1-1-2016

Evaluating the Effectiveness of Integrating Food Science Lessons in High School Biology Curriculum in Comparison to High School Chemistry Curriculum

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By

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A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Food Science and Technology
in the Department of Food Science, Nutrition, and Health Promotion

Mississippi State, Mississippi

August 2016

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Title of Study: Evaluating the effectiveness of integrating food science lessons in high school Biology curriculum in comparison to high school Chemistry curriculum

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Historically, high school chemistry has been the predominate venue for introducing food science curriculum to students. The purpose of this research was to determine if high school students in a biology class without a chemistry background could comprehend eight basic food science principles equally as well as students in a chemistry class that were taught the same principles. This study assessed baseline knowledge of high school students, determined the effect of food science-based lessons on baseline knowledge and level of understanding, and determined the effect of food science-based lessons on students' awareness of and interest in food science. Baseline knowledge and awareness of food science was low. Food science-based instruction resulted in higher post-test scores. Results indicated no differences between biology and chemistry and supported the idea of further incorporating a food science curriculum into high school biology.

Key words: food science, education, biology, chemistry, curriculum, principles, exposure

DEDICATION

I would like to dedicate this paper to my fiancé, my parents, and my advisor.

To Blake, you are my inspiration, my motivation, and my best friend. I could not have done this without your constant support. You have been through every battle right by my side and not once let me falter. I love you with all my heart.

To my parents, Kendra and Terrell, thank you. Thank you for the support, both moral and monetary☺, the life lessons, the faith you have in me and your unwavering love. I appreciate it more than you know. You both deserve a private island and all I can afford is a free dedication in this paper.

To Dr. Schilling, thank you. Thank you for your guidance. Thank you for challenging me. Thank you for providing opportunities I would never have experienced anywhere else. Thank you for providing a family away from home. Thank you for caring about our growth and success more than your own. Thank you for your prayers. And most importantly, thank you for introducing me to the wonderful world of food science.

ACKNOWLEDGEMENTS

I would like to thank all of my committee members for coming together and working on a project slightly out of their comfort zone. Dr. Swortzel, I could not have done this without your lessons and expertise in education and research. Dr. Williams, your guidance and impromptu talks about life will never be forgotten.

I would like to thank my colleagues Elizabeth, Morgan, Hector, Carlos, Xue, Wenjie, Michael, Saxon, Yan Zhao, Yan Campbell, Mike, Monil, Sandy, Vi, and Jasmine who all at one point or another helped complete this master's degree in some way. I enjoyed getting to know every one of you and I hope to keep in touch further into our professional careers.

I would like to thank the faculty and staff of the Department of Food Science, Nutrition and Health Promotion. So many of you have had a hand in preparing me for my future and I cannot thank you enough.

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CHAPTER I

INTRODUCTION

Recent advances in food science and technology have made the food industry one of the fastest growing industries of the twentieth century, both domestically and worldwide. “As the demand for nutritious and convenient products increases, so does industry’s need for many well-trained professionals to develop healthier products, improve processing technologies, and monitor the safety of these products” (Lo, Gdovin, Stankiewicz, Appezzato, & Garvey, 2006). A report by the United States Department of Agriculture (USDA) indicated that college level programs across the United States would not produce enough graduates with majors in natural resources, agriculture, and food science to fill the job demands from 2005 to 2010 (Lang, 2007). This provides a rare opportunity where unlike many fields, food science has a surplus of job openings where many other disciplines have job shortages.

There are many factors contributing to the current shortage, including the fact that food science is not well recognized or understood among high school educators and there is a general unawareness of the career opportunities among guidance counselors, students, peers, and parents (Roberts, Robbins, McLandsborough, & Wiedmann, 2010). Historically, postsecondary education has been the only venue for developing and refining a food science curriculum (Napoleon, Freedman, Seetharaman, & Sharma, 2006). However opportunities exist to develop and implement food science programs for secondary education.

Science classrooms in almost all grade levels present the unique opportunity to transition lessons to focus on food to provide a better understanding of the sciences including chemistry, biology, microbiology, biochemistry, engineering, physics, agricultural production, mathematics, and sensory evaluation. “In addition to the need for food science graduates, there is a growing need for the training of skilled, non-degreed workers within the food industry” (Culbertson & Smith, 2006). To increase awareness and promote interest in food science as a career option for both degreed and non-degreed students, the topic should be incorporated into Kindergarden-12th grade (K-12) curriculua. The Institute of Food Technologists (IFT) supports and encourages K-12 science-based education (Davis, McEntire, & Sarakatsannis, 2007) and has compiled many resources available to the public to promote the field of food science as an exciting career option. Resources such as “Food Science Ambassadors”, “Food 4Thought”, “Find a Food Scientist”, and “Discovery Education Partnership: *The Science and Scientists Behind the Food*” are all geared towards increasing interest in science and educating K-12 students about food science and potential careers in the field.

“When designing programs to assist science teachers as they integrate food science education into their classrooms, it is important to consider the National Science Education Standards (NRC 1996) and local state standards which aim to improve science education and enable students to achieve scientific literacy” (Beffa-Negrini, Cohen, Laus, & McLandsborough, 2007). To ease the burden of the teacher, a new program should always take such standards into account to maximize learning in a limited time. Food science lessons should easily adapt to fulfill such standards at all levels.

Furthermore, recent trends in food preparation and nutrition are likely to prompt educators to implement these topics into their lessons (Hovland et al., 2013). Supplementing educators with the IFT resources and existing curriculum provides a wealth of knowledge and aids that can be trusted, utilized, and customized with positive results. As a result, more students will have the opportunity to learn about food science prior to choosing a career path, which over time, has the potential to significantly increase both non-degreed skilled labor in the food industry as well as undergraduate enrollment in higher education food science programs (Schaich-Rogers, 2007).

By implementing a food science curriculum in secondary education environments, students are given the opportunity to increase their understanding of basic scientific principles and math skills through real world applications including food. By combining these basic principles with a familiar subject such as food, students are more likely to better understand and retain the lessons based on the theory of scaffolding. Students are also provided a potential new career path with the prospect for continuing education in a field that ensures the safety and security of the global food supply, develops innovative products, and helps solve future problems in all parts of the food supply chain.

Purpose of Study

The purpose of this research was to determine if high school students in a biology class without a chemistry background differed in their competency of eight basic food science principles in comparison to chemistry students that were taught the same principles.

Research Objectives

1. Determine and compare the baseline knowledge of food science in high school students between biology and chemistry

2. Determine and compare the effect of food science-based instruction on high school student's baseline knowledge of food science in chemistry and biology

3. Determine and compare the level of understanding and long term memory of food science-based instruction between biology and chemistry students

4. Determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field

Statement of the Problem

Two problems were addressed. The first problem was that many students do not take chemistry in high school and that if food science is introduced at all, it is usually introduced in chemistry classes. The second problem was that since most methods focus on chemistry, food science as a career and academic opportunity is only introduced to a subset of high school students. With advances in science and technology, there is an increased need for food scientists in order to continue to feed the growing population.

Chemistry requirements for high school graduation vary across the states. Some states mandate that chemistry is taken along with biology and physics while others consider it an elective. For example, a student is required to take three science courses as a high school graduation requirement in Mississippi. Biology is a mandatory course. Students have the choice to take Biology II, Chemistry, Plant Science, Anatomy and Human Physiology, Environmental Science, or Concepts of Agricultural Science Technology. With the various choices, it is likely that a student will graduate without taking chemistry. The National Science Board reported that most high school students do not enroll in advanced science courses such as chemistry when given the option (National Science Board, 1999).

It is important that tomorrow's generation is aware of food science and the career options it holds. It is estimated that by the year 2050 the world's population will be 9.1 billion, 34% greater than the current population ("How to Feed the World in 2050," n.d.). To meet the demand for qualified food scientists, programs need to revise their methods of recruitment and public exposure. The agriculture and food industries are important to the nation. However, programs cannot keep up with the demand for qualified candidates. This goes back to the fact that students are rarely introduced to these fields in high school before they have made a career or academic concentration choice. Introducing students to food science before they have entered college is critical to growing enrollment in food science programs and filling the need in the job market. While current methods led by IFT have seen a recent boost in enrollment (Stevenson, 2016), research is needed to elucidate other methods for the introduction of food science to high school curriculum. Therefore, research was conducted to determine if students in biology, with no background in chemistry, could comprehend food science principles. In addition, it was determined if exposure to food science principles increased their awareness and interest in food science.

CHAPTER II

REVIEW OF LITERATURE

Literature presented in this review provides evidence of current programs with positive results in areas such as food science and career awareness, math skills, and scientific literacy. The objectives of this literature review are 1) determine the need for food science programs in secondary education, 2) evaluate programs that have been implemented, and 3) determine additional benefits such as level of understanding of math and science skills and success skills provided by such programs.

STEM & Food Science

Partnering with a successful science program has been an effective method of introducing food science to high school students. STEM (Science, Technology, Engineering, and Mathematics) is a successful program that is in place in many high schools in the United States of America.

Literature Review: Food4Thought Provide Students STEM Opportunities in Food Science

Food4Thought is a program that was developed by the Institute of Food Technologists (IFT) in 2012 and implemented into STEM programs that were already in place in many high schools. The goal was for students to view food science as a premier science with impressive job statistics and opportunities (Wagner, 2015). “Food4Thought is built on 3 foundational pillars: 1. Educate: Position Food Science as a Key STEM

Science; 2. Engage: Implement Pilot Programs for Future Food Scientists; 3. Empower: Develop Learning Resources" (Wagner, 2015). IFT partnered with the Orange County Chapter of Girls, Inc. and Chapman University to pilot this program for 2 years. The all-female student group (n=30-35 high school juniors) visited Chapman University and participated in Food Science 101 to learn about the field and initiated relationships with faculty, undergraduate students, and graduate students. From this group, 4 individuals were selected to attend the IFT Annual Meeting and Food Expo® in 2013 where they were also provided the opportunity for "extensive immersion" including visiting the Wrigley's Gum headquarters and Hamburger University in Chicago and USDA ARS (Agricultural Research Service) in New Orleans. Their onsite experience also included a tour of the expo floor, meeting with members of IFTSA (IFT Student Association), and learning the science behind flavors, textures, military MREs, and product canning" (Wagner, 2015). Such extensive experiences were only made possible by generous corporate support. After this pilot program, greater than 50% of the students applied to food science programs. In addition, positive feedback was received from all participants, including IFT members.

Food4Thought provided a unique opportunity to a select group of girls over the course of two years. These ladies were enrolled in an introductory college level food science course and were provided numerous education industry experience opportunities. IFT has continued to develop programs to promote food science and encourage relationships between academia and industry. This program is difficult to implement since it requires 1. A local STEM program near a school with a food science program, 2. Generous support from corporate donors to send 4 students to the annual meeting each year, and 3. Flexibility for students to attend a college course while still in high school. One weakness addressed was the added need for a job shadowing/ internship to expand their learning experience beyond that of the class and IFT meeting (Wagner, 2015).

Literature Review: Using Food Science Demonstrations to Engage Students of All Ages in Science, Technology, Engineering, and Mathematics (STEM)

Schmidt et al. developed six food science experiments to deliver STEM lessons at all educational levels (Schmidt, Bohn, Rasmussen, & Sutherland, 2012). "First, students are familiar with food materials which helps the instructors begin with what they already know. Second, there is currently a strong public interest and awareness of food and health. Third, by its very nature, food science allows for an interdisciplinary approach to learning, because food science itself is a union of several disciplines, including chemistry, microbiology, engineering, nutrition, and sensory sciences" (Schmidt et al., 2012). Experiments included (1) making ice cream using liquid nitrogen to study matter of exchanging phases; (2) sampling drinks of varying flavor and color combinations to study sensory factors; (3) whipping heavy cream to observe structural changes and the effect of mechanical shearing; (4) evaluating differences between milk chocolate and dark chocolate through defining key terms and learning standards of identity; (5) using a bomb calorimeter to determine calculated calories and comparing the results to the ingredient label; and (6) molecular gastronomy; spherification, the wonders of cross-linking between sodium alginate and calcium ions (Schmidt et al., 2012). Simplifying the terminology and using age appropriate science content can make these demonstrations applicable to K-12 and not just STEM classes.

Six demonstrations were developed to incorporate food science in STEM across K-12 and were implemented with positive results. While this article provided an in depth description of said demonstration it lacked any evidence of assessment and learning outcomes. The addition of a survey on awareness and food science knowledge base before and after the demonstration would provide a better assessment of student competency.

Literature Review: National Science Foundation Graduate Teaching Fellows Promote Food Science Education in K-12 Schools in Maine

In 1999, the National Science Foundation (NSF) developed a fellowship program that matched STEM teachers with outstanding graduate students to improve the Fellow's communication skills and enhance K-12 education. For ten hours a week, Fellows implemented food science lessons that met state standards in K-12 classrooms in Maine. Calder et al.(2006) reported that the food science lessons that were most enjoyed by grades 2-10 were "making models of DNA with licorice, toothpicks, and gumdrops; decorating "cell" cookies to make different organelles with frosting and candy decorations on top of the sugar cookie "cytoplasm" or preparing "cell" pizzas using different toppings were the favorites of 5^{th}-8^{th} grade; and using flavored gelatin to study the cell and organelles in a 3-d matrix were enjoyed most by 2^{nd}-4^{th} graders" (Calder, Brawley, & Bagley, 2006). Other lessons listed in the article successfully integrated 6 of the 13 standards set by the state. Assessment was conducted of both the Fellow and the students. The Fellow's communication skills improved, and the students (assessed by the cooperating teacher) improved their use of the scientific method and scientific writing. In addition, students also garnered a better understanding of science and careers in science.

Graduates of STEM programs were selected and given a fellowship to go back and teach food science in STEM K-12 programs under a major professor to (1) improve the Fellow's communication skills; (2) promote inquiry-based science using food; and (3) serve as a role model in the field for K-12 students. Assessment included the Fellow, the students, and the cooperating teacher, all of which assessed the program with positive feedback (Calder et al., 2006). However, formal assessment was lacking and the article did not provide statistical data. Also, options of combining a Fellow with a local STEM program could prove limiting. Simple outreach of faculty and graduate students could suffice with proper training and orientation to the local state's scientific education standards.

Food Science Summer Scholars & FoodMASTER

Others have taken the opportunity to develop their own programs to introduce food science across all levels of education. Food science has been used to develop math and science skills that are generally lacking in K-12 and college students in the United States through summer scholar programs at Cornell and the FoodMASTER program.

Literature Review: A 10-Year Review of the Food Science Summer Scholars Program: A Model for Research Training and for Recruiting Undergraduate Students into Graduate Programs and Careers in Food Science

In 2000, the Cornell Institute of Food Science established an annual Food Science Summer Scholars Program as an effort to help fulfill the need for more students pursuing M.S. and Ph.D. degrees in food science and to increase interest in food science careers (Roberts et al., 2010). The program was an experiential summer research program for undergraduates in different disciplines. "The goals of the Food Science Summer Scholars

Program were (1) to recruit students from related academic disciplines into food science to increase the supply of qualified food science graduates, (2) to recruit students into advanced degree programs in food science, (3) to recruit students from underrepresented minorities into food science, and (4) to develop a model for joint, multi-institutional, minority, and undergraduate recruitment that can be expanded to other institutions" (Roberts et al., 2010). Student selection for the program was based off of a competitive application process. The successful applicants were matched up with their faculty mentors based on the candidate's expressed research interests. The selection committee consisted of 2-3 faculty and1-2 industry representatives. A standardized application evaluation form was used and the top-ranking applicants were invited to join the program. The foundation of the program was a 10 week research project with students working at least 40 hours a week independently in the faculty's lab. Each week required a meeting with their faculty mentor to address questions and develop learning objectives for their research project. After 10 weeks, the students were required to write an abstract and deliver an oral presentation to their mentors and peers. The program also consisted of workshops, field trips to food companies, including their research development laboratories, and regular mandatory meetings. The semiweekly workshops/presentations covered topics such as "applying to graduate school, ethics in food science, reconciling professional and personal responsibilities, effective strategies for oral presentations, the use of library and internet resources, and a *Careers in Food Science and Agriculture Panel Discussion*" (Roberts et al., 2010). The program was financed through internal and external funding including industry donations and two USDA Higher Education Challenge Grants (Improved Food Science Undergraduate Education through

Experiential Learning) & (National Multidisciplinary Food Science Summer Research Program) (Roberts et al., 2010).

The program was evaluated using a questionnaire-survey evaluation on a yearly basis. After 10 years of successfully implementing this program, the program was expanded to include other universities. Other measures of the program's success include "(1) a large and diverse applicant pool and program enrollment, (2) a high level of student and faculty satisfaction with the program, and (3) 101 of 147 program participants have or are currently pursuing graduate studies in food science or related fields and/or entering careers in food science" (Roberts et al., 2010).

Cornell University and The University of Massachusetts have provided hands-on research, industry learning experiences, communication skills, and exposure to food science careers to 147 undergraduate students, over a 10 year time span. At the conclusion of the 10 year study, out of the 147 participants, 60 nonfood science majors were introduced to food science, 54 enrolled in M.S. or Ph.D. programs in food science, 31 enrolled in M.S. or Ph.D. programs in food science-related fields, and 25 students from minority groups were exposed to food science. IFT has reviewed and approved this program as a means to promote food science and recruit students. However, there are a few discrepancies that should be evaluated. First, there is the restriction of the application process. Only those with the highest scores are invited to complete the program. Many of the students would likely go on to M.S. and/or Ph.D. programs regardless of their participation in the program and those that score lower would likely benefit more from the program. The program was developed in 2005-2007 and could benefit from a secondary evaluation that assessed how much the program helped the participant with job placement and ability to move upwards within a company. It would also be beneficial to contact their immediate employer upon graduation and assess their abilities against similar past graduate hires without a similar experience. This program could be further expanded by opening it up to high school juniors and seniors who would not normally attend post-secondary school.

Literature Review: Using Food as a Tool to Teach Science to 3rd Grade Students in Appalachian Ohio

A food curriculum for elementary school aged children was developed by professionals in nutrition and education with the goal of using food to teach mathematics and science and evaluate the attitude outcomes towards science subjects due to implementing this program. This program was developed in 2005-2007 and is called the Food, Math, and Science Teaching Enhancement Resource Initiative, also known as FoodMASTER. In 2007-2008 this program was tested in ten 3rd grade Ohio classrooms. The curriculum included measurements, food safety, vegetables, fruits, milk and cheese, meat, poultry, fish, eggs, fats, grains, and meal management (Duffrin et al., 2010). The control for this test was four other classrooms that used normal lesson plans. A pre-test and post-test were used to determine attitudes towards science subjects upon completion of this course in comparison to the control group. Teachers participating in the program received training over four days at Ohio University and were provided all the materials required to complete the program in their classrooms. The curriculum consisted of 45 lessons that would theoretically take one hour and should be able to blend into lesson plans at any time during the year. The FoodMASTER curriculum comprised of hands-on activities aimed at satisfying national standards, engaging the students, and developing higher level thinking skills based on Bloom's Taxonomy such as analysis, synthesis, and evaluation.

Results indicated that significant differences occurred between the test and control groups with regards to male and female attitudes towards certain science subjects covered (Duffrin et al., 2010). Their attitudes declined toward some of the subjects by the end of the course. There were many potential reasons as to why this happened. These reasons included everything from gender preferences to inconsistencies between data collected and classroom observation recordings. Duffrin et al. concluded,

> "Commonly, elementary school children do not equate science learning and discussion with investigation, experimentation, and activity. Therefore, it is entirely plausible that the FoodMASTER curriculum did not generate positive growth in student attitudes towards science because students perceived FoodMASTER as fun and engaging and very different from typical science instruction. Although the connection of food and nutrition to science is explicit within the learning activities, curriculum developers realize that the connection has to be made even more explicit to the students engaged in the instructional materials" (Duffrin et al., 2010).

FoodMASTER is a math and science teaching enhancement course that is focused around using food to engage students in many different science subjects. This course was tested on a group of 3rd grade classrooms. Results were ultimately inconclusive and require further testing. Applying the course to older students may help provide a better understanding of how the curriculum should be modified and reducing the number of lessons may help prevent fatigue.

Literature Review: Food-based Science Curriculum Increases 4th Graders Multidisciplinary Science Knowledge

This FoodMASTER program was evaluated for a second time using 4th grade students in Ohio and North Carolina. Changes from the previous test include assessment and comparison of food science knowledge gains, reducing the number of lessons from 45 to 24, reducing time per lesson from 1 hour to 45 minutes, and gearing the curriculum to 3rd-5th grade students. The pre-and post-test subjects included five questions on life science, two on science in personal and social perspectives, three on physical science, and three on science and technology. Significant differences were present between the test and control group. The test group received higher scores in three of the four science subjects. Experiencing the curriculum led to increased food science based knowledge (Hovland et al., 2013).

When FoodMASTER was revised and deemed FoodMASTER Intermediate, the changes resulted in better assessment of knowledge gains and a curriculum that was more suitable for a wider range of students. These changes produced positive results in food science based knowledge and general understanding of four science subjects. The first lesson on weights and measurements may need to be revised throughout the course to ensure a proper working knowledge of the lesson since it is crucial to the understanding of future lessons (Hovland et al., 2013). One other limitation of this study was the distance between test classrooms between and within the states and the challenges it created for site visits.

Immersion Approaches, Food Industry Needs, Workshops

When considering the implementation of a food science knowledge based curriculum, higher education competencies and career skills desired by the food industry should be considered.

