues, and viruses (so prevalent in our nation’s school systems in cold winter months).

Additionally, future research should include teaching about food safety at an elementary age level, introducing food technologies in advanced coursework, and then monitoring the youth as they become older and increasingly responsible for food handling for themselves, their families and friends, and for the general public. In this manner, assessments can be developed and reviewed to observe if the learned practices as young children are truly being regularly practiced as young adults.
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CHAPTER 4. GENERAL CONCLUSIONS

The development of effective pedological methods to teach high school students about food irradiation and safe food handling practices is very important in ultimately reducing the numbers of persons across the world who suffer from foodborne illnesses. As stated earlier, the numbers of teenagers who are becoming employed in the food service industry, and the numbers of teenagers who are becoming more and more responsible for food preparation for themselves and their friends and families, continues to grow. Combine this fact with an aging population and the numbers of births across the world, and the chances of increased foodborne illnesses continue to climb.

Active learning has been shown to be the most effective method to teach high school students about food irradiation and its uses for a safe food supply, as well as safe food handling practices. The use of a jigsaw reading system with cooperative learning can expand the scope of this material far beyond the classroom. This approach should not be limited to the classroom, but should also be used with all populations, whether with the elderly or with elementary aged children in meetings such as 4-H, Boy Scouts, or Girl Scouts. The possibilities are endless, and food safety educators should never cease to incorporate lessons of new food technologies, older (although maybe not familiar) food technologies such as irradiation, and the 4 C’s—cook, clean, chill, and avoid cross contamination with every opportunity when preparing public presentations. Reiterating Blaser’s comment in 1996 suggesting that, “Food is not sterile, and eating cannot be made risk-free,” will forever become the driving force behind the importance of food safety education. The continued development of educational methods that can teach high school students about the importance of a safe food supply for our world will only prove to benefit our society and future generations.

References
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APPENDIX A. ACCOMPANYING CD-ROM AND RELEVANT TECHNICAL INFORMATION

System requirements for CD-ROM: MacIntosh G3 or higher; 384 Mb; Windows 95 or higher; MS Office 2003 or higher.

The CD-ROM contains materials required for the Iowa High School Vocational Agriculture Students Irradiation Workshops. Provided are the authorizations for the school administrators, parents/guardians, and students. Also provided is the cooperative learning-jigsaw reading activity titled “Iowa State University Food Science and Technology Spring 2006” and the Iowa State University Beef Irradiation Education Manual.