Literature Review: An Immersion Approach to Teaching Food Science

In Introduction to Food Processing, a freshman level course at Ohio State University, an immersion approach is applied to introduce students to basic concepts, expand their food science vocabulary, and provide a foundation for future courses (Harper, Courtney, & Chism, 2006). This immersion approach includes less lecture and more hands-on experiences of the basics of food processing with respect to terms, equipment, and evaluation covered in the class. Team learning is utilized to conduct a semester long project of making processed products. The first 3 lab sessions introduce the pilot plant equipment used to process dairy foods, snack items, bakery goods, meat products, and fruit and vegetable products. In addition, the analytical instruments that are used to evaluate the foods were discussed and demonstrated in these lab sessions; 2 labs covered 6 engineering operations; and the last 3 labs covered the planning, manufacturing, and evaluation of 3 food products per team (Harper et al., 2006). This program used "recitation" in the place of traditional lecture, where the class met once a week and covered one form of preservation with a 15 minute presentation, and then broke up into groups and discussed case studies. Level of understanding was assessed per group resolution. Another unique form of assessment used in this class was the final exam. "The final exam was given orally to 2-3 students at a time. The students enter the classroom to find 50 to 100 packages of processed food products. Typical initial questions might be for all students to “select a product that requires all 6 unit operations” or “select a product that requires 1 (2, 3, 4, 5) unit operations”. The students might then be asked to agree or disagree with the choice of their classmate” (Harper et al., 2006). Further questions were asked regarding the chosen product and assessment was based on answers provided, level of question difficulty, and number of answers given in the time provided. A pre-test and post-test was also administered to measure student learning in the class. In previous years of this course, none of the students passed the pre-test whereas upon completion, greater than 90% have passed the post-test (Harper et al., 2006). The results have been used to strengthen areas where instruction was lacking and improve the course.

Introducing students to a new topic through the immersion approach works well when that topic can be experienced first-hand. In this course, students were introduced to processing principles, use of the processing equipment and then evaluation of the food products. While the results indicated an improvement in food science based knowledge, an oral examination for two students at the same time may not be an effective assessment method. The assessor could have a difficult time keeping answers straight between students and getting a valid representation of what the individual actually knows.

Literature Review: An Educational Needs Assessment of Pennsylvania Workforce: Opportunity to Redefine Secondary Career and Technical Education to Meet Food Industry Needs

Napoleon et al. (2004) set out to discern workforce needs with respect to food science knowledge and how education can be tailored to meet those needs. The Bureau of Labor Statistics reported that many food industry line-workers are high school graduates with no postsecondary education (BLS 2004). Although it is not necessary to have a degree in food science to work in the food industry, a basic food science background can directly impact the company, product, and ultimately the consumer (Napoleon et al., 2006). Multidisciplinary partnerships among industry, universities, and school districts demonstrate the potential to educate the non-degreed workforce, thus positively impacting the industry (Napoleon et al., 2006). Assessment of industry needs included concerns about workplace safety, food safety, food and production systems from pre-to post-harvest, basic mathematical skills, and professional conduct (Napoleon et al., 2006). Focus groups from 5 major national companies with representatives from human resources, production, quality assurance, purchasing, and product development were conducted to collect data. Questions were provided during the 2 hour sessions and multiple sessions were conducted. The number one concern identified was the need for education in food safety and workplace safety training (Napoleon et al., 2006).

A need exists to implement food science based curriculum in secondary education that also includes career and success skills that are associated with the food industry. The four primary themes discovered could likely be the basis for such a curriculum and could greatly benefit the companies and individuals by producing qualified employees.

Literature Review: Science Content Courses: Workshop in Food Chemistry for 4th Grade School Teachers

An Inquiry Based Science Program was designed and implemented in K-5 to improve science education and understanding in the Seattle school district (Chaiyapechara & Dong, 2006). Individual units were developed for each grade and workshops were provided to the educators by local scientists. Participating teachers received a stipend and continuing education credits for completing the workshop (Chaiyapechara & Dong, 2006). This workshop consisted of the following goals (1)

Foster an environment of inquisition by creating a nonthreatening rapport of question and positive feedback; (2) Provide educators with scientific material and reference material facts where to find trusted answers; (3) Provide educators hands-on experiments to take back to the classroom; (4) Present field trip opportunities; (5) Relate food chemistry to everyday household items (Chaiyapechara & Dong, 2006). The workshop spanned 4 days in August and 12 to 15 teachers participated each year. There was no formal assessment other than feedback and observation as to how much the instructors gained from the workshop.

Hosting a workshop to train teachers in food science is very important so that their students are receiving accurate information. While the workshop was rated very high by the attendees, the main goal of providing knowledge was not formally assessed, which is necessary to evaluate program effectiveness. Although it is important for educators to feel more confident about what they are teaching, their level of understanding is also very important. Developing and implementing a food science based curriculum through conducting a similar workshop could be a viable means to foster a learning environment like the one here.

Upon the review of multiple literary sources, there is potential and need to deliver food science curriculum to secondary schools and assess the impact that delivering this curriculum has on the food industry and students' career paths.

CHAPTER III

MATERIALS AND METHODS

Participants

Students (n=73) from a private school in Starkville, Mississippi with an enrollment of approximately 709 students served as the participants in this study. A signed form was obtained from the school to conduct this research during the school year from January 2016 to May 2016 (Appendix A). An initial research announcement email was sent out to the school to recruit teachers and their classes to implement this study (Appendix B). Two teachers volunteered their classes to serve as the subjects for the study. Students were enrolled in either one of three biology classes or one of three chemistry classes taught during the spring semester of 2016.

Student placement was random and not due to prior academic performance or standardized test results. Of the biology classes, two periods served as the treatment groups and one group served as the control. The first period biology class (n= 11) consisted of three males and eight females. The fourth period biology class (n=18) consisted of fourteen males and four females. The seventh period that served as the control for biology (n=12) consisted of eight males and four females. There were a total of 41 biology students in the study. None of the students had previously taken chemistry or were repeating biology. The second period chemistry class (n=12) consisted of six males and six females. The fourth period that served as the control for chemistry (n=12) consisted of seven males and five females. The sixth period chemistry class (n=8) consisted of seven males and one female. There was a total of 32 chemistry students. All of the chemistry students had previously taken biology. In total, there were 49 students in the treatment groups and 24 students in the control groups for a total of 73 students. All participants signed an assent form with the IRB approval stamp (Appendix C) and had their parents or legal guardians sign a permission form with the IRB approval stamp (Appendix D).

Food Science-Based Instruction

Students participated in a series of lessons, activities, and experiments over eight weeks that presented eight core food science principles (Table 1). Each lesson that was presented had an accompanying activity or experiment to further explain the topic and provide a hands-on approach (Table 2). Each lesson had at least one objective that aligned with the 2010 Mississippi Science Framework (Bounds & Sewell, 2008). Lessons were implemented on a Thursday or Friday for eight weeks (Appendix E through L). The eight principles covered included water activity and food spoilage, proteins, lipids, carbohydrates, dairy, preservation, enzymes, and sensory evaluation. These eight specific topics were chosen as they align with some of the topics covered in many food science curriculum across the nation and would provide a good baseline understanding of what food science is. Students vividly expressed their enthusiasm or disdain for certain lessons and activities. The favorites included cooking eggs to learn about salt soluble proteins and protein denaturation, trying different candies to learn about crystalline vs. non-crystalline sugar structure and the candy industry, and the ultimate favorite, sensory evaluation of chocolate chip cookies and chocolate chips by difference from control and a consumer acceptability test. The least favorite by far was the taste test of sugar solutions of various sweeteners. Instead of simply stating that Sweet' N Low® is three hundred times sweeter than sugar, students sampled a sugar and water solution at a one cup of solute to one gallon of solvent ratio. Student could barely taste the sweetness of sugar in water but the Sweet' N Low® was undrinkable. I used this information to explain low sugar foods and why the formulations must be altered to account for their sweetness levels as well as other functional properties. One activity that the students were surprisingly hesitant to participate in was making butter from heavy cream. Even though students were familiar with the ingredients and the butter resembled what you buy in the grocery store, most were weary to try the homemade butter on some crackers. However once one student found it to be perfectly acceptable they all followed suit and asked to take some home to share with their families. It is experiences like these that open up a world of possibilities and inquisition into food science as students learn where there food comes from and how satisfying it can be to play a small part even in something as simple as butter.

Data Collection

A two-part instrument was used in this study for pre and post-assessment of student knowledge (Appendix M). Part one of the instrument was designed to collect students' knowledge of food science with eight sub-scales, one per principle. Each principle (sub-scale) had four to six accompanying questions for a total of forty questions (Table 3). The eight principles selected were based on topics covered in the course "Food Composition and Chemical Reactions FNH 4243" taught at Mississippi State University in the Department of Food Science, Nutrition, and Health Promotion. Part two of the instrument included five “open-response” questions that comprised two sub-scales. Of the five, two were designed to gauge students’ awareness of food science (sub-scale 1) and three were designed to gauge interest in food science (sub-scale 2) (Table 4). All questions for the survey were multiple choice, true false, and fill in the blank. The survey was tested on 60+ college students to test for feasibility and grammatical errors. The college students were asked to review the survey, check for any errors, and make comments or suggestions. Some of the changes made following the review included re-wording of some questions for better understanding and changing some answer options to reduce the chance of picking the correct answer based on deductive reasoning. The final survey instrument was distributed and collected by the participating teachers one week prior and one week post lesson implementation.

Research Design

A two by two mixed factorial design (school subject* food science curriculum) was used. Biology and Chemistry each had three classes that met during the spring semester. Two periods of each served as the treatment groups with one group from each subject serving as the control. Data was analyzed using the Statistical Package for the Social Science (SPSS) version 23.0 for Microsoft Windows. Means and standard deviations were calculated for part one and part two of the survey and for each individual item for pre- and post-evaluations. Comparisons were made through the use of t-tests, cross tabulations, frequencies and analysis of variance (ANOVA). The interaction effects were also evaluated to determine if the treatment effect differed between school subjects. Statistical comparisons were made based on the four objectives of the study.

Objective One

Part one of the instrument focused on evaluating whether there was a difference in the baseline knowledge of food science in high school biology and chemistry students. The following 5 comparisons were made: 1) Pre-score means of biology and chemistry were compared for all groups; 2) Pre-score means of just the treatment groups of biology and chemistry were compared; 3) Pre-score means of just the control groups of biology and chemistry were compared; 4) Pre-score means of all treatment groups were compared to all control groups; and 5) Pre-score means of males and females were compared.

Objective Two

Five comparisons were made to determine and compare the effect of food science-based instruction on high school students' baseline knowledge of food science in chemistry and biology. Part one of the instrument focused on answering this objective. 1) Post-score means of biology and chemistry were compared for all groups; 2) Post-score means of just the treatment groups of biology and chemistry were compared; 3) Post-score means of the biology and chemistry control groups were compared; 4) Post-score means of all treatment groups were compared to all control groups; and 5) Post-score means of males and females were compared.

Objective Three

Cross tabulations were run on each question from the pre- and post-surveys to determine and compare the level of understanding and long term memory of food science-based instruction between biology and chemistry students. Frequencies were also used to determine which questions were answered correctly the most and the least.

Objective Four

Cross tabulations, frequencies and chi-square were used to determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field. Part two of the survey focused on answering this objective. Questions 41 through 45 were compared pre- and post-survey for the control and treatment groups.

Protection of Human Subjects

Mississippi State University Office of Regulatory Compliance Institutional Review Board (IRB) for the Protection of Human Subjects reviewed and granted approval to conduct this research project and the use of collected data on January 22, 2016, research docket #15-397 (Appendix N).

Table 1 Food science-based instructional lessons used in the experiment (n=8).

Lesson	Core Study	Description
Properties of Water	Water activity A_w	Students will learn basic water and food spoilage principles by measuring the water activity of five different foods with varying water activities.
Building Blocks of Food	Proteins	Students will learn how to identify proteins in a food item, the effect salt has on proteins, and how the industry uses salt to make meat tender.
Hydrates of Carbon	Carbohydrates	Students will explore the differences in water based on the type of sweetener added and how it affects flavor and sweetness intensity. An introduction to a wide variety of liquid, granulated, and alternative sugars will be covered. Students will also learn about the chemical structure of sugar and how that structure affects its functionality in foods by comparing fudge made using ingredient and processing variations.
Edible Emulsion	Lipids	Students will be introduced to various terms pertaining to lipids in food. Students will discover the differences in solid and liquid fats and what makes them that way. They will experience how emulsions mix fat and water and will also perform sensory analysis on various fats and their outcome on a baked good.
Major Components of Milk	Dairy	In this lesson, students will be introduced to a large portion of the dairy products made from milk. Students will learn about the components in milk, products that can be made from milk, and how to make butter at home.
To Infinity and Beyond	Preservation	In this lesson students will learn about the various ways different foods are preserved to extend shelf life and provide a year-round food supply.
Jiggly Jell-O	Enzymes	This lesson explains the science behind the fresh pineapple warning on JELL-O boxes; specifically the effect of enzymes on proteins and how methods of preservation affect them.
How We Eat	Sensory	This lesson introduces students to how taste is perceived and how taste tests are conducted, the components of flavor, and how our 5 senses affect the perception of flavor.

Table 2 Food science-based lessons and their accompanying activity

Lesson	Activity
Properties of Water	Students will use the Aqua Lab water meter to measure the amount of free water in various food products. The assignment involves students forming a hypothesis on expected moisture content, testing the product, and then comparing the results.
Building Blocks of Food	Students will complete two experiments in this lesson. The first is a chemical test to determine the presence or absence of proteins in a food. The second is a cooking experiment to determine the ideal salting time for eggs. Students will also be shown a visual demonstration of how pulling a vacuum affects the marinating process.
Hydrates of Carbon	Students will explore the differences in fudge based on the type of sweetener added and how it affects flavor and level of sweetness. Students will be provided various fudge pieces that differ by changing one variable that affects crystal formation.
Edible Emulsion	Students will experience how fat and water can be mixed in an evaluation and perform sensory analysis on various fats through their interaction in a baked shortbread cracker.
Major Components of Milk	Students will make butter using a mason jar with a secure fitting lid, one cup of heavy cream, and two marbles to experience how butter is made.
To Infinity and Beyond	Students will compare fresh foods to their preserved counterparts to examine flavor and texture differences.
Jiggly Jell-O	Students will explore the differences when fresh, frozen, and canned pineapple are used to make Jell-O.
How We Eat	Students will participate in a difference from control test to experience how industry uses people to determine if a difference exists between one or more samples and a control and to estimate the size of any such differences. Students will also participate in an acceptability test to experience how product researchers determine how well it is liked by consumers.

Table 3 Eight food science principles and there accompanying questions on the survey.

Principle	Questions 1	2	3	4	5	6
Water Activity	What is the definition of water activity?	Which water activity level in food would lead to high perishability?	Decreasing the moisture content increases the products shelf life.	Every food item has its own unique moisture content.	Water is usually a ________ portion of the foods we eat.	
Proteins	Cuts of meat under vacuum pressure ________.	Many meat products, such as hotdogs, would not be possible without ________.	________ soluble proteins help tenderize meat when exposed to marinades.	Proteins are affected by pH changes.	Which is not a source of protein?	
Carbohydrates	If you want to make gummy worms, you need to heat the solution to as high a temperature as when you make lollipops.	A sugar/water solution that is heated to make lollipops has more sugar in solution than normally possible. This is called ________.	Which of the following is **not** a functional property of sugars?	Starch is a large number of glucose units joined together by glycosidic bonds.	Crystal formation in sugar solutions decreases due to all of the following except ________.	

Table 3 Continued

Lipids	The number of ________ and ________ influences the melting point of some common fats/oils.	During frying, fat replaces the water in the product near the surface.	The melting point of all fats/oils are the same.	Which of the following is considered a saturated fat?	Oil and water can be mixed when ________ is added.	Fatty Acids are also known as _______.
Preservation	Canning preserves foods by:	All of the following are examples of foods made from fermentation except:	The products produced after yeast fermentation are ________ & ________.	Which method is not a method of preservation?	What is the definition of an acidic food?	
Enzymes	Adding fresh pineapple to a Jell-O recipe will keep the Jell-O from setting up.	Certain enzymes can denature proteins.	Enzymes are deactivated by freezing.	Papain is the main enzyme in ________.		
Sensory	What human factor(s) comprise perception of taste?	Horseradish, peppermint, chili pepper, and wasabi are examples of foods that provide a ________.	If we cannot smell our food, we cannot properly taste our food.	All people have the same sense of taste.	Which taste is not detectable by everyone?	

Table 4 Questions comprising sub-scales in part two of the survey

Sub-scale	Question	Answer options
1. Awareness	1. Are you familiar with the term "food science"? 2. Food science is the same as nutrition.	A. Yes B. No C. Maybe D. Not sure
2. Interest	1. I am interested in food science. 2. Do you want to learn more about food science? 3. I would consider a college degree in food science.	A. Yes B. No C. Maybe A. Not sure

CHAPTER IV

RESULTS AND DISCUSSION

Purpose of Study

The purpose of this research was to determine if high school students in a biology class without a chemistry background differed in their competency of eight basic food science principles in comparison to chemistry students that were taught the same principles.

Research Objectives

1. Determine and compare the baseline knowledge of food science in high school students between biology and chemistry
2. Determine and compare the effect of food science-based instruction on high school student's baseline knowledge of food science in chemistry and biology
3. Determine and compare the level of understanding and long term memory of food science-based instruction between biology and chemistry students
4. Determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field

Data Analysis

Research Objective One

Determine and compare the baseline knowledge of food science in high school students between biology and chemistry.

Findings

Results indicated that there was no difference ($P>0.05$) in baseline knowledge of food science among the students ($n=73$) that participated in this study (Table 5). However, it should be noted that two comparisons came very close to being significantly different. Biology (21.6 ± 4.2) students almost had a slightly higher average ($P=0.08$) on the pre-survey compared to the chemistry class (19.7 ± 4.9) (Figure 1) (Table 5). Students in the treatment group of biology (21.9 ± 4.3) also almost had a slightly higher average ($P=0.06$) on the pre-survey compared to the students in the treatment group of chemistry (19.3 ± 5.0) (Figure 2) (Table 5). No difference ($P>0.05$) was found between the control groups of biology and chemistry on the pre-survey (Table 5). In addition, there was no interaction between science class and treatment for the pre- or post-survey. Therefore, t-tests were used to evaluate treatment effects and class effects.

Test scores from the pre-survey ranged from a minimum of 9 to a maximum of 30 correct answers, out of 40 questions (Figure 3). Overall, the average number of correct answers was (20.6 ± 4.5) with a cluster of students ($n=38$) scoring 20 to 24 on the pre-test. Ten students answered 25 to 30 questions correctly and twenty five students only answered 9 to 19 questions correctly. This finding provided baseline data describing students' existing food science knowledge. Such data can be useful in identifying starting points for educators (Moreno et al., 2004). Overall means for pre-survey results between the treatment groups and control groups indicated no difference ($P>0.05$) (Table 6).

Pre-survey means between male and female students for all groups, male and female students for treatment groups, and male and female students for control groups, were not different (P>0.05) (Table 7). Overall, no significant differences were found among any of the groups on any pre-survey measures. This indicates that all students had a similar baseline competency of food science at that time.

Research Objective Two

Determine and compare the effect of food science-based instruction on high school student's baseline knowledge of food science in chemistry and biology.

Findings

Teachers administered the post-test one week after the final lesson. The questions and order were identical to the pre-test that was taken in January. No review or study materials were provided to any of the students. Post-survey the treatment group (25.2 ± 6.2) scored higher (P=0.001) than the control group (18.8 ± 5.8) (Table 6). This finding suggests that students exposed to food science principles increased their overall knowledge of food science. Other researchers such as Hovland and Wagner have reported similar results (Wagner, 2015) (Hovland et al., 2013). Students involved in the FoodMASTER curriculum significantly increased (P<0.001) their test scores pre- to post-test suggesting an increase in their multidisciplinary science knowledge related to food (Hovland et al., 2013).

In the biology class, the treatment group scored higher (P=0.002) on the post-test. When compared to the pre-test no difference existed (P>0.05) for the biology control group with respect to pre- and post-test (Table 8). Chemistry treatment groups also experienced an increase (P=0.002) on the post-test (24.9 ± 8.5) in comparison to the pre-test (19.3 ± 5). No difference existed (P>0.05) between the control group pre-test (20.3 ±

4.9) and post-test (17.6 ± 6) for chemistry (Table 9). Overall among the treatment groups, there was an increase of an additional 4.6 questions answered correctly. Although there was no review session, this is a relatively low increase compared to other similar studies. If student participation and worksheet completion had affected their grade in the class, there may have been more of an average score increase.

To address the overall research question "Can high school students in a biology class without a chemistry background comprehend eight basic food science principles as well as students in a chemistry class taught the same principles" comparisons were made between the biology class and the chemistry class. No differences ($P>0.05$) were found between biology and chemistry classes on the post-survey for all students, for treatment groups, or the control groups (Table 10). These results suggest that students enrolled in high school biology with no chemistry background have the ability to comprehend these eight basic food science principles as well as high school chemistry students. Post-survey means between male and female students were not different ($P>0.05$) for all groups (Table 11).

Research Objective Three

Determine and compare the level of understanding and long term memory of food science-based instruction between biology and chemistry.

Findings

Four questions were answered correctly by more than 75% of all students. Question 8 was answered correctly by 82% of all students. Question 24 was answered correctly by 89% of students. 88% of students answered question 32 and question 36 correctly on the pre-survey (Figure 5). All four questions had a 50/50 chance of being answered correctly due to the nature of being true or false questions. There was a total of twelve true or false type questions on the survey.

Four questions were answered incorrectly by more than 75% of all students. Question 10 was answered incorrectly by 75% of the students on the pre-survey. 77% of students incorrectly answered question 11 and question 28. Question 26 was answered incorrectly by 80% of the students (Figure 6). All four question were fill-in-the-blank with four choices available. All four questions would not be considered common knowledge among high school students.

To determine level of understanding and any effects of lessons implemented on the aforementioned questions, post-survey responses of only the treatment groups were compared to the pre-survey responses. The number of questions answered correctly increased from four to ten questions, more than doubling the amount of questions answered correctly by 75% or more of the students (Figure 5). These ten questions included all principles covered in the lessons with the exception of lesson 5, Major Components of Milk.

Post-survey results indicated that students incorrectly answered question 7 82% of the time, question 11 78% (which was a 1% increase from the pre-survey) of the time, question 13 80% of the time, and question 28 80% (which was a 3% increase from the pre-survey) of the time. Questions 10 and 26 were answered correctly by at least 25% of the students on the post-survey. Question 7 and 13 covered principles from preservation and carbohydrates. This change may be due to the fact that the information posed in the questions was not reflected in the activity that accompanied those principles. To better explain the definition of an acidic food, pH measurements could have been taken by the students for multiple common foods. Question 13 pertained to sugar crystal formation. Due to time constraints students were not actively involved in the process of making the fudge to explain this principle. If the students had experienced this hands-on they may have better understood the principle.

Test scores from the post-survey ranged from a minimum of 10 to a maximum of 40 correct answers, out of 40 questions (Figure 6). It was apparent from figure 3 and figure 6 that some students did not improve their score but there was a large subset (n=35) that increased from 20-24 to 23-30. There was also a small group (n=7) that scored greater than the highest pre-test score and one student that answered every question correctly.

Research Objective Four

To determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field.

Findings

Questions 41 through 45 were compared pre- and post-survey for the treatment groups. Students in the treatment groups that answered "yes" to question 41, "Are you familiar with the term "food science" increased significantly (P=0.04) from 43% on the pre-survey to 76% on the post-survey. While the answers "no" at 20% and "maybe" at 31%, both decreased to 10% post-survey (Figure 7). A possible explanation as to why 100% of students did not answer yes may be that the definition of the term was discussed at the beginning of the first lesson and not specifically addressed after that. Each lesson was referred to as a food science lesson however students may not have made the connection that each lesson was considered a part of the whole term food science.

The percent of students that answered “no” to question 42, “Food science is the same as Nutrition” increased from 35% to 55% post-survey (Figure 8). There are two possible explanations as to why students did not answer “no” 100% post-survey. The first is that the definition of “nutrition” was never provided to the students. It was assumed students would have a better baseline understanding of the term “nutrition” compared to “food science”. In hind sight, it may have helped to provide the definition at some point during the lessons. The second possible explanation is based on this assumption and its anticipation that the students would determine food science and nutrition are not the same on their own accord after comparing the lessons to their understanding of nutrition.

Answers to question 43, “I am interested in food science” stayed about the same with a slight increase in the answer “no” from 27% to 43% post-survey (Figure 9). Such an increase may be due to several factors. One of the possible explanation could be that after exposure to food science, students realized that they were not interested in the subject but were unsure in the beginning. Another may be that some students did not enjoy the methods in which the lessons were taught which could have had an impact on their interest. Additionally, students may have felt the topic was covered in depth and did not wish to investigate the subject any further.

The largest change for question 44, “Do you want to learn more about food science” was a decrease in the number of students who answered “not sure” from 20% to 4% pre- to post-survey (Figure 10). These eight students were evenly split between answering “yes” and “no” post-survey. However, the majority of students, n=22, remained unchanged in their answer of “maybe”.

Question 45, “I would consider a college degree in food science” saw the least amount of change for all answers between pre- and post-survey responses, however the answer “maybe” increased from 12% to 22% (Figure 11). The increase in “maybe” should be considered a positive effect as these students are now aware of food science as an option and may consider it when planning for their future. While there was not a significant change overall in the number of students that would consider a college degree in food science, it should be noted that these students can now make a more informed decision before entering the workforce or college.

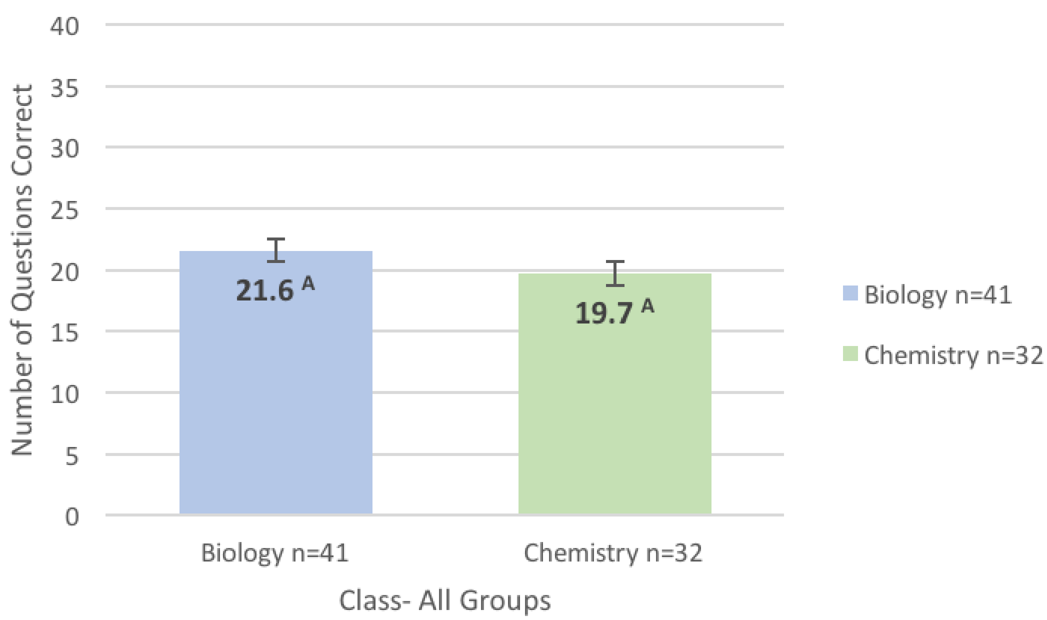

Figure 1 Comparison of means for the pre-survey results between biology and chemistry students (n=73) in the study.

A Means with the same letter are not significantly different (P>0.05)

Table 5 Overall means for pre-survey results of all students (n=73) in biology and chemistry, treatment students in biology (n=29) and chemistry (n=20), and control students in biology (n=12) and chemistry (n=12)

Group	Class	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
All	Biology	41	21.6 [A]	4.2	0.66	0.08
	Chemistry	32	19.7 [A]	4.7	0.86	
Treatment	Biology	29	21.9 [A]	4.3	0.79	0.06
	Chemistry	20	19.3 [A]	5.0	1.11	
Control	Biology	12	20.9 [A]	4.3	1.23	0.73
	Chemistry	12	20.3 [A]	4.9	1.41	

[A] Means with the same letter are not different (P>0.05) within either overall, treatment, or control
SEM Standard Error Mean

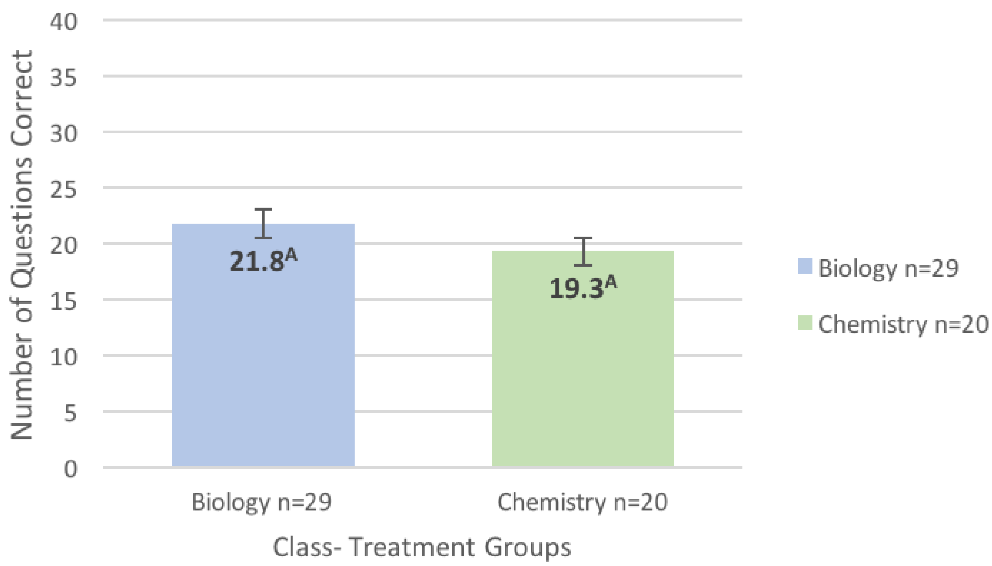

Figure 2 Comparison of means for the pre-survey results between treatment groups in biology (n=29) and chemistry (n=20).

A Means with the same letter are not significantly different (P>0.05)

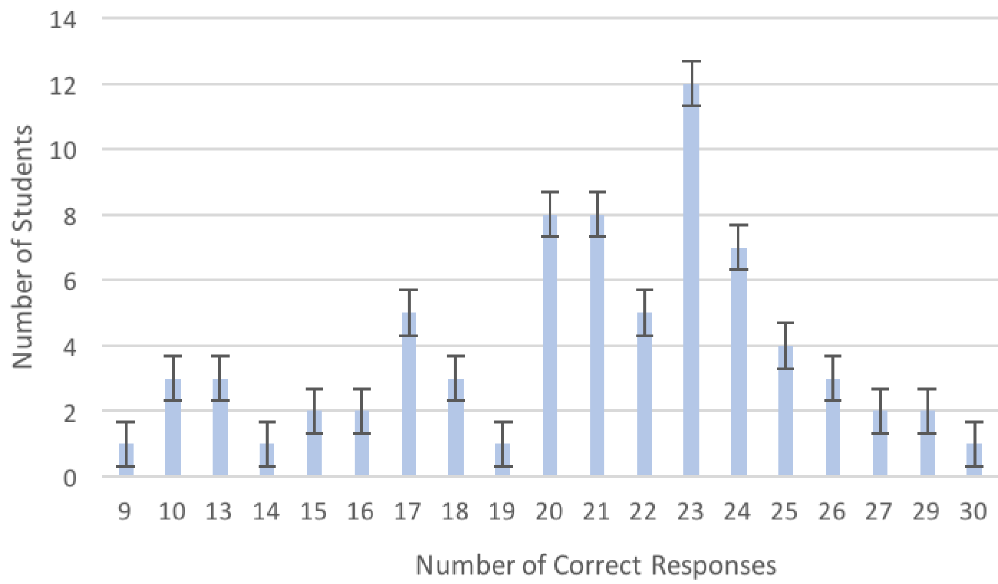

Figure 3 Distribution of pre-survey results for all students (n=73) in the study.

Table 6 Overall means for pre- and post-survey results of students in the treatment groups (n=49) and students in the control groups (n=24)

Type	Group	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Pre	Treatment	49	20.9 ^{A}	4.7	0.67	0.84
	Control	24	20.6 ^{A}	4.5	0.92	
Post	Treatment	49	25.3 ^{A}	6.2	0.88	0.0001
	Control	24	18.8 ^{B}	5.8	1.19	

$^{A\text{-}B}$ Means with the same letter are not significantly different (P>0.05) within either pre- or post-test

SEM Standard Error Mean

Table 7 Overall means for pre-survey results of male student and female students in the study by overall (n=73), by treatment (n=49), and by control (n=24)

Group	Gender	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Overall	Male	45	20.0 [A]	5.4	0.80	0.08
	Female	28	21.6 [A]	2.7	0.51	
Treatment	Male	30	20.1 [A]	5.5	1.01	0.20
	Female	19	21.9 [A]	2.7	0.63	
Control	Male	15	19.9 [A]	5.3	1.36	0.33
	Female	9	21.8 [A]	2.7	0.89	

[A] Means with the same letter are not significantly different (P>0.05) within either overall, treatment and control
SEM Standard Error Mean

Table 8 Overall means for pre- and post-tests of biology students in the treatment groups (n=29) and the control group (n=12)

Biology Group	Type	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Treatment	Pre	29	21.9 [A]	4.3	0.79	0.002
	Post	29	25.5 [B]	3.9	0.74	
Control	Pre	12	20.9 [A]	4.3	1.23	0.58
	Post	12	20.1 [A]	5.7	1.64	

[A-B] Means with the same letter are not significantly different (P>0.05) within either treatment and control group
SEM Standard Error Mean

Table 9 Overall means for pre- and post-tests of chemistry students in the treatment groups (n=20) and the control group (n=12)

Chemistry Group	Type	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Treatment	Pre	20	19.3 [A]	5	1.12	0.002
	Post	20	24.9 [B]	8.5	1.91	
Control	Pre	12	20.3 [A]	4.9	1.41	0.19
	Post	12	17.6 [A]	6	1.73	

[A-B] Means with the same letter are not significantly different (P>0.05) within either treatment and control group
SEM Standard Error Mean

Table 10 Overall means for post-survey results of all students (n=73) in biology and chemistry, treatment students in biology (n=29) and chemistry (n=20), and control students in biology (n=12) and chemistry (n=12)

Group	Class	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Overall	Biology	41	24.0 [A]	5.1	0.80	0.26
	Chemistry	32	22.1 [A]	8.4	1.49	
Treatment	Biology	29	25.5 [A]	4.0	0.74	0.71
	Chemistry	20	24.9 [A]	8.5	1.91	
Control	Biology	12	20.1 [A]	5.7	1.63	0.30
	Chemistry	12	17.6 [A]	6.0	1.73	

[A] Means with the same letter are not significantly different (P>0.05) within either overall, treatment and control
SEM Standard Error Mean

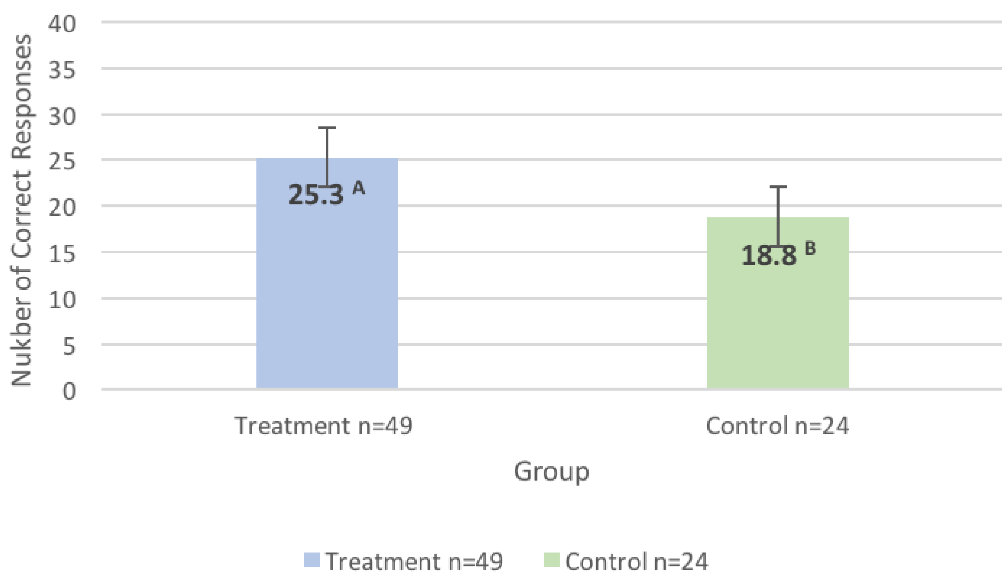

Figure 4 Comparison of means for the post-survey results between treatment and control

A-B Means with the same letter are not significantly different (P>0.05)

Table 11 Overall means for post-survey results of male and female students in the study by all groups (n=73), by treatment (n=49), and by control (n=24)

Group	Gender	N	Mean	Std. Dev	SEM	Sig. (2-tailed)
Overall	Male	45	23.0 [A]	7.6	1.13	0.77
	Female	28	23.4 [A]	5.2	0.98	
Treatment	Male	30	25.4 [A]	7.23	1.32	0.79
	Female	19	24.9 [A]	4.16	0.95	
Control	Male	15	18.0 [A]	5.84	1.51	0.38
	Female	9	20.2 [A]	5.89	1.96	

[A] Means with the same letter are not significantly different (P>0.05) within either overall, treatment or control
SEM Standard Error Mean

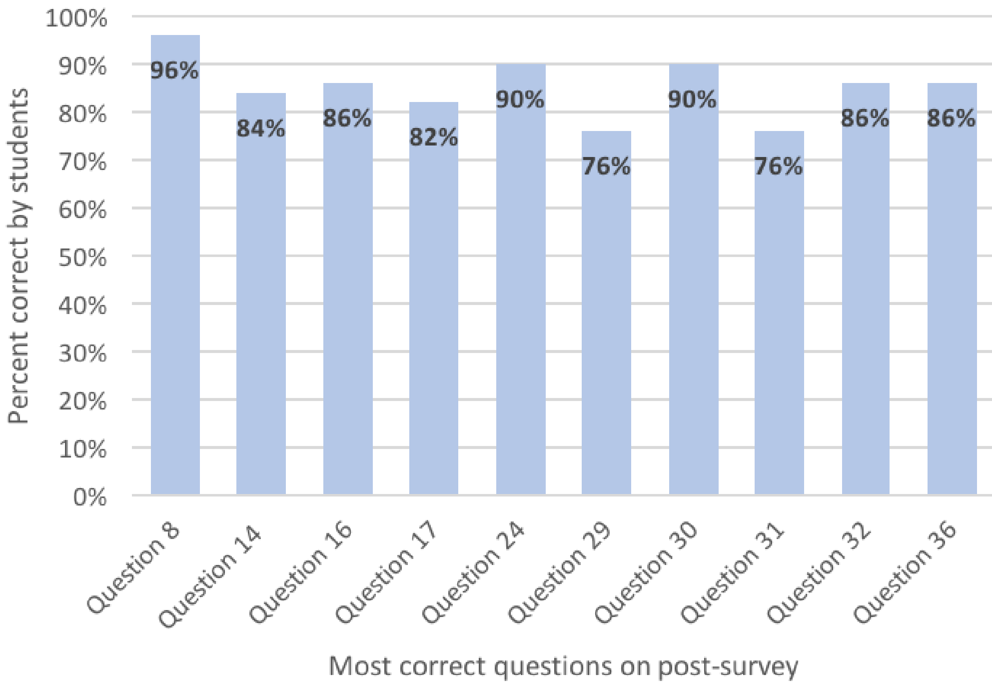

Figure 5 Post-survey questions answered correctly by 75% or more of students in the treatment groups

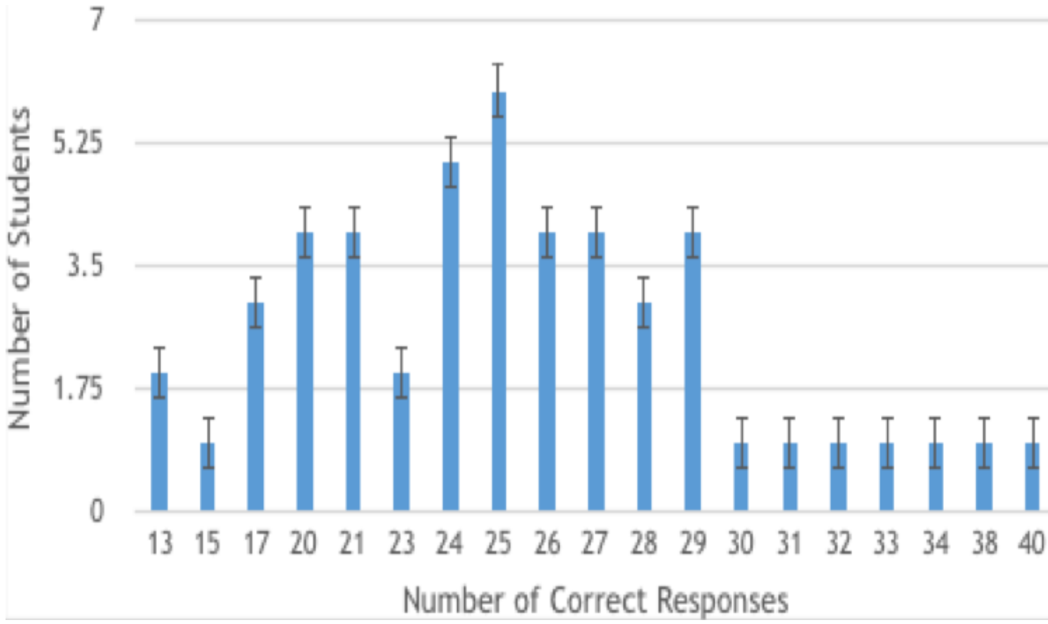

Figure 6 Distribution of post-survey results for treatment students (n=49) in the study.

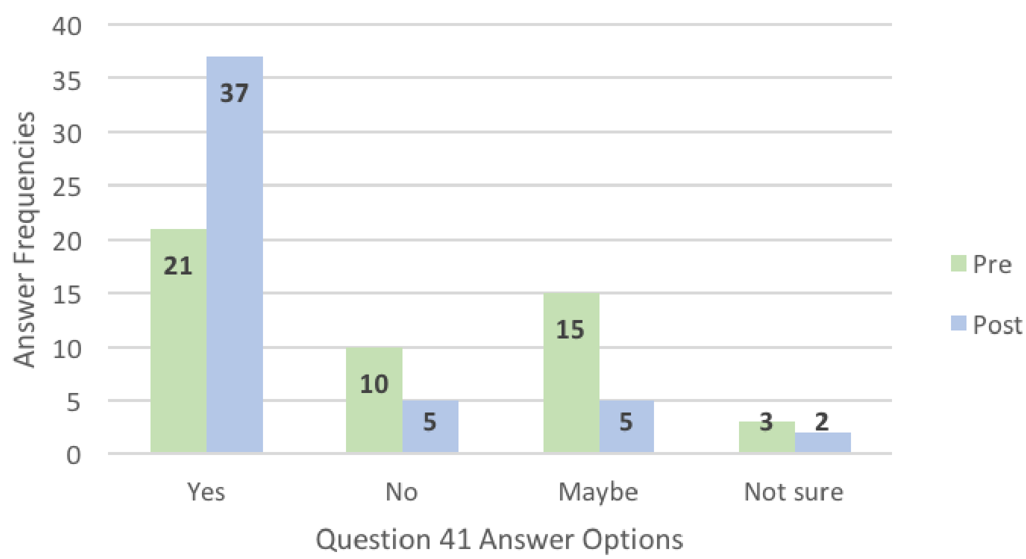

Figure 7 Pre- and post-survey results among treatment students based on Question 41: "Are you familiar with the term "food science"?"

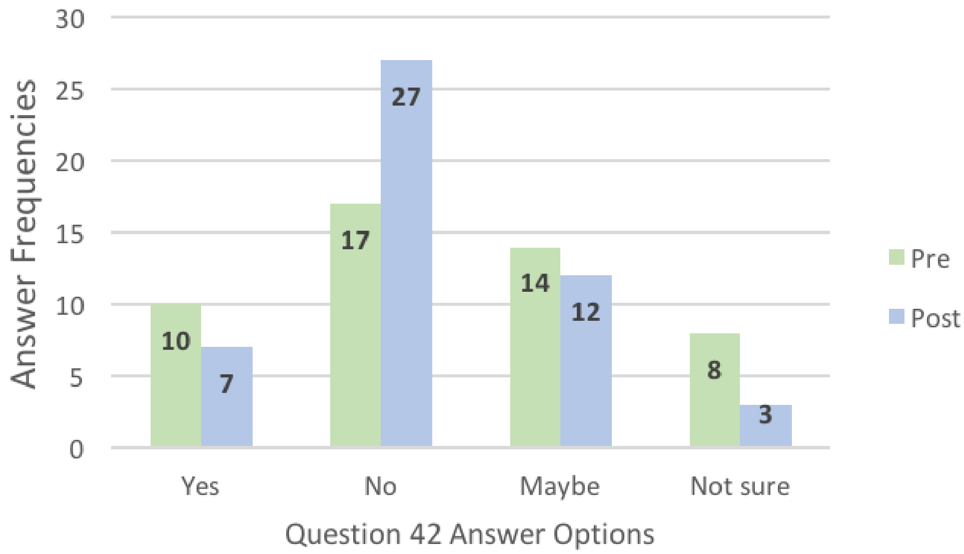

Figure 8 Pre- and post-survey results among treatment students based on Question 42: "Food science is the same as Nutrition".

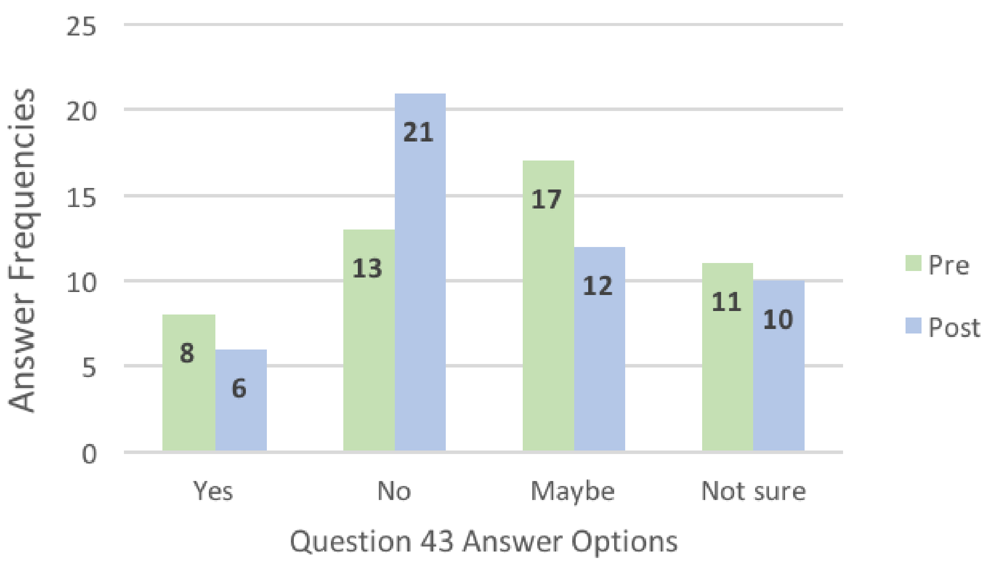

Figure 9 Pre- and post-survey results among treatment students based on Question 43: "I am interested in food science".

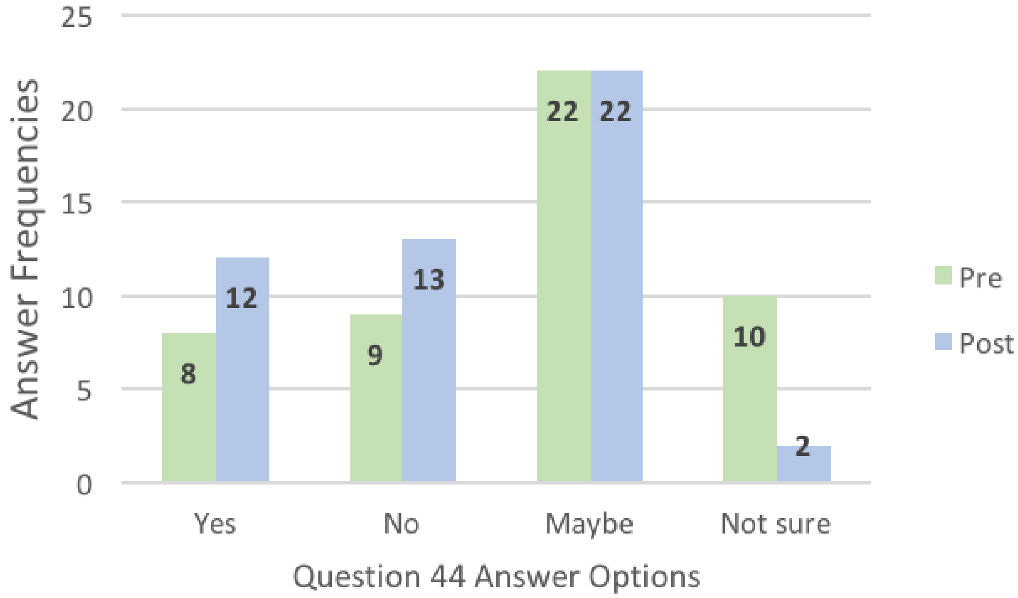

Figure 10 Pre- and post-survey results among treatment students based on Question 44: "Do you want to learn more about food science?"

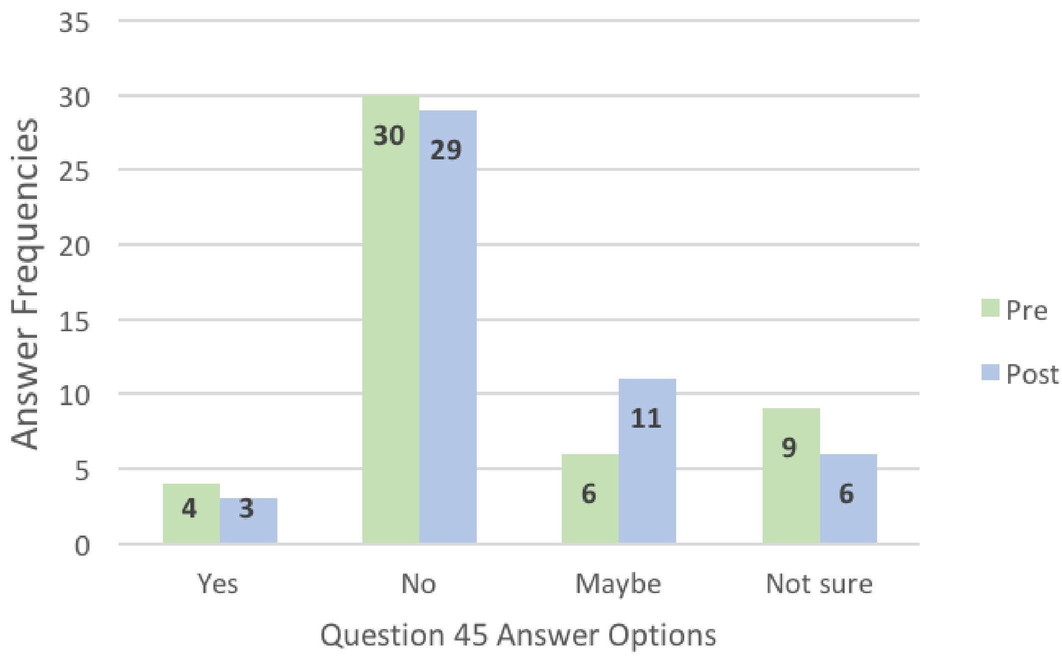

Figure 11 Pre- and post-survey results among treatment students based on Question 45: "I would consider a college degree in food science."

CHAPTER V

CONCLUSION

Purpose of Study

The purpose of this research was to determine if high school students in a biology class without a chemistry background differed in their competency of eight basic food science principles in comparison to chemistry students that were taught the same principles.

Research Objectives

1. To determine and compare the baseline knowledge of food science in high school students between Biology and Chemistry;
2. To determine and compare the effect of food science-based instruction on high school student's baseline knowledge of food science in Chemistry and Biology;
3. To determine and compare the level of understanding and long term memory of food science-based instruction between Biology and Chemistry students;
4. To determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field;

Objective One

Determine and compare the baseline knowledge of food science in high school students between Biology and Chemistry.

Conclusions

Pre-survey results indicated that all students in the study had a similar baseline knowledge of food science before the study began. On average, students answered twenty out of forty questions correctly. No differences were observed when pre-survey results were grouped by gender, grade, class, treatment, or control.

Objective Two

Determine and compare the effect of food science-based instruction on high school students' baseline knowledge of food science in Chemistry and Biology.

Conclusions

Food science-based instruction had a positive effect on students' baseline knowledge. Students in the treatment groups performed better on the post-survey after the eight lessons compared to the students in the control groups. No significant effect was found when pre- and post-surveys were grouped by gender, grade, or class. These findings support the idea of further incorporating a food science curriculum into high school biology. While there was a difference overall for pre- and post-survey results, there may have been a larger difference had all lessons and activities not been voluntary. Students were not graded on any of the assignments nor did participation affect their grade in the class.

Objective Three

Determine and compare the level of understanding and long term memory of food science-based instruction between Biology and Chemistry students.

Conclusions

Four questions were answered correctly by at least 75% of all students on the pre-test. With all four of these questions being true or false answer options, students had a 50% chance of answering correctly. Two of the questions could be considered common knowledge while the other two would not be considered common knowledge among high school students without previous food science exposure. Six additional questions were answered correctly by at least 75% of the students in the treatment groups post-test.

There were also four questions answered incorrectly by at least 75% of all students on the pre-test. The principles covered by these questions were split between proteins and dairy. Two of these questions were still answered incorrectly by at least 75% of students in the treatment groups as well as two additional questions that were not answered at least 75% of the time during the pre-test.

Objective Four

Determine the effect of food science-based instruction on high school students' awareness of food science in both academic and career opportunities in the field.

Conclusions

Student awareness of food science was low. There was a large increase in the percentage of students that demonstrated awareness of food science. However, the percentage of students that were interested in food science decreased by 29% following the lessons. While previous research indicated that incorporating food science lessons into high school science classes presented great potential to increase the number of students enrolling in food science programs, this study did not have the same outcomes

(McEntire & Rollins, 2007). There was a 2% decrease in the number of students that would consider a college degree in food science. Yet, there was a 10% increase in students that answered “maybe”. Since awareness of food science pre-survey was low, these results potentially indicate that students may have answered yes even though they did not know what food science was. By introducing high school students to food science, there is the potential to increase the supply of interested and qualified individuals and foster a well informed decision. Overall, students’ increased awareness of food science and academic opportunities in food science stands to benefit university food science programs and the food industry.

Recommendations for Research

Developing this curriculum was the first step in this process. The next step would be to both rework and refine the curriculum based on the post-survey results and then implement the curriculum into a larger setting that includes both private and public schools. If the data further supported the hypothesis that students in biology with little to no chemistry background understood basic food science principles then the next step would be to implement the curriculum in select schools across the nation. This curriculum could also translate well to vocational and technical schools either attached to secondary or post-secondary schools. The curriculum could also be further developed into its own class to provide college credit much like an A.P. science course. An alternative to implementing these lessons during class could potentially be to make the curriculum into a summer camp hosted by universities for high school students interested in food and science. Additional questions could be added to the survey to provide a better picture of what fields students are currently interested in for post-secondary school or careers.

Recommendations for Practice

To successfully incorporate a curriculum similar to the one used in this study, additional materials would need to be provided to the instructor to provide a greater depth of food science information. A workshop held by a host university with professors and industry representatives would provide teachers an opportunity to learn about food science before implementing the lessons as well as a chance to practice presenting the lessons and accompanying activities. To get a better understanding of how transferable the food science information is from research to teacher, teacher involvement should be included. This could provide essential information to further develop easily transferable curriculum that did not rely on the presence of the researcher during instruction. Furthermore, by having the instructor present the lessons, students may be more likely to take the lessons more seriously and pay closer attention. This in turn may result in students learning more about the principles and providing larger differences pre- and post-evaluation.

Summary

The use of biology as a context to introduce food science to high school students has shown equal potential to improve baseline knowledge when compared to chemistry at a private school in Mississippi. The additional increase in food science awareness following a food science curriculum provides the unique opportunity to increase the supply of interested students to food science programs and related careers. To successfully implement a food science curriculum into high school biology classes in both private and public sectors, further research should be completed to provide additional support and generate new lesson plans and activities.

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APPENDIX A

SIGNED SCHOOL PERMISSION FORM TO CONDUCT RESEARCH

School Permission to Conduct Research

01/13/2016

Dear Institutional Review Board:

The purpose of this letter is to inform you that I give Lauren Elizabeth Ivey permission to conduct research titled *Effectiveness of Implementing a Food Science Curriculum into High School Biology as Compared to High School Chemistry* at Starkville Academy from January 2016 to May 2016. This also serves as assurance that this school complies with the requirements of the Family Education Rights and Privacy Act (FERPA) and will ensure that these requirements are followed in the conduct of this research.

APPENDIX B

INITIAL RESEARCH ANNOUNCEMENT AND RECRUITMENT EMAIL

Dear Starkville Academy Staff,

My name is Liz Ivey and I am a graduate teaching assistant under Dr. Wes Schilling in Food Science & Technology. I am reaching out on behalf of Dr. Schilling, Dr. Swortzel, and myself in regards to my thesis research. My objective for this project is to implement practical food science lessons into high school science classes to help students better understand basic scientific principles. I would like to base the lessons off of your current curriculum, especially those topics students struggle to grasp. Food science provides a platform for students to relate science topics to everyday products. For example, Acids and Bases can be easily explained and well understood when relating them to food items. I would greatly appreciate the opportunity to discuss this further and would love to meet with you. Feel free to contact me at lei15@msstate.edu or by phone at 678-467-2144. Thank you and I look forward to hearing back from you! Have a great week!

Cheers & Hail State!

Lauren Elizabeth Ivey
Graduate Teaching Assistant
Department of Food Science, Nutrition and Health Promotion
Mississippi State University
945 Stone Blvd. 156 Herzer Bldg.
Mississippi State, MS 39762
678-467-2144

APPENDIX C

ASSENT DOCUMENT

Assent Document

Project Title: Effectiveness of Implementing a Food Science Curriculum into High School Biology as Compared to High School Chemistry

Investigator: Lauren Elizabeth Ivey

I can be reached by email at: livey@foodscience.msstate.edu

For immediate assistance please feel free to call 662-325-7698

Your parent knows that we are going to ask you to participate in this project throughout the spring semester and fill out a pre and post survey. We want to know about students' experiences with food science and develop a curriculum. It will take 30-45 minutes of your time to complete the survey. We also want to help further your education in food science with labs throughout the semester that will involve participation. Your name will not be written anywhere on the research data. No one will know these answers came from you.

If you don't want to participate, you can stop without penalty. You can ask questions if you do not understand any part of the survey.

Do you understand what you are being asked to do? Is this OK with you?

Participant's Name (Please Print):____

____

Signature Date

____

Investigator's Signature Date

MSU HRPP
Approved: 1/22/16 Expires: 9/1/16
IRB # 15-397

APPENDIX D

PARENT AND LEGAL GUARDIAN CONSENT FORM

Mississippi State University
Parental or Legally Authorized Representative Permission Form
for Participation in Research

You are being asked to allow your child to participate in a research project. This form provides you with information about the project. Please read the information below and ask any questions you might have before deciding whether or not to allow your child to participate.

Title of research project: *Effectiveness of Implementing a Food Science Curriculum into High School Biology as Compared to High School Chemistry*

The purpose of this research project:

- Broaden students' view of how science relates to their everyday life through introducing them to food science and careers in food science.
- Improve their level of understanding in basic sciences and math through association with food and food science.
- Gain an understanding of students' current knowledge of food science.

If you agree to allow your child to participate in this research project, we will ask your child to do the following things:

- Provide discussion in class
- Complete a pre and post survey
- Participate in lab activities

The total estimated time to participate in this research project: *1 school semester*

Confidentiality and privacy protections:

- No names or personal data of any kind will be collected at any time during the study.
- ***It is important to understand that these records will be held by a state entity and therefore are subject to disclosure if required by law.***

Contacts and questions:

- If you have any questions, please ask now. If you should have any questions later or want additional information, please contact Lauren Ivey at 662-325-7698 or by email at *livey@msstate.edu*. For information regarding your rights as a research subject, please contact the MSU Research Compliance Office at irb@research.msstate.edu

Please turn over for signature.

MSU HRPP | Approved: 1/22/16 | Expires: 9/1/16 | IRB # 15-397

If you do not want your child to participate:

Please understand that your child's participation is **voluntary.** Your refusal to allow your child to participate will involve **no penalty** or loss of benefits to which you or your child is otherwise entitled. Your child may skip any items that he or she chooses not to answer. Your refusal will not impact current or future relationships with Mississippi State University. To do so, simply tell the researcher that you wish to stop.

If after reading the information above, you agree to allow your child to participate, please sign below. If you decide later that you wish to withdraw your permission, simply tell the researcher. You will be given a copy of this form for your records.

____

Child's name (please print)

____

Parent or *Legally Authorized Representative's Signature Date

____

Investigator's Signature Date

If you are a Legally Authorized Representative (rather than a parent), please provide documentation to show LAR status.

MSU HRPP

Approved: 1/22/16 Expires: 9/1/16

IRB # 15-397

APPENDIX E

LESSON 1

Title	Properties of Water: Water Activity: a_w
Subject	Food Science
Author	Lauren Elizabeth Ivey
Grade level	9-12
Time duration	1 hour
Overview	Students will learn basic water and food spoilage principles by measuring the water activity of five different foods with varying water activities. Students will use the Aqua Lab water meter to measure the amount of free water in various food products. The assignment involves students forming a hypothesis on expected moisture content, testing the product, and then comparing the results. Students should work in groups to prepare and test the samples.
Primary Learning Objectives	1. Students will be able to define water activity and relate this knowledge to food safety and shelf life. 2. Students will be able to calculate moisture content of various foods and use this data to determine and explain shelf stability, shelf life, and properties of water. 3. Students will be able to communicate data among groups, calculate mean values, and demonstrate the importance of replication and precision in experimental design.
2010 Mississippi Science Framework	Biology 1a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2) 1b. Formulate questions that can be answered through research and experimental design. (DOK 3) 1c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2) 1f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3) Chemistry

1c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development).
(DOK 3)

1e. Evaluate procedures, data, and conclusions, to critique the scientific validity of research. (DOK 3)

Materials

- AquaLab Water Activity Meter; Decagon Devices, Inc.
- AquaLab Disposable Sample Cups & Lids; Decagon Devices, Inc.
- AquaLab Verification Standards a_w 0.790 ± 0.003
- 1 medium size cutting board per group
- 2 small paring knives per group
- 1 Ritz cracker per group
- 1 slice cheddar cheese per group
- 1 fresh strawberry per group
- 2-3 pieces dehydrated fruit (apple, raisins, pineapple)
- 1 slice deli meat per group (turkey, chicken, ham)
- Disposable gloves
- Water activity worksheet

Activities and procedures

Introduction: Begin the lesson with an interest approach.

Poll students, "What is the one ingredient that is in every single thing you eat?"

You may get no answers or some crazy ones!

The answer: Water! Water is in every item you eat and drink daily. It may not seem that way but we will do an experiment today that proves this.

So today our focus is on water and its interaction with the foods you eat.

Poll students, "How much water do you think is in apple juice? Give me some percentages." (Students will provide answers) (Can provide visual aid) Write answers on board in a table.

"Ok, so how much water do you think is in an apple?" (Students will provide answers) (Can provide visual aid) Write answers on board.

Compare the two. Clearly the amount of water varies depending on the item. That leads us to the first key point about water: **Each item**

has its own unique moisture content and water is a very large portion of the majority of fresh foods that you eat.

“So why is this even important?” Poll students on why they believe food spoils. Is this a chemical or physical change?

Poll students on how long it takes foods to spoil.

Right, it depends on the item. But what it really depends on is the amount of water in that particular item and I will tell you why in a little bit. First let’s define Water Activity. **Water activity, abbreviated a_w, is the measured amount of water molecules in the food that leads to microbial growth, and enzymatic and chemical reactions.** We are just going to focus today on water activity and how it affects foods shelf life and spoilage from microbial growth.

We are going to perform a lab today that will determine the water activity in a variety of foods. But before we do let’s learn a little more about why we are doing this.

So we already learned that each food item has its own unique water content. What makes this significant is that water plays a major role in microbial growth which ultimately leads to spoilage or rotten foods. Bacteria, yeasts, and mold require water to live and grow. Hence, if we can control the amount of water in a product, we can control the shelf life and spoilage

Water activity is measured on a scale from 0 to 100 percent. 100 clearly being pure water.

Most produce has a water activity above 0.90 and that will provide sufficient moisture to support the growth of bacteria, yeasts, and mold. To keep this growth from happening the product needs a water activity level below 0.90. That means that decreasing the water activity will increase the shelf life. For example, dehydrated fruit. A raisin has a much longer shelf life than a grape.

To see this first hand we will do an experiment that will measure the water activity of various foods.

Provide handout and go over instructions. Show students the equipment being used and go over safety guidelines for using a knife before beginning.

Students should complete Part One of the Discussion Questions found on the student handout.

Following student completion of the questions, conduct a class discussion, having students share their hypotheses as to what they believe will be the water activity of the foods provided. It is hoped students will attribute water activity to shelf life and spoilage rates.

Following the class discussion, ask students to break into groups of three or four depending on class size and time allotted.

Students will need to prepare their samples to fit in the sample cups. It is best to get pieces as small as possible.

Have groups take turns using the aqua lab once their samples are ready.

To use the aqua lab first make sure it is calibrated by using the provided solution. Follow the instructions provided. Once set, students can begin reading their samples one at a time. Make sure students are recording all data.

While students are conducting the experiment draw the table shown at the bottom of this lesson plan on the board. The students should fill this in as they go so all groups can compare results.

Following completion of the experiment, have students answer Part Two of the Discussion Questions.

For conclusion, discuss with the class their findings. Does this match with anyone's hypothesis? Are there any inconsistencies? Poll the students for an explanation as to why that happened. Hopefully student will answer with the fact that each item has its own unique water activity as mentioned before. Even if it is the same item such as strawberries. Just like every snowflake is unique.

Assessment

Students should be assessed on completion of the handout.

Aqua Lab a_w	Cheese	Deli Meat	Strawberry	Dehydrated Fruit	Crackers
Group 1					
Group 2					
Group 3					
Group 4					
Group 5					

WATER ACTIVITY WORKSHEET

Class:
Period:

Lesson 1: Aqua Lab

Introduction: Water is the major component of most foods, and each has its own characteristic water content. Water content, also known as water activity, greatly affects a food items shelf life and preservation. Spoilage organisms require water to survive and thrive, reduced amounts of water can greatly affect the survival of spoilage organisms.

Procedure:
1. Obtain food samples from teacher. You should have 1 strawberry, 2-3 pieces dehydrated fruit, 1 cracker, 1 piece of deli meat, and 1 slice of cheese.
2. To prepare the samples your group will need 2 small paring knives, 1 cutting board, and gloves.
3. Finely dice the strawberry, dehydrated fruit, deli meat, and cheese. Crush the cracker into fine pieces.
4. Once samples are prepared they can be placed into the provided containers.
5. Measure the water content using the Aqua Lab machine provided.
6. Record you results in the table provided and obtain results from other groups from the board. Write your groups results on the board
7. Find the average moisture content for each item by totaling the percentages and dividing by number of groups/measurements.

Example: Strawberries. (0.94, 0.95, 0.92, 0.94)

$$\frac{0.94+0.95+0.92+0.94}{4} = 0.9375$$

8. Complete the handout and accompanying questions.

Part One:

1. Write a hypothesis as to what you think the water activity will be for the various foods used in the experiment and explain why.

2. Write a definition in your own words of what water activity is.

____

____

____

Table:

Aqua Lab Group:	Measurement 0.00-1.00	Group	Group	Group	Group	Average from class
Strawberry						
Dehydrated Fruit						
Cheese						
Deli Meat						
Cracker						

Part Two:

1. Why were the measurements different among groups for the same food item?

____

____

____

____

2. Did you results match your hypothesized guesses for moisture content for any of the food items?

____

____

____

3. Relate moisture content/water activity (a_w) to spoilage rates/shelf life. Is there a trend? If yes, what is it?

____

____

____

____

APPENDIX F

LESSON 2

Title	Proteins: Building Blocks of Food
Subject	Food Science
Author	Lauren Elizabeth Ivey
Grade level	9-12
Time duration	1 hour
Overview	Students will learn how to identify proteins in a food item, the effect salt has on proteins, and how industry uses those effects to make meat tender. Student will complete two experiments in this lesson. The first is a chemical test to determine the presence or absence of proteins in a food. The second is a cooking experiment to determine the ideal salting time for eggs. Students will also be shown a visual demonstration of how a vacuum affects the marinating process.
Objective	1. Students will be able to identify the presence of proteins in a food system by comparing the color results from the chemical reaction. 2. Students will be to relate the effect salt has on proteins by comparing the results of varying salting times on eggs. This will also demonstrate the importance of salt in meat processing. 3. Students will be able to relate the effect of air pressure on food products when under vacuum and how this applies to meat processing.
2010 Mississippi Science Framework	Biology 1a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2) 1a. Demonstrate accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers. (DOK 2) 1b. Formulate questions that can be answered through research and experimental design. (DOK 3) 1c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2) 1f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)

Chemistry

1c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)

1e. Evaluate procedures, data, and conclusions, to critique the scientific validity of research. (DOK 3)

Materials

Experiment 1: Proteins in Food (Biuret Test)

- Egg whites (1 per group)
- Grapes (1 per group)
- Bread (1/4 slice per group)
- Butter (1 small cube per group)
- Test Tubes (4 per group)
- Test Tube Rack (1 per group)
- Scalpel (1 per group)
- Spatula
- 10% Sodium Hydroxide Solution (2.5 mL per test tube) for 160 mL use 16 mL NaOH and 144 mL H_2O
- 1% Copper Sulfate Solution (3 drops per test tube) for 10 mL use 0.1 mL copper sulfate and 9.9 mL H_2O
- Pipette
- Dropper

Experiment 2: Salting Eggs

- Sautee pan (1 per group)
- Electric burner (1 per group will do but they can share)
- Rubber Spatula (1 per group)
- Bowl (1 per group)
- Eggs, Large (2 per group)
- Salt (1.3 grams per group) can be pre measured out into weight boats
- Milk (3/4 tablespoon per group) can be pre measured out into ounce portion cups
- Pan spray

Experiment 3: Exploding Marshmallows

- Vacuum pump
- Glass jar suitable to be attached to the vacuum pump
- Marshmallows (any size will do)

Activities and procedures

Demo: Exploding Marshmallows (Video option too)

1. Place a marshmallows inside the glass jar. Fill it about half way.
2. Cap the jar.
3. Turn on the vacuum. What happens?
4. Turn off the vacuum. What happens now?
5. Discuss your results.

Results: Marshmallows are a mixture of sugar, air, and gelatin. The sugar makes them sweet, the air makes the fluffy, and the gelatin is a protein that holds everything together. By volume, marshmallows are mostly air. When subjected to a vacuum, the air from around the marshmallow is removed. This decrease in pressure causes the air trapped in the marshmallow matrix to push outward, expanding it. Eventually the vacuum is strong enough to pull even that air out causing it to shrink. When the air is returned to normal atmospheric pressure, you end up with a mallow "raisin" because the air from inside has been removed.

These same principles apply when making marinated meat in the food industry. For example, why is the grilled chicken from Chick-Fil-A always perfect? They marinate the meat under a vacuum that causes the protein fibers to stretch out and the marinade to mix deeper into the meat. Once the vacuum pressure is removed the marinade is trapped inside the meat making it juicy and tasty.

Experiment 1 Proteins in Food:

1. Have students make a hypothesis as to the presence or absence of proteins in the food samples. They should make educated guesses and then report the results after the experiment.
2. Students should break into four groups and go their set up stations. Directions for the experiment are on their worksheets.
3. The results should find that grapes are the only food that do not have protein.

Proteins are considered the building blocks of life and are in almost everything edible. They form many functions in food such as structure, browning, and gelling.

Experiment 2 Salting Eggs:

1. Have a student read over the scenario. Students should complete the experiments in their groups. Assign times to the groups. For example group 1-0 minutes; group 2- 5 minutes; group 3- 10 minutes; and group 4- 15 minutes. Minutes refers to the amount of time the salt mixes with the raw egg in the mixing bowl.
2. Have students compare results from the other groups.

Turns out that salt can have quite a drastic effect on how eggs cook. When eggs cook and coagulate, the proteins in the yolks pull tighter and tighter as they get hotter. When they get too tight, they begin to squeeze liquid out, resulting in eggs that weep. Adding salt to the eggs well before cooking can prevent the proteins from bonding too tightly by reducing their attraction to one another and dissolving salt soluble proteins. The proteins then acted like glue and held the water in place as well as not tightening as much. Adding salt immediately before cooking helps, but to get the full effect, the salt must have time to dissolve and become evenly distributed.

This experiment shows that salt also creates the protein structure necessary to make processed meats like hot dogs and deli meats. Salt helps bind meat by extracting its proteins, which "glue" together adjacent pieces of meat. Salt also increases water-binding properties, which reduce cook losses and contribute to enhanced texture. It also helps give a smooth, firm texture to processed meats.

Did You Know?

Without salt, it would be impossible to make hot dogs, deli meats, and other processed meats. Can you explain why?

Assessment

Students should be assessed on completion of the handout.

Citations

Exploding Marshmallows: Experiments in Food Science Laboratory Manual, Mississippi State University, Extension Service, msucares.com

Salting Eggs: The Food Lab *Better home cooking through science,* J. Kenji Lopez-Alt

Proteins in Food (Biuret Test); British Nutrition Foundation

PROTEIN ACTIVITY WORKSHEET

Demo: Exploding Marshmallows:

1. What happened to the marshmallow when the air was pumped out?

___

___

2. What happened when the air came back?

___

___

3. What does this experiment mimic in the food industry?

___

___

___

Experiment 1: Proteins in Food

In this test blue copper sulfate solution is used as an indicator. It will turn violet or purple if added to a soluble protein. This is the Biuret Test which can be used for soluble protein but not for insoluble material.

Hypothesis: (Which foods do you think will have protein?)

___

___

___

___

You will need:

1. Test tubes (4 per group)
2. Test tube rack
3. Spatula
4. Dropping pipette
5. Eye protection
6. Food samples:
   - Egg whites (1/2 Tablespoon)
   - Grapes (1 per group)
   - Bread (small piece)
   - Butter (small cube)
7. Distilled water
8. 1% Copper sulfate solution
9. 10% Sodium hydroxide solution

Method:

1. Prepare the food sample by cutting the grape in half and tearing the bread into tiny pieces.
2. Place each food sample into assigned test tube.
3. Add a small amount of water to the grape and the bread.
4. Add 2.5 mL Sodium hydroxide solution to each test tube.
5. Add 3 drops copper sulfate solution to each tube.
6. Observe and record results.
7. Does this match your hypothesis? ___________

Did a color change occur?

Food Sample	Yes	No
Egg White		
Bread		
Grape		
Butter		

Experiment 2: Salting Eggs

Here's the scenario: You've just beaten a few eggs with a pinch of salt, getting ready to cook them, when suddenly the dog gets stuck in the toilet. Thirty minutes later, you get back to those eggs you left on the counter and realize they've completely changed color. Once bright yellow and opaque, they are now dark orange and translucent. What's going on? And more important, will it affect the way they cook?

Hypothesis (What do you think will happen the eggs once cooked?)

____
____
____
____

You will need:

1. 2 eggs
2. 1.3 grams salt
3. ¾ tablespoon milk
4. Pan spray
5. Hot plate
6. Rubber spatula
7. Non-stick skillet
8. Plate
9. Mixing bowl
10. Fork

Method:

1. Combine the eggs, salt, and milk in a bowl and whisk with a fork until slightly frothy, about 1 minute.
2. Group 1: Cook your eggs immediately. Group 2: Wait five minutes then cook your eggs. Group 3: Wait 10 minutes then cook your eggs. Group 4: Wait 15 minutes then cook your eggs.
3. Observe the color change after the time for your group is up and write down the results in the table.
4. To cook the eggs, spray the pan lightly with pan spray.
5. Heat over medium high heat for one minute then add your eggs.
6. Cook, slowly scrapping the bottom and sides of the pan with the spatula as the eggs solidify.
7. Continue to cook, scraping and folding constantly, until the eggs have formed solid with no liquid egg remaining, about 2 minutes.
8. Transfer to a plate and observe the amount of water that weeps out after a few minutes.

Salting Eggs	Describe the color of the raw eggs with salt. Scale 1-10 1-bright yellow 10-dark orange	How much water seemed to weep out? Scale 1-10 1-none 10-a lot	How firm are the cooked eggs? Scale 1-10 1-very soft 10- very firm
Group 1: 0 minutes			
Group 2: 5 minutes			
Group 3: 10 minutes			
Group 4: 15 minutes			

Questions:

1. Which amount of time seems to be ideal to retain the most water?

    ____

2. Did the results match your hypothesis? ______________
3. If you did this experiment again, what would you change?

    ____
    ____
    ____

4. Why did the eggs that salt with the salt the longest have the least amount of water on the plate? What did you learn about salts effect on meat that explains this?

    ____
    ____
    ____
    ____

APPENDIX G

LESSON 3

Title	Hydrates of Carbon: Sugar
Subject	Food Science
Author	Lauren Elizabeth Ivey
Grade level	9th-12th
Time duration	1 hour

Overview

In this lesson, students will explore the differences in water based on the type of sweetener added and how it affects flavor and level of sweetness. An introduction to a wide variety of liquid, granulated, and alternative sugars will be covered.

Students will also learn about the chemical structure of sugar and how that affects its functionality in foods by comparing fudge made in various ways with varying end results.

Objective

1. Students will able to identify sweetness levels associated with various sweeteners and relate that knowledge to how and why it is used in various products.
2. Students will be able to describe sugars chemical structure and why it is important.
3. Students will be able to define supersaturation and explain what that means in terms of candy production.
4. Students will be able to describe sugar crystal formation and explain the pros and cons of crystal formation in candy making as well as what affects its rate of formation.

2010 Mississippi Science Framework

Biology

1f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)

Chemistry

1e. Evaluate procedures, data, and conclusions, to critique the scientific validity of research. (DOK 3)

Materials

Experiment 1

Materials and Equipment:

For Teacher Preparation:

(For 50 student)

1. ½ Cup sucrose (table sugar)
2. ½ Cup sucralose (Splenda®)
3. ½ Cup saccharin (Sweet'N Low®)
4. ½ Cup stevia (Truvia)
5. 250, 5-oz. Plastic cups
6. 5 Gallons of drinking water

Per Student:
1. *How Sweet It Is!* student handout
2. 5-oz. Cup of Solution A
3. 5-oz. Cup of Solution B
4. 5-oz. Cup of Solution C
5. 5-oz. Cup of Solution D
6. 5-oz. Cup of Water

Experiment 2
Materials and Equipment
For Teacher Preparation:
Yield: Makes 1 8x8 pan.

Ingredients

- 2 and 1/2 cups white granulated sugar
- 3/4 cup butter
- 2/3 cup evaporated milk
- 12 ounce package (2 cups) semi-sweet chocolate chips
- 7 ounce jar marshmallow cream (also called marshmallow fluff)
- 1 teaspoon vanilla

Instructions

1. Line an 8 or 9 inch square pan with aluminum foil or parchment paper. Coat with nonstick spray. Set aside.
2. In a 3 quart HEAVY saucepan over high heat, combine sugar, butter, and evaporated milk. Use a wooden spoon to stir slowly until butter melts, scraping sides of pan to get all the sugar crystals.
3. Bring to a full rolling boil, stirring constantly with a long wooden spoon. Once it starts boiling, set a timer for 5 minutes and turn the heat down to medium so that you don't burn your fingers off--it should be boiling the full 5 minutes. Stir constantly.
4. When the timer goes off, remove from heat and add chocolate chips. Stir until all chips are melted and mixture is smooth.

Add marshmallow creme and beat with a wooden spoon until well blended. Add vanilla and mix well. Immediately pour into the prepared pan.

5. Let cool to room temperature.
6. Slice and serve. Store on the counter covered.
7. To make alternates, change various factors such as stirring when cooling, excluding the butter or the evaporated milk.

Notes

This recipe is easy to double, just use a 9x13 pan.

Microwave your marshmallow creme for 10 seconds to make it easier to scrape out.

Activities and procedures

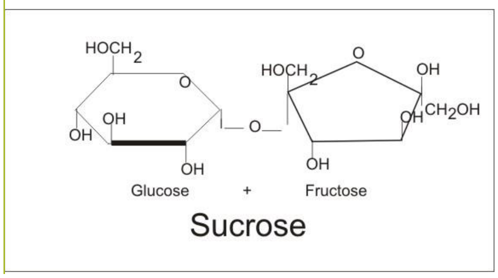
Activity 1

How Sweet it is! Introduction:

During the development of a new food product, each ingredient (*i.e.* chemical) is selected because of its specific function within the food. Sugar sweetens. Vanilla flavors. Flour thickens. The specific function of an ingredient is a result of its chemical structure, and therefore, any changes in the chemical structure alter the function of the ingredient. Sugar has many functional properties. (List on board)

- Flavor and sweetens
- Texture
- Structure from crystallization
- Prevents spoilage
- Absorbs water
- Adds color (caramel)

As with any ingredient function, it is the chemical structure of sweeteners that allows them to function as such. (Draw structure on board)



Sucrose (Figure 1), or common table sugar, is a carbohydrate and is a major source of calories and energy in the human diet. Among the more than 50 sweeteners known to food scientists, the natural sugars, such as sucrose and fructose, are the best known and most commonly used. Sucrose is actually a disaccharide that is composed of the two monosaccharides glucose and fructose. Table sugar is refined from sugarcane and sugar beets and is considered the standard when measuring the sweetness of compounds.

Because of the interest in low-calorie and low-sugar foods that has developed over the last few decades, interest has grown in using low-calorie or no-calorie sweeteners. These sweeteners, such as sucralose, saccharin, stevia, and aspartame, are either not metabolized or are so intensely sweet that very small quantities can be used.

Sucralose is the one newest artificial sweetener to enter the market and is known by the trade name Splenda®. Sucralose is made through a process that converts sucrose to a noncaloric, non-carbohydrate sweetener by replacing three –OH groups on the sucrose molecule with three Cl atoms. The result is a stable compound, **600-times sweeter than sucrose**, which is not metabolized by the body and is stable at high temperatures.

Saccharin, the world's oldest low-calorie sweetener, was discovered accidentally in 1879 when a researcher at Johns Hopkins University spilled the compound on his hand and later noticed his hand to have a sweet taste. **Saccharin is 300-times sweeter than sucrose**. Today, saccharin is sold as a tabletop sweetener under the trade name Sweet'N Low® and is used in such products as baked goods, gum, candy, and salad dressings.

Stevia is unique among food ingredients because it's most valued for what it doesn't do. It doesn't add calories. Unlike other sugar substitutes, stevia is derived from a plant. Stevia has no calories, and it is **200 times sweeter than sugar** in the same concentration. Other studies suggest stevia might have extra health benefits.

Explain to students that they will be sampling sucrose, saccharin, sucralose, and stevia. Each of these is an organic compound that is used as a sweetener in food and beverage products.

Estimated Time:
10 minutes
Activity:

Provide each student with the materials listed above for experiment 1. Ask students to sample the solutions and rank the relative sweetness intensities according to the instructions given on the *How Sweet It Is!* student handout. Before sampling each solution, students should use the water and crackers to cleanse their palates.

Estimated Time:
5 minutes
Conclusion:
On the board, note the consensus of student rankings. Confirm the correct rankings and discuss any differences observed by the students. Have students individually answer the post-laboratory questions found on the *How Sweet It Is!* student handout.

Activity 2:
Sugar crystallization and Candy making. Introduction:
Crystallization of sugar is a major factor in the candy industry. Candies can be divided into groups, crystalline and non-crystalline. Crystalline candies include fudge, fondant, and rock candy. Non-crystalline candies include caramels, brittle, taffies, lollipops, marshmallows, and gum drops.

When it comes to non-crystalline candies such as lollipops and gummies, it is very important to consider factors such as the sugar concentration and temperature. Sugar concentration for most candy making needs to be a super-saturated solution. Supersaturated means the solution, such as sugar and water, is more concentrated than normally possible. This is accomplished when the sugar is heated and melts. So now that we have enough sugar the next important factor is temperature. Sugar cooked to different temperatures reacts in very different ways.

Continuing with our lollipops and gummy worm example, you need to heat the sugar solution much higher to around 300˚F, also known as hard crack stage, compared to gummy worms which would only need to be heated to around 245˚F, also known as firm ball stage.

Crystallization is where sugar particles come together to form a crystalline structure. The rate at which crystal grow depends on a variety of factors. A more concentrated solution (more sugar) will grow rapidly. Higher temperatures slows growth whereas cooler temperature speeds up growth. Agitation (such as stirring) also speeds up growth. Impurities such as fat and protein greatly slow growth and may even keep crystals from forming. This is why caramel does not crystalize and why you add butter to cooked sugar to make caramel candies.

Crystal Formation	
Slows it down	**Speeds it up**
• Less sugar	• More sugar
• High temperatures	• Low temperatures
• Not stirring	• Stirring
• Impurities (Fat & Protein)	• No impurities

Through the fudge experiment you will see and be able to taste how these factors affect the same recipe with varying results.

Explain to students that they will be sampling fudge that represents each of the different factors that effects crystallization. Every sample is made exactly the same way except for one variable being changed so they can see and be able to explain what that variable does to crystal formation.

Have students sample the fudge one variable at a time. Converse with students about each sample and which variable was changed and how that affected the end result. Which one is the creamiest? Which one seems to have the most crystal formation? Why?

Assessment Assessment should be based on completion of the *How Sweet It Is!* student handout.

References Introduction to Food Science. Rich Parker

CARBOHYDRATE ACTIVITY WORKSHEET

HOW SWEET IT IS! *Student Handout*

Introduction:

Sucrose (Figure 1) (drawn on board), or common table sugar, is a carbohydrate and is a major source of calories and energy in the human diet. Because of the interest in low-calorie and low-sugar foods that has developed over the last few decades, interest has grown in using low-calorie or no-calorie sweeteners. Stevia (Figure 2) (drawn on board), is unique among food ingredients because it's most valued for what it doesn't do. It doesn't add calories. Unlike other sugar substitutes, stevia is derived from a plant. Sucralose (Figure 3) (drawn on board), is another sweetener on the market and is known by the trade name Splenda®. Sucralose is made through a process that converts sucrose to a non-caloric, non-carbohydrate sweetener by replacing three –OH groups on the sucrose molecule with three Cl atoms. Saccharin (Figure 4) (drawn on board), the world's oldest low-calorie sweetener, is known by the trade name Sweet'N Low®. Saccharin is a synthetic compound derived from toluene. Table sugar is refined from sugarcane and sugar beets and is considered the standard when measuring the sweetness of compounds. Compared to sucrose, artificial sweeteners exhibit much more intense sweetness. Saccharin is 300-times sweeter than sucrose, while sucralose is 600-times sweeter than sucrose and stevia is 200-times sweeter than sucrose.

Purpose:

To identify common food sweeteners, sucrose, stevia, saccharin, and sucralose, by comparing sweetness intensity rankings of solutions of each compound.

Materials:

1. 4 Sweetener solutions (A, B, C and D)
2. Cup of water
3. Saltine® crackers
4. Napkin

Intensity Ranking:

Sample each solution, from A to D. Rank (1 being least intense and 4 being most intense) the sweetness of each solution.

Sample

Sweetness Intensity Ranking Comments

A ___________ ___________________________

B ___________ ___________________________

C ___________ ___________________________

D ___________ ___________________________

Post-Laboratory Questions:

1. Identify solutions A, B, C and D as sucrose, stevia, saccharin, or sucralose based on your sweetness intensity rankings.

    A. ________________________

    B. ________________________

    C. ________________________

    D. ________________________

2. Other than sweetness intensity, what differences did you detect among the samples?

____

3. Can you change sucrose for another sugar seen today in a recipe equally? (cup for cup) Why or why not?

____
____
____
____
____

APPENDIX H

LESSON 4

Title	Lipids: Butter is Better
Subject	Food Science
Author	Lauren Elizabeth Ivey
Grade level	9th – 12th
Time duration	1 hour
Overview	Students will be introduced to various terms pertaining to lipids in food. Students will discover the differences in solid and liquid fats and what makes them that way. They will experience how emulsions mix fat and water and will also perform sensory analysis on various fats through their interaction in a baked shortbread cracker.
Objective	1. Students will be able to explain saturated and unsaturated fats and relate the terms to the functions and properties of each type. 2. Students will be able to identify various sources of fats and oils. 3. Students will be able to explain how an emulsifier mixes oil and water and why this is important. 4. Students will be able to determine the effect of various sources of lipid on the tenderness and flakiness of a pastry product.
2010 Mississippi Science Framework	Biology 1a. Demonstrate accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers. (DOK 2) 1c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2) Chemistry 1c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
Materials	Oil and Water Magic Trick: 1. One glass jar (8oz mason jar) with lid per group 2. Water 3. Vegetable Oil 4. Lecithin (emulsifier) 5. Food coloring (blue is most visible) 6. Measuring spoons 7. Timer

Shortbread Bars:

(Instructions below in activities section)

(Can be made in class if time permits and oven is available)

1. Flour 174 gm
2. Salt 3 gm
3. Lipid* 94gm
4. Water 59 gm
5. Fork or pastry cutter
6. Bowl
7. Parchment paper
8. Cookie tray
9. Wax paper
10. Rolling pin
11. Knife or pizza cutter
12. Plates

Instructions:

1. Weigh out all ingredients 4 times.
2. Treatment 1 (control) is shortening
3. Treatment 2 is butter
4. Treatment 3 is vegetable oil
5. Treatment 4 is margarine spread
6. Preheat oven to 425˚F
7. Place flour and salt into a medium sized mixing bowl. Blend with a fork.
8. Using pastry blender or food processor, add fat/oil until the particles are the size of dry rice/peas.
9. Sprinkle on the water and mix only until combined.
10. Make a ball of dough and transfer to wax paper.
11. Cover with another piece of wax paper and gently roll out with a rolling pin to 0.25" inch thickness.
12. Gently peel off wax paper and use knife or pizza cutter to cut 2"x1" pastry strips.
13. Prick the center of each strip with the fork to prevent blistering during baking.
14. Bake until light brown in color, 15 to 20 minutes. Let cool before testing.

Activities and procedures

Introduction: Fatty Acids: aka Lipids include fats and oils from plants and animals. Plant and vegetable fats include cocoa butter, corn oil, sunflower oil, soybean oil, peanut oil, olive oil, canola oil, and many others. Animal fats include lard from pigs, tallow from beef, and butterfat from milk.

Role of Fats in Foods: In food, fats provide a source of essential fatty acids, add calories, carry flavors, carry fat soluble vitamins, contribute to texture and mouthfeel, lead to flavor, and provide heat transfer in frying. Food science is mainly concerned with simple lipids also known as triglycerides that make up the major components of fat, butter, shortening, and oil.

The structure of these fatty acids determine their properties as fats and if they are solid or liquid at room temperature. The chemical structure of fatty acids are pretty simple. They are a chain of carbon and hydrogen with a group on the end that contains oxygen. Function and properties are determined by whether or not there is a double bond in the chain.

What is the difference between solid fats like butter and shortening and liquid fats such as vegetable oils?

The difference between solid and liquid fats primarily relates to the type of fats they contain. All fats contain both saturated and unsaturated fats. Fats with a higher level of saturated fats are firmer at room temperature and need more heat to melt. Ask students to list some hard fats. (butter, lard, coconut oil, and shortening)

Fats with a higher level of unsaturated fats tend to be liquid at room temperature. Ask student to list some liquid fats (canola oil, peanut oil, olive oil) These properties help guide functional use in food preparation. For instance, more saturated (solid) fats perform better in certain cases, such as creaming a cake batter. More unsaturated (liquid) fats may function better in other applications, such as making salad dressings.

Due to this fats and oils have various melting points. Those that are liquid (unsaturated/less hydrogen) at room temperature have the lowest melting point and those that are firm solids (saturated/full amount of hydrogen) have high melting points.

Saturated fatty acids contain no double bonds and have at least two more hydrogen atoms.

For example CH3-CH2-CH2-CH2-CH2-COOH.

Unsaturated fatty acids contain at least one double bond.

For example CH3-CH2-CH=CH-CH2-COOH.

Fats have seven major uses in foods.

1. Texture
2. Emulsions (mix oil and water)
3. Tenderize or shorten
4. Transfer heat (frying)
5. Aeration
6. Spray oils
7. Flavor

Why do we need different products like butter, shortening, margarine products and oil?

In baked goods such as cakes, fats help produce a high, fine texture. When "creaming" fats and sugar— the first step in mixing many cake batters—fats trap tiny air bubbles that help the batter to rise. Fats also help keep dough and batter from separating and falling. And fats coat the proteins in flour to make a tender or flaky product.

While butter, shortening, margarine products and oils contain fat, each have different properties that affect how they work. Thus, they produce different results that can be key to the acceptance of many foods. Shortening works best for some types of baking because it contains no water that would otherwise mix with flour and form gluten that toughens a product. As a result, shortening produces tender, flaky pie crusts and biscuits. Butter and margarine products contain water and hence produce a different, but still acceptable, texture. Vegetable oil (with the exception of olive oil) yields the best results in many box cake mixes.

	Baking	Frying	Dressings/Spreads
Butter & Margarine	Adds flavor; produces tender, crisp, chewy and brown cookies; tender pie crusts; cake frostings	Pan sautéing; burns easily	Suitable for spreading directly on foods
Margarine Spreads	Cookies have "cake-like" texture; not suitable for pie crusts	May not be suitable	Suitable for spreading directly on foods
Non-fat/low-fat spreads	Not suitable	Not suitable	Suitable for spreading directly on foods
Salad/Cooking Oil	For special recipes such as carrot cake, box cake mixes and quick breads	Pan sautéing; frying and deep-fat frying	Mix with vinegar or herbs/spices

Shortening	Produces tender, light, moist texture; best for flaky pie crust; thick cake frostings	Pan sautéing; frying and deep-fat frying	May not be suitable
Cooking Spray	Pan coating	Can be used to sauté in nonstick pans, if watched carefully	Not suitable

Experiments

Oil and Water Magic Trick:

Ask for a volunteer to shake a bottle of oil and water for 10 seconds. It may stay kind-of mixed for a few seconds but you can still the fat particles floating around in the water. We are going to do an experiment today that involves adding what is called an emulsifier to an oil and water and mixture and see if we can get the two to mix and how much it takes to make this happen.

Instructions:

1. Each group should have in front of you a bottle that contains water.
2. Measure out the assigned amount of "magic crystals" and add into the water.
3. Replace lid and shake until dissolved.
4. Add 2oz oil to the bottle.
5. Shake the bottle for 1 minute.
6. Record results.

Questions:

1. Did the water and oil mix together easily?
2. What happened when the amount of "magic crystals" increased?
3. Why is this different than what happened to the oil and water used in the demonstration?

Assessment

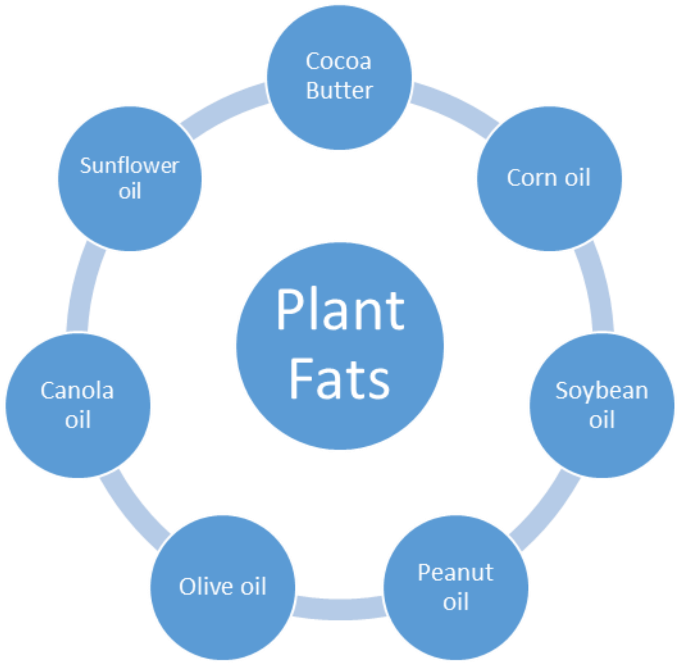
Students should be assessed on their completion of the worksheet.

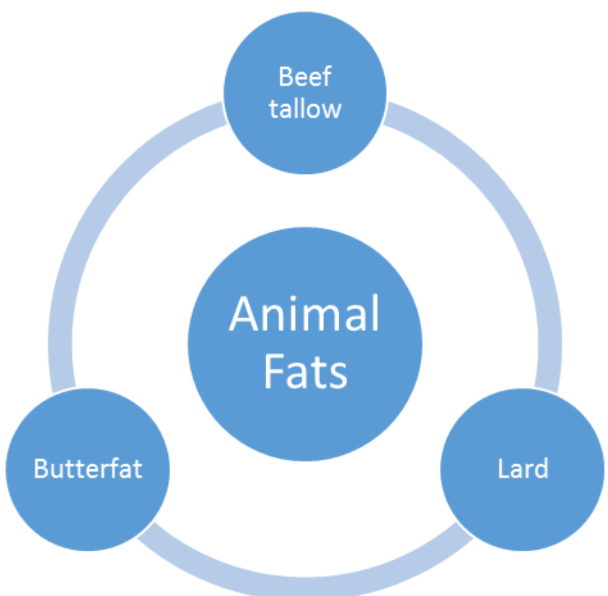
LIPIDS ACTIVITY WORKSHEET

Facts about Fats

Fatty Acids=Lipids=Fats=Oils

Origins: Plants and animals provide natural fats and oils used in food production.





Role of fats in foods:

- Source of essential fatty acids
- Calories
- Flavor
- Carries fat soluble vitamins
- Texture
- Mouthfeel
- Tenderize
- Heat transfer by frying

*Frying cooks foods be replacing surface water with the very hot oil causing the food to rapidly heat up and cook. This is also why fried foods are less healthy.

Chemical Structure:

Unsaturated fats contain one or more double bonds. CH3-CH2-CH2-**CH=CH**-CH2-COOH

- Tend to be liquid at room temp, such as olive oil, canola oil, and peanut oil.

Saturated fats contain no double bonds and at least two more hydrogen atoms.

CH3-CH2-CH2-CH2-CH2-CH2-COOH

- Tend to be solid or firm at room temp, such as lard, butter, coconut oil, and shortening.

Why do we need different fats for different products?

In baked goods such as cakes, fats help produce a high, fine texture. When "creaming" fats and sugar— the first step in mixing many cake batters—fats trap tiny air bubbles that help the batter to rise.

While butter, shortening, margarine products and oils contain fat, each have different properties that affect how they work. Thus, they produce different results that can be key to the acceptance of many foods.

Shortening works best for some types of baking because it contains no water that would otherwise mix with flour and form gluten that toughens a product. As a result, shortening produces tender, flaky pie crusts and biscuits.

Butter and margarine products contain water and hence produce a different, but still acceptable, texture.

Vegetable oil (with the exception of olive oil) yields the best results in many box cake mixes.

	Baking	Frying	Dressings/Spreads
Butter & Margarine	Adds flavor; produces tender, crisp, chewy and brown cookies; tender pie crusts; cake frostings	Pan sautéing; burns easily	Suitable for spreading directly on foods
Margarine Spreads	Cookies have “cake-like” texture; not suitable for pie crusts	May not be suitable	Suitable for spreading directly on foods
Non-fat/low-fat spreads	Not suitable	Not suitable	Suitable for spreading directly on foods
Salad/Cooking Oil	For special recipes such as carrot cake, box cake mixes and quick breads	Pan sautéing; frying and deep-fat frying	Mix with vinegar or herbs/spices
Shortening	Produces tender, light, moist texture; best for flaky pie crust; thick cake frostings	Pan sautéing; frying and deep-fat frying	May not be suitable
Cooking Spray	Pan coating	Can be used to sauté in nonstick pans, if watched carefully	Not suitable

Shortbread Sensory Evaluation:

To explore the texture and flavor properties of various fats and oils, students will perform sensory analysis on shortbread bars made with different fats and oils. Students will have to determine the treatments (which oil or fat was used) based on the finished products and its qualities. Due to lack of time and space, the samples for this experiment were prepared beforehand.

Sensory Evaluation:

Evaluate each product numerically in terms of flakiness and tenderness using the scorecard provided below. Refer to these definitions during your evaluation.

Flakiness: Thin layers of baked dough; cells and layers should be medium to large

Tenderness: Pastry should “melt in the mouth”; little resistance when bitten into

	1	2	3	4	5
Flakiness	Very thick or no layers	Moderately thick layers	Thick and thin layers	Moderately thin layers	Very thin layers
Tenderness	Very tough/crumbly	Moderately tough/crumbly	Slightly tough/crumbly	Tender	Very tender

Evaluate Pastry Samples:

Treatment	Flakiness	Tenderness
Treatment 1		
Treatment 2		
Treatment 3		
Treatment 4		

Results and discussion:

1. Which sample had the best flakiness? __________________
2. Which sample was the most tender? __________________
3. Which would make the best pie crust and why?

____
____
____

APPENDIX I

LESSON 5

Title	Dairy: Major components of Milk
Subject	Food Science
Author	Lauren Elizabeth Ivey
Grade level	9-12
Time duration	1 hour
Overview	In this lesson students will be introduced to a large portion of the dairy products made from milk. Students will learn about the components of milk, what products they make, and how to make butter at home.
Objective	1. Students will be able to describe the "solids" composition of milk. 2. Students will be able to discuss the separation of butterfat and its uses 3. Students will be able to list the steps in cheese making 4. Students will be able to define milk 5. Students will be able to explain pasteurization and homogenization
2010 Mississippi Science Framework	Biology 1b. Formulate questions that can be answered through research and experimental design. (DOK 3) Chemistry 1b. Clarify research questions and design laboratory investigations. (DOK 3)
Materials	Experiment 1: Butter 1. 1 cup heavy cream per group 2. Clean jar with secure, tight fitting lid 3. Marbles (2 per jar) 4. Salt 5. Crackers 6. Plate
Activities and procedures	See accompanying power point for the lesson portion. Slide 1: Introduction Slide 2: Poll the students. Odds are at least a couple of them can list what dairy products they have had that day. Slide 3: Talk about the various dairy products available. Slide 4: Introduction to milk. Slide 5: picture of raw versus pasteurized milk. Ask students to identify the biggest seeable difference. Key note here is the separation of the cream from the liquid milk portion in the raw. Could also talk about the health concerns with raw milk. Slide 6: Explains the differences in the last slide or raw versus pasteurized milk. Can insert a video here as well. Slide 7: Introduction to cheese and how it is made from milk.

Slide 8: Introduction to butter and how it is made from the cream portion of milk.

Experiment 1: Butter

Instructions:

1. Pour 1 cup of heavy cream into the jar, add the marbles and 1 teaspoon salt and place on lid.
2. Shake the jar. Take turns shaking, you may need to shake it or 15 to 20 minutes. The cream will start to thicken and become hard to shake. Keep shaking!!! (Be careful not to shake too hard and break the jar)
3. You should reach a point where the solid (butter) separates out from the liquid (buttermilk).
4. Pour off the buttermilk. Can be saved for later use.
5. Spread on crackers or bread and enjoy!

The science behind it:

The density of cream is the basis for butter making. The cream is churned to separate the butter (solids) from the buttermilk (liquids). Butter contains at least 80% fat by weight.

When heavy cream is shaken or churned, the fat globules (microscopic membranes filled with fat) burst and join together since fat and water don't mix.

The first stage, whipped cream, has air trapped between all the solid and liquid particles and can be used to top desserts and coffees. If you continue to shake or churn the heavy cream the bubbles will begin to burst and you will begin to separate the fat solids from the liquids. Eventually all liquids will separate out from the solids and you will be left with butter and buttermilk.

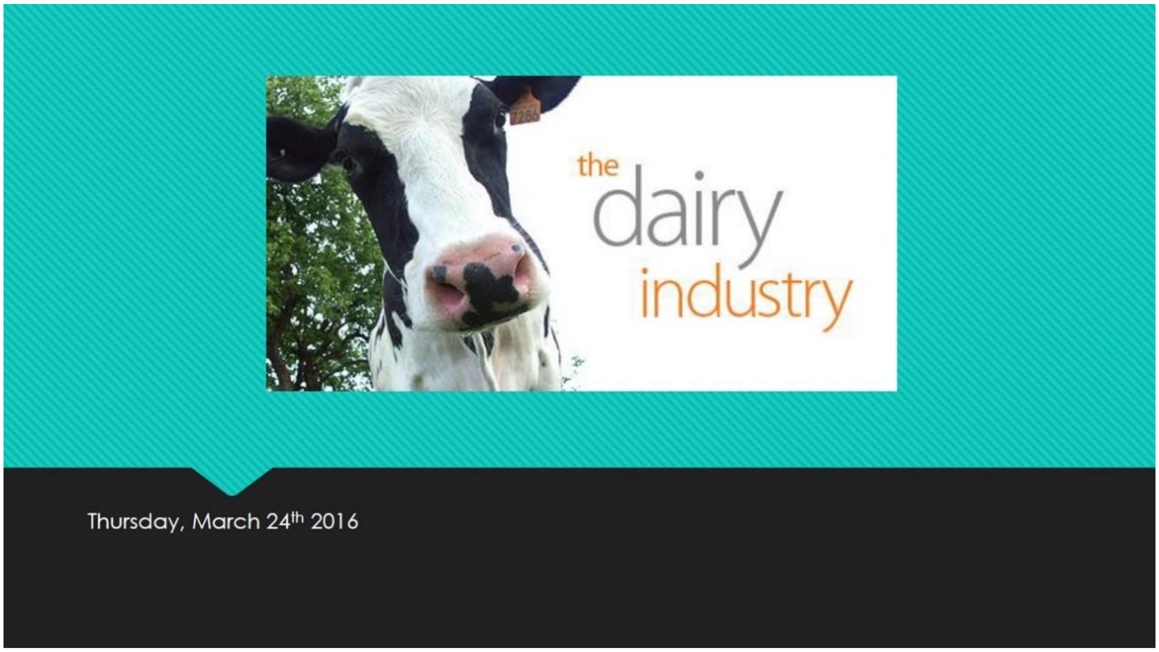
Assessment

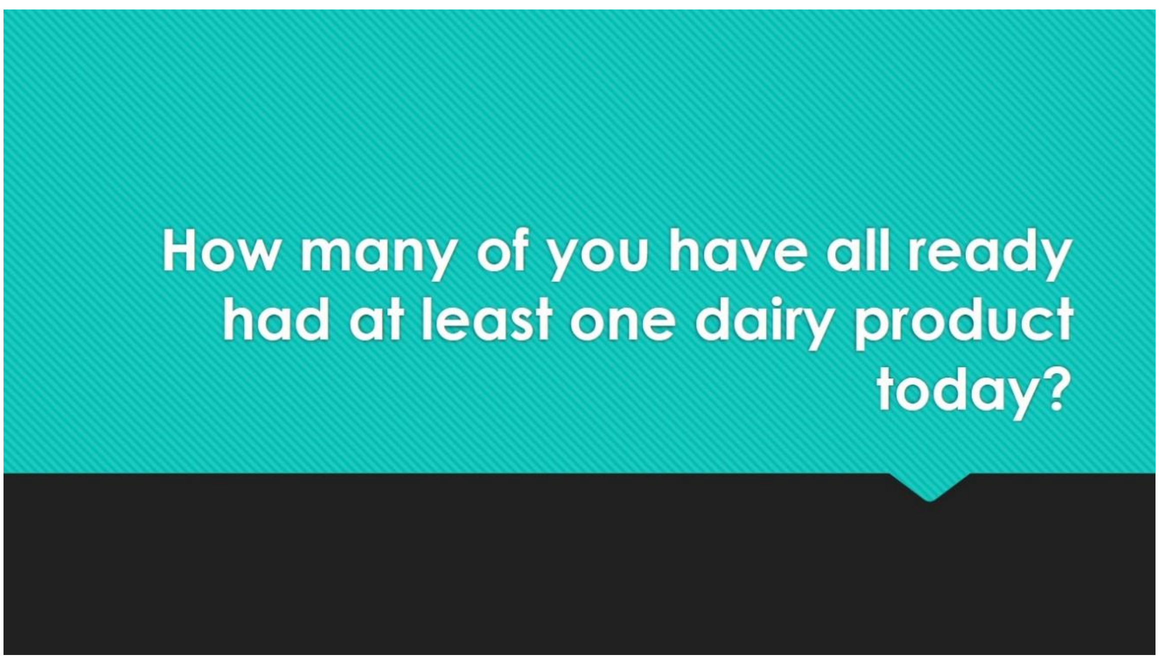
Students should be assessed on lecture and activity participation.

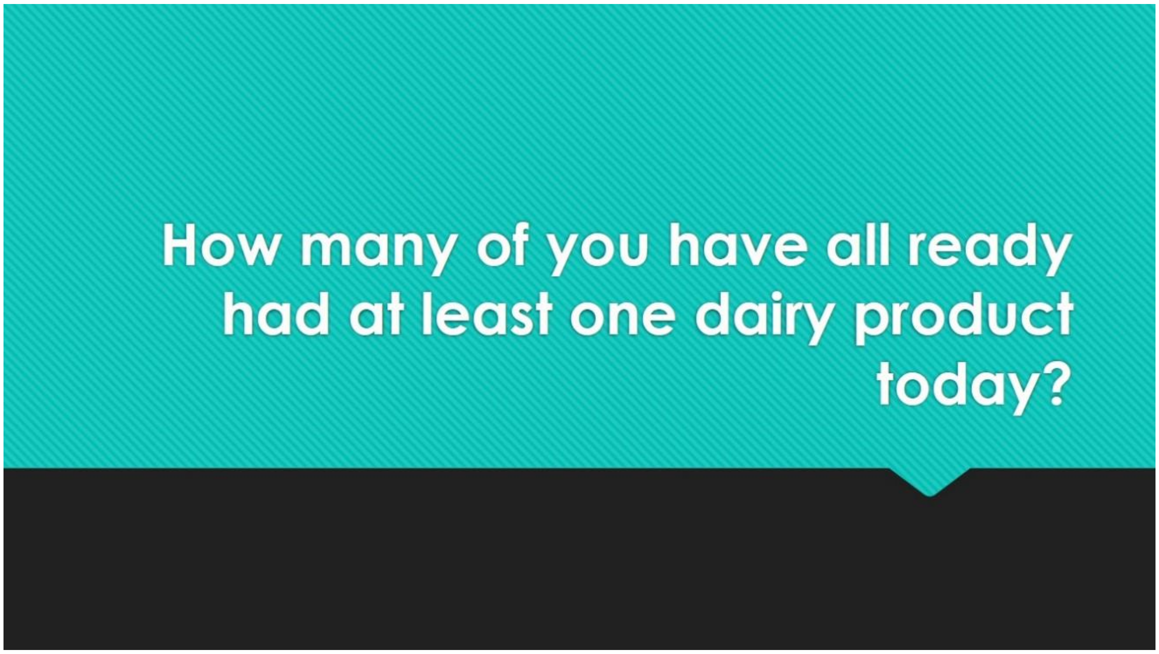
References

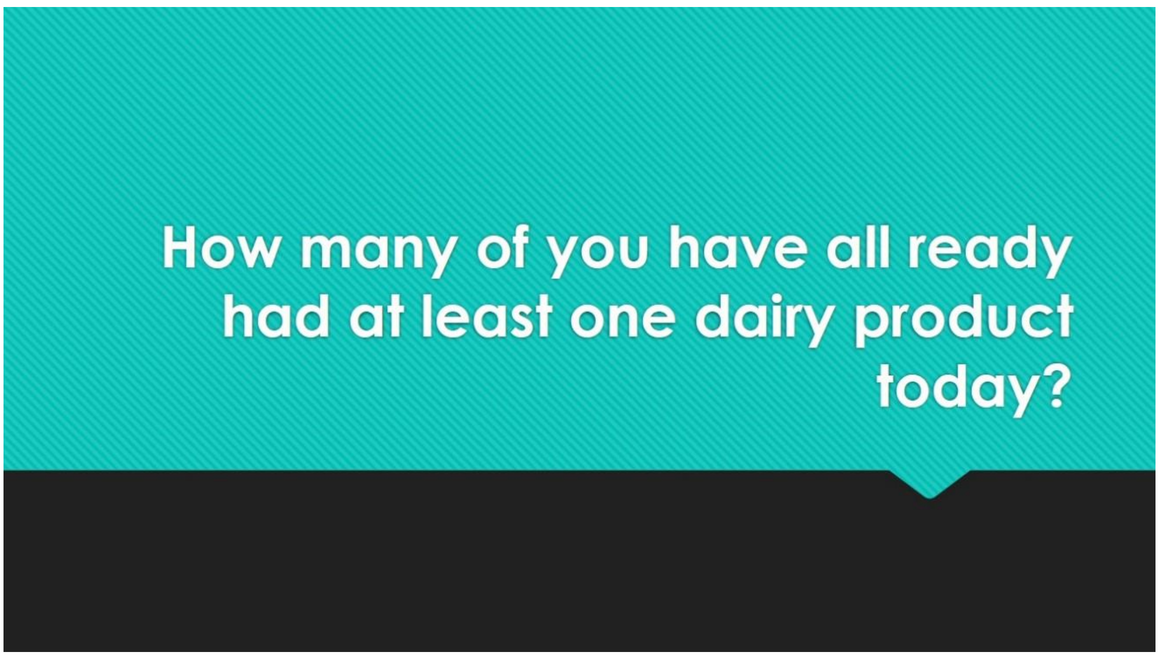
Butter: Experiments in Food Science Laboratory Manual, Mississippi State University, Extension Service, msucares.com

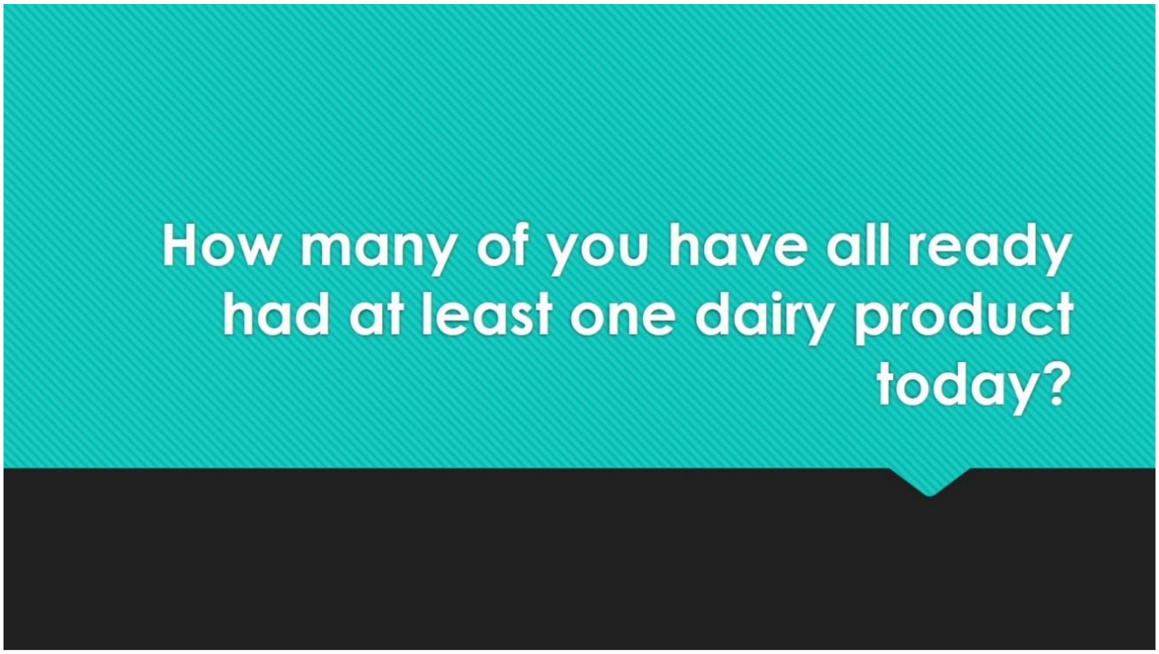
DAIRY POWERPOINT PRESENTATION

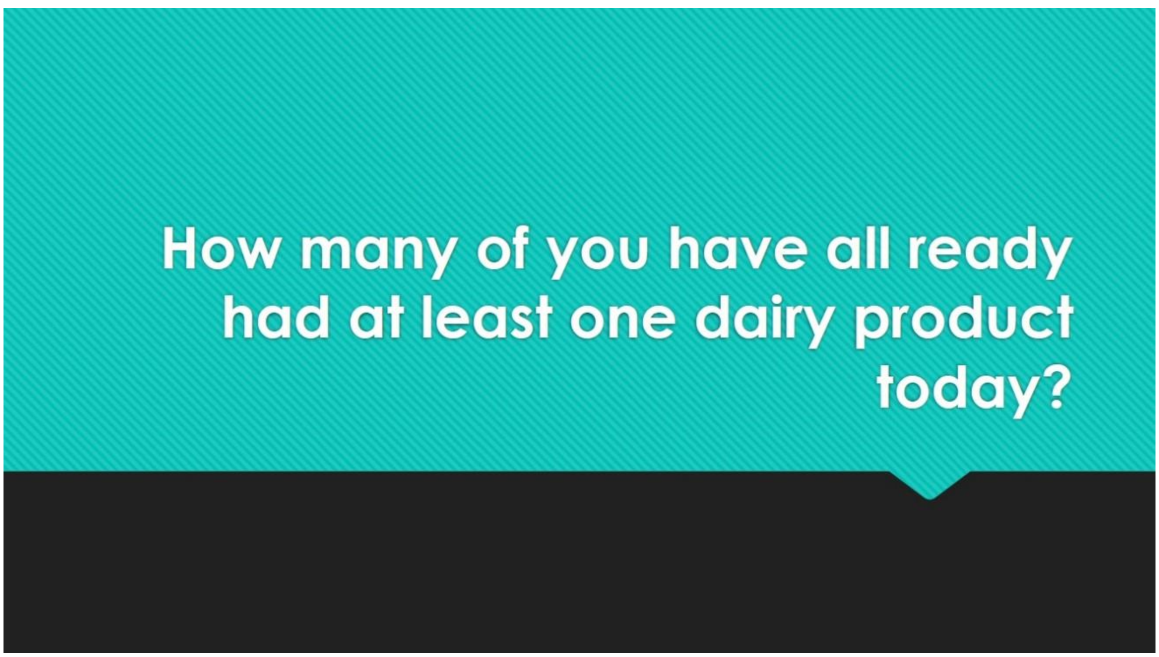


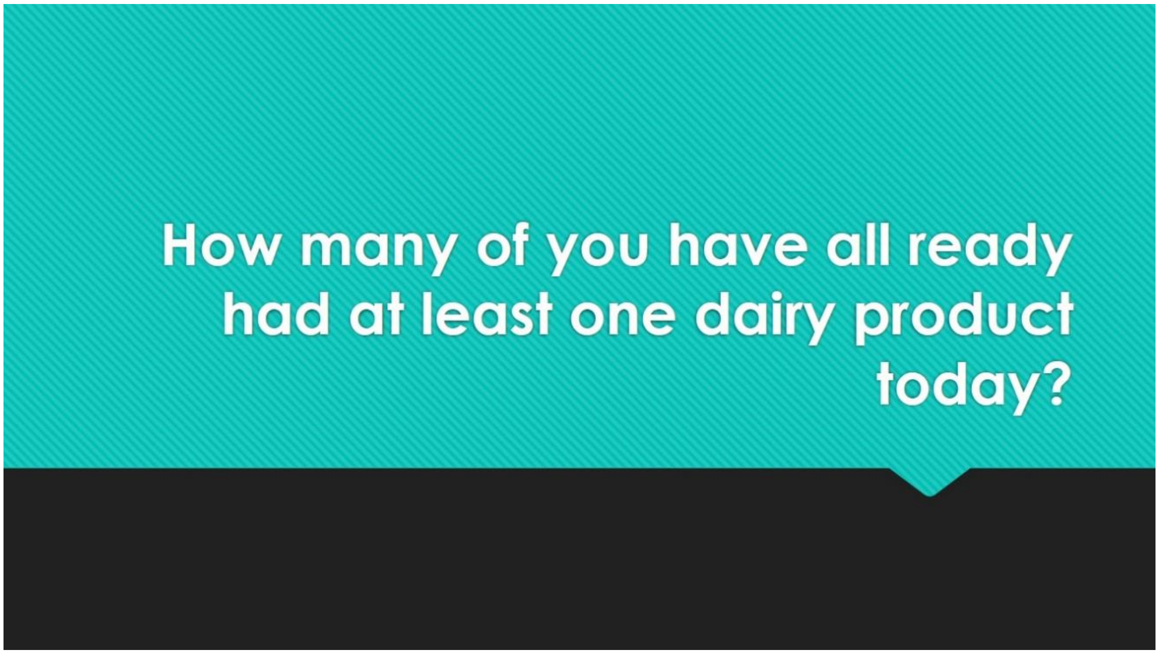


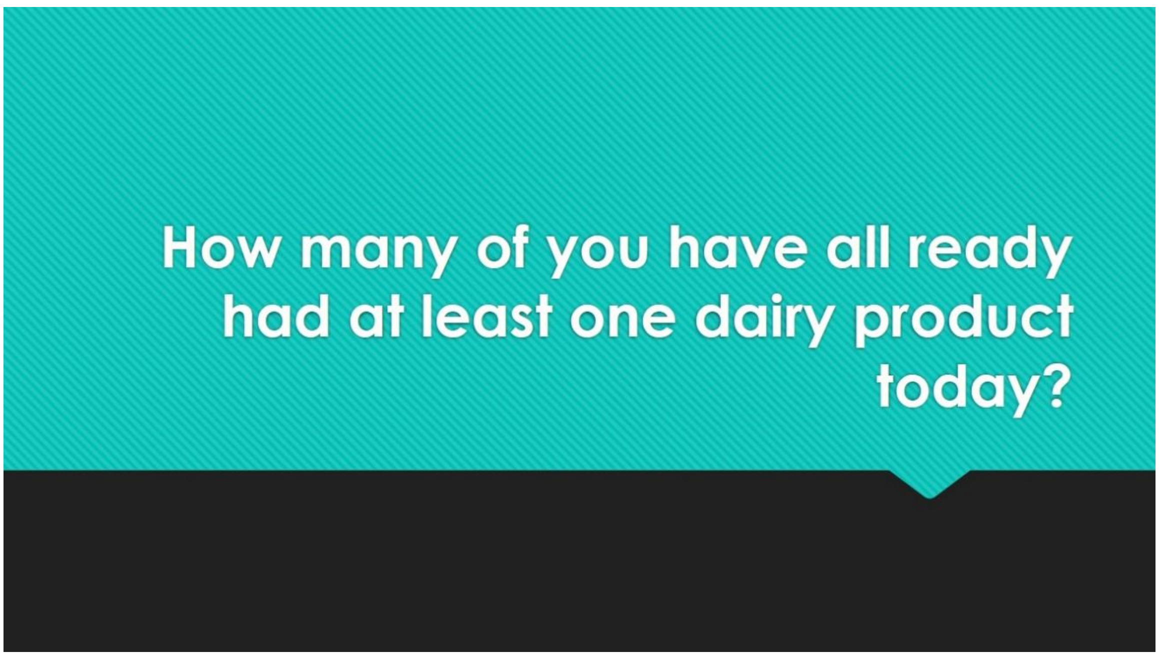

How many of you have all ready
had at least one dairy product
today?


How many of you have all ready
had at least one dairy product
today?


How many of you have all ready had at least one dairy product today?


How many of you have all ready had at least one dairy product today?


How many of you have all ready had at least one dairy product today?


How many of you have all ready had at least one dairy product today?

Dairy Products

Milk, Butter, Yogurt, Buttermilk, Cheese, Ice Cream

Milk

- First food of young mammals
- Provides a high-quality protein, source of energy, and vitamins & minerals
- Composed primarily of water (87-89%) and also contains:
  - Carbohydrates
  - Lactose
  - Fat
  - Protein (2 main)- Casein and Whey
  - Vitamins & Minerals

Raw vs. Pasteurized

What's the difference?

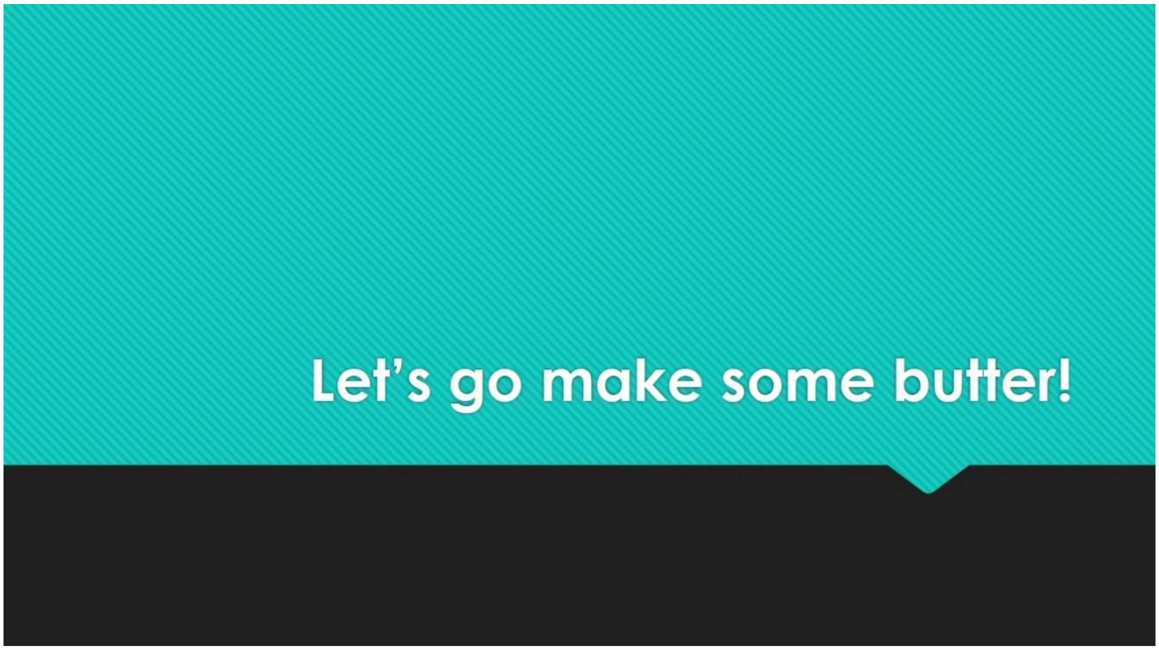
- Fresh milk is virtually sterile, however
- Milk is the perfect growing media for pathogens and bacteria
- Milk is processed 2 ways
  - Homogenized- Breaks the fat globules down so they mix with the liquid portion making an emulsion
  - Pasteurized- Heated up to kill pathogens. Some bacteria survives this process and make milk spoil and "go sour"

Cheese

- A traditional way of preserving milk
- Today there are thousands of varieties
- Cheese is the fresh or ripened product after coagulation (curds) and whey separation of milk
- This happens after milk has been heated and acid is added
- The whey is drained off and the curds will be made into fresh cheese right away or made into molds to be ripened

Butter

- Butter is made by churning pasteurized cream
- Churning breaks the fat globules cause the fat to separate out from the liquid and join together
- The liquid, buttermilk, is drained off
- Butter consist of milk fat, water, salt and sometimes coloring
- Butter is a fat-and-water emulsion called an amphipathic system
  - It has both hydrophilic (water loving) and hydrophobic (water hating) portions


Let's go make some butter!

APPENDIX J

LESSON 6

Title	Preservation & Fermentation: To infinity and beyond
Subject	Food Science
Author	Elizabeth Ivey
Grade level	9-12
Time duration	1 hour
Overview	In this lesson students will learn about the various ways different foods are preserved to extend shelf life and provide a year-round food supply. Students will compare fresh foods to their preserved counterparts to examine flavor and texture differences.
Objective	1. Students will be able to identify the various methods of food preservation and provide an example of the food that matches the method. 2. Students will be able to explain how canning preserves foods and why canned foods are important in today's food chain 3. Students will be able to define what an acidic food is and how it pertains to canned foods. 4. Students will be able to explain the process of fermentation and list some key food items that are only possible through fermentation.
2010 Mississippi Science Framework	Biology 1b. Formulate questions that can be answered through research and experimental design. (DOK 3) Chemistry 1b. Clarify research questions and design laboratory investigations. (DOK 3)
Materials	Activities: 1 piece per student 1. Fresh pineapple 2. Canned pineapple 3. Fresh grapes 4. Raisins 5. Cucumber 6. Pickles 7. Fresh blueberries 8. Frozen blueberries

Activities and procedures

Chemical vs. Physical

Chemical: High salt and high sugar both absorb the water in the product and suffocate any microorganisms. Citric and ascorbic acid can inhibit the enzymes that turn fresh cut surfaces brown on apples and avocados. Last is antioxidants that inhibit oxidation of products.

Physical: This include freezing, vacuum packaging, drying, smoking, pasteurization, canning

Preservation:

Canning: As we learned during our first lesson, most fresh foods have a very high percentage of water in them which makes them very perishable. They spoil or lose their quality for several reasons:

1. Growth of bacteria, yeast, and mold
2. Activity of food enzymes
3. Reactions with oxygen
4. Moisture loss

By preserving food by canning these practices remove oxygen, destroy enzymes, and prevent growth of undesirable bacteria, yeasts, and molds. Canning can preserve a food for up to 5-10-even 20 years. (canned fruit)

Video: https://www.youtube.com/watch?v=-15bEIG7sRY

How it's made Pineapple

Activity: Have students taste and compare the fresh pineapple to the canned pineapple. Does it taste the same? Are there color differences? Is the texture the same? What is the biggest difference between the two?

Drying & Dehydrating: Mainly remove water from foods but also costs less to ship and takes up less space. There are multiple methods to drying. You can use a dehydrator, an oven, room drying, or sun drying. It depends on the product and the end results as to which method is best. (sun dried raisins)

Video: https://www.youtube.com/watch?v=7e8DepWX4_4

How it's made Raisins

Activity: Have students taste the fresh grapes and compare them to the raisins. Does it taste the same? Are there color differences? Is the texture the same? What is the biggest difference between the two?

Freezing: Freezing preserves foods by greatly slowing down microorganisms and enzymes reducing their deteriorative effects. Some foods are blanched prior for freezing to deactivate these enzymes to increase the shelf-life of fresh vegetables and keep their bright vibrant color. Frozen foods typically retain good quality for up to a year. (frozen blueberries)

Video: https://www.youtube.com/watch?v=PwpPUwouy0w

How it's made Frozen Fruit

Activity: Have the students taste the frozen blueberries and compare them to the fresh blueberries. Does it taste the same? Are there color differences? Is the texture the same? What is the biggest difference?

Fermentation: Fermentation is the oldest form of food preservation. The principle of fermentation is the breakdown of carbohydrates by bacteria to produce acids and alcohols. Products produced by fermentation help preserve foods against microbial spoilage. Fermentation by lactic acid bacteria produces:

1. Pickles
2. Olives
3. Sausage and salami
4. Sour cream
5. Some cheese
6. Coffee
7. Beer
8. Wine

Video: https://www.youtube.com/watch?v=pL0uzZJ_4Fk

How it's made Beer

Activity: Have the students taste the pickles and compare them to the fresh cucumber. Does it taste the same? Are there color differences? Is the texture the same? What is the biggest difference?

Poll students on reasons we preserved food in the past and still today.

Benefits of preserving foods: Saves money and reduces food waste, supplies food year-round, and prevents food spoilage.

Assessment Students should be assessed based on class participation.

ACTIVITY WEB LINKS

Canning: https://www.youtube.com/watch?v=-15bEIG7sRY

Drying & Dehydrating: https://www.youtube.com/watch?v=7e8DepWX4_4

Freezing: https://www.youtube.com/watch?v=PwpPUwouy0w

Fermentation: https://www.youtube.com/watch?v=pL0uzZJ_4Fk

APPENDIX K

LESSON 7

Title	Enzymes: Jiggly Jell-O
Subject	Food Science
Author	Elizabeth Ivey
Grade level	9-12
Time duration	1 hour
Overview	This lesson explains the science behind the fresh pineapple warning on JELL-O boxes. Specifically, enzymes effect on proteins and how methods of preservation affect them. The warning advises against the use of certain fresh or frozen fruits because they will not allow the jello to set up or solidify. Students will explore the differences when fresh, frozen, and canned pineapple are used to make jello. Students will see first-hand how the canned pineapple allows the gelatin to set up properly due to the fact that canned pineapple is cooked to a high temperature that denatures the enzyme bromelin, causing it to become non-reactive. This also reinforces the previous lesson when canning was mentioned.
Objective	1. Students will learn what enzymes are and how they affect food. 2. Students will understand what enzymes do in foods and relate this information to quality and problem solving. 3. Students will relate how enzymes work to why they cause adverse reactions in some foods. 4. Students will relate meat tenderization by enzymes to why gelatin cannot be mixed with certain fruits unless canned.
2010 Mississippi Science Framework	Biology 1a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2) 1a. Demonstrate accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers. (DOK 2) 1b. Formulate questions that can be answered through research and experimental design. (DOK 3) 1c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2) 1f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3) Chemistry

1b. Clarify research questions and design laboratory investigations. (DOK 3)

1c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)

1e. Evaluate procedures, data, and conclusions, to critique the scientific validity of research. (DOK 3)

Materials

1. Gelatin (powdered) 1 packet per group
2. Disposable Test Tubes
3. Fresh pineapple, a few small pieces per group
4. Frozen pineapple, a few small pieces per group
5. Canned pineapple, a few small pieces per group
6. Can opener
7. Water
8. 500 mL Beaker
9. Ice water bath
10. Test tube rack
11. Hot plate or microwave
12. Oven mitt

Activities and procedures

Class introduction:

Enzymes are present in all living tissue. Enzymes are small macromolecular biological proteins that act as a catalyst to speed up chemical reactions. In both plants and animals, enzymes carry out all the activities of metabolism. Some enzymes from the plant or animal's life are retained in uncooked food.

Foods that contain high amounts of enzymes in their raw form include:

1. Avocado
2. Figs
3. Guava
4. Kiwi
5. Mango
6. Papaya
7. Pineapple
8. Cucumber
9. Olives
10. Mushrooms
11. Honey
12. Cultured foods such as yogurt and cheese

The heating of food destroys its enzymes. Cooking, canning, pasteurization – all permanently deactivate any enzymes in food.

Hand out the activity sheet and have students read over introductions out loud to their groups and begin the activity.

Watch groups carefully and warn them off the hot gelatin.

Assessment

Students should be assessed based on class participation and completion of worksheet.

ENZYMES ACTIVITY WORKSHEET

Tropical Fruit Gelatin Lab

Have you ever noticed the warning on a JELL-O package about pineapple?
Today you will learn the science behind that food warning.

Background: The enzymes in some tropical fruits can break down proteins. For example, papaya contains the digestive enzyme *papain*, which is often found as a component in meat tenderizers. Pineapple contains a digestive enzyme named *bromelin*.

Hypothesis: Form a hypothesis as to what you think will happen when each type of pineapple is added to the gelatin and whether or not you think it will set-up. Form a hypothesis for each type of pineapple. Use information learned today and from the last lesson about food preservation to form your hypothesis. (Fresh, frozen, canned)

____

____

____

____

____

Materials:

4 test tubes
Fresh pineapple
Frozen pineapple
Canned pineapple (chunky)
Powdered gelatin
Ice water bath
Test tube rack
Plastic knife
Sharpie
Hot plate
Oven mitt

Procedure:

1. Using the plastic knife, cut equal sized pieces of fresh, canned, and frozen pineapple.

   The pieces should be small enough to easily fit inside the test tube and be covered by the hot gelatin.

2. Label the test tubes 1-4
3. Prepare gelatin as stated by your teacher.
4. Pour ~1.5 inches of hot gelatin into each of the four test tubes.
5. Place the piece of fresh pineapple into test tube #2, frozen pineapple into test tube #3, canned pineapple into test tube #4. Make sure that test tube#1 contains only gelatin and no fruit.
6. Slowly mix the contents of the tubes by rolling them upright between the palms of your hands.
7. Place all four test tubes into the ice water bath.
8. Every few minutes check to see if the gelatin in tube #1 has solidified. When test tube

#1 has solidified, you can remove all the tubes and compare the consistency.

9. Record all observations in the table provided.

Tube Contents	Observations
#1 Gelatin	
#2 Gelatin & Fresh Pineapple	
#3 Gelatin & Frozen Pineapple	
#4 Gelatin & Canned Pineapple	

APPENDIX L

LESSON 8

Title	Sensory Science: How we eat
Subject	Food Science
Author	Elizabeth Ivey
Grade level	9-12
Time duration	30 min
Overview	This lesson introduces students to how we taste, the components of flavor, and how our 5 senses affect the perception of flavor. Students will participate in a difference from control test to experience how industry uses people to determine if a difference exists between one or more samples and a control and to estimate the size of any such differences. Students will also participate in an acceptability test to experience how product researchers determine how well it is liked by consumers.
Objective	1. Students will be able to identify flavor, texture and aroma as the components of taste. 2. Students will be able to identify the five categories of taste (sweet, sour, salty, savory, and bitter) and map where each is sensed on their tongue. 3. Students will be able to discuss the reasoning behind why we like sweet, salty, and savory foods and why we do not like sour and bitter. 4. Students will discover how sensory testing provides data on consumer acceptability and whether consumers can perceive a difference between similar products.
2010 Mississippi Science Framework	Biology 1e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3) Chemistry 1b. Clarify research questions and design laboratory investigations. (DOK 3) 1e. Evaluate procedures, data, and conclusions, to critique the scientific validity of research. (DOK 3)
Materials	Difference from control test: 1. Sample cups (2oz Dart Conex clear portion containers) (3 per student) labeled with 3 digit codes ex. 460, 792, and 1 labeled control 2. 3 similar types of semi-sweet chocolate chips

3. Score sheet

Consumer acceptability test:

1. Sample plate (1 per student) labeled with 3 digit codes (854 & 643)
2. 2 products (regular(854) vs. reduced fat (643) or lower calorie works great) ex. Chips Ahoy
3. Score sheet

Activities and procedures

Interest Approach: What are the 5 main senses?

List on board. Since we are focusing on taste, ask students what they think taste is exactly?

Taste is perceived when a substance enters the mouth and reacts chemically with taste receptor cells located on your taste buds. Human factors that perceive and relate how something tastes to your brain are aroma, texture, and flavor.

Texture will affect the overall perception of taste in various ways, however the most common is when the texture no longer matches a previous understanding. For example, when a French fry is soggy rather than crisp it may seem to "taste" different.

Aroma greatly affects perception of taste. So much so that without it we can hardly taste at all. That means that if we cannot smell, then we cannot properly taste our food. This is because our sense of smell is stronger than our sense of taste and the two work together in sending the signal to the brain.

When it comes to sense of taste, not everyone's is the same. In fact, some people cannot taste bitterness at all while others are what are called "super tasters" and have a heightened sense of taste.

The tongue is covered with 2000 to 500 taste buds that each have 50 to 100 taste receptor cells.

Most bitter and sour foods are found unpleasant, while salty, sweet and meaty tasting foods generally are found pleasant. These five specific tastes received by taste receptors are saltiness, sweetness, bitterness, sourness, and umami, which means "delicious" in Japanese.

I mentioned before that taste is when a substance reacts chemically, with your saliva specifically, in your mouth. The five specific tastes served very important roles in keeping humans alive. There is a reason we love the taste of candy and chips and not so much grapefruit and broccoli.

Salt plays a critical role in the human body with water so we liked salty tasting foods because we needed enough salt in our diet to live. Saltiness is perceived on both sides of the tongue from the front to back.

Bitter taste is almost universally unpleasant to humans. This is because many poisons foods contain bitter compounds and this detection system kept us from eating harmful foods. Bitterness is perceived in the center back portion of the tongue.

Sweet taste signals the presence of carbohydrates and since they have a high calorie count they are desirable to the human body, which has been designed to seek out the highest calorie intake foods, as the humans were unaware when their next meal would occur. Sweetness is perceived in the center front portion of the tongue.

Sour taste can be pleasant in small quantities, as it is linked to the salt flavor, but in large quantities it becomes more and more unpleasant. This is because sour taste signals under-ripe fruit, rotten meat, and other spoiled foods that can be dangerous to the human body. Sourness is perceived on the back corners of the tongue.

Umami, or meaty taste, signals the presence of proteins and amino acids vital to building muscles and organs.

All of our tastes were made that way for a very specific reason and that was to help keep us alive. Today our taste buds still react in the same way to compounds and have evolved very little.

Some foods also cause what is known as a stimulus reaction. This is when your mouth gets hot from peppers, cool from mints, and puckers from wine. This stimulus reaction is a chemical reaction just like taste is but it is affecting trigeminal receptors instead of taste receptors.

Some substances activate cold trigeminal receptors even when not at low temperatures. This is the “fresh” or “minty” sensation from peppermint and spearmint.

Now that we have learned a little about taste we are going to test our sense of taste. Food scientists use sensory science to determine things such as do we like a product as much as we say we do and can we notice if they change an ingredient in a familiar product. All of this is done to save a company time and money. It helps keep bad ingredient replacements from reaching the market and companies losing loyal customers but it also can help a company understand why a product is no longer selling like it used to.

To do this food scientists use what are called sensory tests to determine if there are true perceivable differences between products.

The first example test we will do is called a “difference from control” test. This test is designed to determine whether a difference exists between one or more samples and a control and to estimate the size of any such differences. Generally one sample is designated as the “control” and all other samples are evaluated with respect to how similar or different each sample is from the “control”.

The second test we will do is called a “consumer acceptability test”. This provides information as to how much a consumer likes or dislikes a product and in what areas specifically. For example you can ask them to rank the sweetness, texture, aroma, appearance, and overall acceptability on two products based on a 9 point hedonic scale to determine where the true differences lie.

A 9 point hedonic scale is a scale used to provide numbers or words to express the intensity of a perceived attribute. Numerical values are often assigned to the scale so the data can be treated statistically.

In today’s activity you will be using this scale and we will compare results for the consumer acceptability test.

Assessment

Students should be assessed based on class participation and worksheet completion.

SENSORY ACTIVITY WORKSHEET

Difference from Control – Chocolate chips

Date: 4/14/2016

You have been provided with a tray containing a control sample and 2 coded samples. Please, follow the instructions below:

1. Taste 'control'
2. Taste coded samples and compare with the control
3. Assess sensory difference (in terms of flavor, texture and appearance) between the control and the coded sample
4. Thank you for your participation!

Flavor compared to control

643 **792**

	No difference		No difference
	Slight difference		Slight difference
	Moderate difference		Moderate difference
	Large difference		Large difference
	Very large difference		Very large difference

Texture compared to control

643 **792**

	No difference		No difference
	Slight difference		Slight difference
	Moderate difference		Moderate difference
	Large difference		Large difference
	Very large difference		Very large difference

Appearance compared to control

643 **792**

	No difference		No difference
	Slight difference		Slight difference
	Moderate difference		Moderate difference
	Large difference		Large difference
	Very large difference		Very large difference

Does the quality of chocolate chips differ? Why or why not?

Consumer Acceptability of Chocolate Chip Cookies

Date:

You have been provided with a plate with two samples of cookies.

Please follow the instructions as indicated:

1. **Evaluate each sample starting with the first number listed and continue down the page and until you have evaluated each sample.**
2. **Rate each sample in each of the categories listed and place a check mark to indicate your choice.**

Sample 854	**Appearance**	**Aroma**	**Flavor**	**Texture**	**Overall Acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

Sample 460	**Appearance**	**Aroma**	**Flavor**	**Texture**	**Overall Acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

Comments

APPENDIX M

PRE- AND POST-SURVEY

Food Science Pre-Test

Q. Gender

What is your sex?

- Male
- Female

Q. Age

In what year were you born? ______

Q. Grade Level

What grade are you currently enrolled in? _______________

Q. Class

What class are you in?

- *Biology*
- *Chemistry*

Directions: Please circle the letter for the best answer to your knowledge. Each question has one answer.

1. When an acid, such as vinegar, is added to milk, the protein comes out of solution making it "snow". This is similar to what process in the Dairy Industry?

A. Making cheese curds
B. Making whey protein
C. Making buttermilk
D. Both A & B

2. Papain is the main enzyme in ________.

A. Fig
B. Pineapple
C. Papaya
D. Potato

3. To make gummy worms, the sugar solution should be heated to the same temperature as when making lollipops.

A. True
B. False

4. A sugar and water solution that is heated to make lollipops has more sugar dissolved in water than normally possible. This is called _________.

A. Unsaturation
B. Supersaturation
C. Saturation
D. Polyunsaturation

5. Which of the following is **not** a functional property of sugars?

A. Sweetens
B. Texture
C. Adds structure due to protein
D. Adds structure due to crystallization

6. What is the definition of water activity?

A. A measure of the glucose molecules in food to cause microbial, enzymatic, or chemical reactions
B. A measure of the water that has evaporated from the food
C. A measure of the amino acids in food to cause microbial, enzymatic, or chemical reactions
D. A measure of the availability of water molecules in the food to cause microbial, enzymatic, or chemical reactions

7. What is the definition of an acidic food?

A. A food that has a pH of 4.6 or below
B. A food that has a pH of 8.6 or higher
C. A food containing mostly water, e.g., lettuce and milk
D. A food containing mostly starch and has a pH higher than 7.0

8. Starch is a large number of glucose units joined together.

A. True
B. False

9. Which water activity level in food would lead to high perishability?

A. 97%
B. 73%
C. 45%
D. 12%

10. Cuts of meat under vacuum pressure ________. This helps a marinade mix in with the protein fibers.

A. Expand
B. Rise
C. Collapse
D. Denature

11. Homogenized milk is an emulsion with _________ suspended in the water portion of milk.

A. Proteins
B. Fat globules
C. Sugars
D. Calcium

12. Canning preserves foods by:

A. Preventing exposure to oxygen
B. Destroying enzymes
C. Preventing growth of bacteria, yeast, and mold
D. All of the above

13. Crystal formation in sugar solutions decreases due to all of the following except _________.

A. Agitation (Stirring)
B. Heating
C. Fat content
D. Protein content

14. Certain enzymes can denature proteins.

A. True
B. False

15. The number of ___________ and ____________ influences the melting point of some common fats/oils.

A. Carbon atoms, saturation
B. Carbon atoms, plasticity
C. Hydrogen atoms, saturation
D. Hydrogen atoms, plasticity

16. What food factor(s) comprise perception of taste?
    A. Aroma
    B. Texture
    C. Flavor
    D. All of the above

17. Decreasing the moisture content increases the products shelf life.
    A. True
    B. False

18. One of the most important ingredients in many meat products, such as hotdogs, is ______.
    A. Salt
    B. Calcium
    C. Egg whites
    D. Organs

19. After cream is churned into butter, the liquid leftover is called _______.
    A. Skim Milk
    B. Buttermilk
    C. Whey
    D. Whole Milk

20. All of the following are examples of foods made from fermentation except:
    A. Pickles
    B. Bread
    C. Wine
    D. Jelly

21. Adding fresh pineapple to a Jell-O recipe will keep the Jell-O from setting up.
    A. True
    B. False

22. Water on the surface of a food being fried is replaced by the oil. This is why it "pops".
    A. True
    B. False

23. Horseradish, peppermint, chili pepper, and wasabi are examples of foods that provide a ___________.

A. Stimulus
B. Trigeminal Effect
C. Chemical Effect
D. All of the above

24. Every food item has its own unique moisture content.

A. True
B. False

25. ________ soluble proteins help tenderize meat when exposed to marinades.

A. Water
B. Fat
C. Salt
D. Acid

26. Milk has __ main protein(s).

A. 3
B. 1
C. 4
D. 2

27. The products produced after yeast fermentation are _________ and ___________.

A. Carbon dioxide, alcohol
B. Acid, alcohol
C. Carbon dioxide, bacteria
D. Acid, bacteria

28. Butter is a fat and water emulsion called a(n) __________.

A. Hydrocolloid
B. Hydrophilic system
C. Amphipathic system
D. Hydrophobic system

29. The melting point of all fats/oils are the same.

A. True
B. False

30. If we cannot smell our food, we cannot properly taste our food.
    A. True
    B. False

31. Water is usually a _______ portion of the foods we eat.
    A. Small
    B. Medium
    C. Large

32. Proteins are affected by pH changes.
    A. True
    B. False

33. Which method is **not** a method of preservation?
    A. Dehydration
    B. Baking
    C. Salting
    D. Fermentation

34. Enzymes are destroyed by freezing.
    A. True
    B. False

35. Which of the following is considered a saturated fat?
    A. Canola Oil
    B. Lard
    C. Olive Oil
    D. Peanut Oil

36. All people have the same sense of taste.
    A. True
    B. False

37. Which is not a significant source of protein?
    A. Bananas
    B. Soy beans
    C. Beef
    D. Milk

38. Oil and water can be mixed when _________ is added.
   A. Air
   B. More oil
   C. More water
   D. An Emulsifier

39. Fatty Acids are also known as _______.
   A. Lipids
   B. Carbohydrates
   C. Proteins
   D. Minerals

40. Which taste is **not** detectable by everyone?

   A. Sweet
   B. Bitter
   C. Sour
   D. Salty

41. Are you familiar with the term "food science?"

   A. Yes
   B. No
   C. Maybe
   D. Not sure

42. Food science is the same as Nutrition.
   A. Yes
   B. No
   C. Maybe
   D. Not sure

43. I am interested in food science.
   A. Yes
   B. No
   C. Maybe
   D. Not sure

44. Do you want to learn more about food science?

A. Yes
B. No
C. Maybe
D. Not sure

45. I would consider a college degree in food science.

A. Yes
B. No
C. Maybe
D. Not sure

APPENDIX N

IRB APPROVAL DOCUMENT

Protocol Title: Effectiveness of Implementing a Food Science Curriculum into High School Biology as Compared to High School Chemistry

Protocol Number: 15-397

Principal Investigator: Ms. Lauren Elizabeth Ivey

Date of Determination: 1/22/2016

Qualifying Exempt Category: 45 CFR 46.101(b)(2)

Dear Ms. Ivey:

The Human Research Protection Program has determined the above referenced project exempt from IRB review.

Please note the following:

- Retain a copy of this correspondence for your records.
- An approval stamp is required on all informed consents. You must use the stamped consent form for obtaining consent from participants.
- Only the MSU staff and students named on the application are approved as MSU investigators and/or key personnel for this study.
- The approved study will expire on 9/1/2016, which was the completion date indicated on your application! . If additional time is needed, submit a continuation request. (SOP 01-07 Continuing Review of Approved Applications)
- Any modifications to the project must be reviewed and approved by the HRPP prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project.
- Per university requirement, all research-related records (e.g. application materials, letters of support, signed consent forms, etc.) must be retained and available for audit for a period of at least 3 years after the research has ended.
- It is the responsibility of the investigator to promptly report events that may represent unanticipated problems involving risks to subjects or others.

This determination is issued under the Mississippi State University's OHRP Federalwide Assurance #FWA00000203. All forms and procedures can be found on the HRPP website: www.orc.msstate.edu.

Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact me at amassey@orc.msstate.edu or call 662-325-3294.

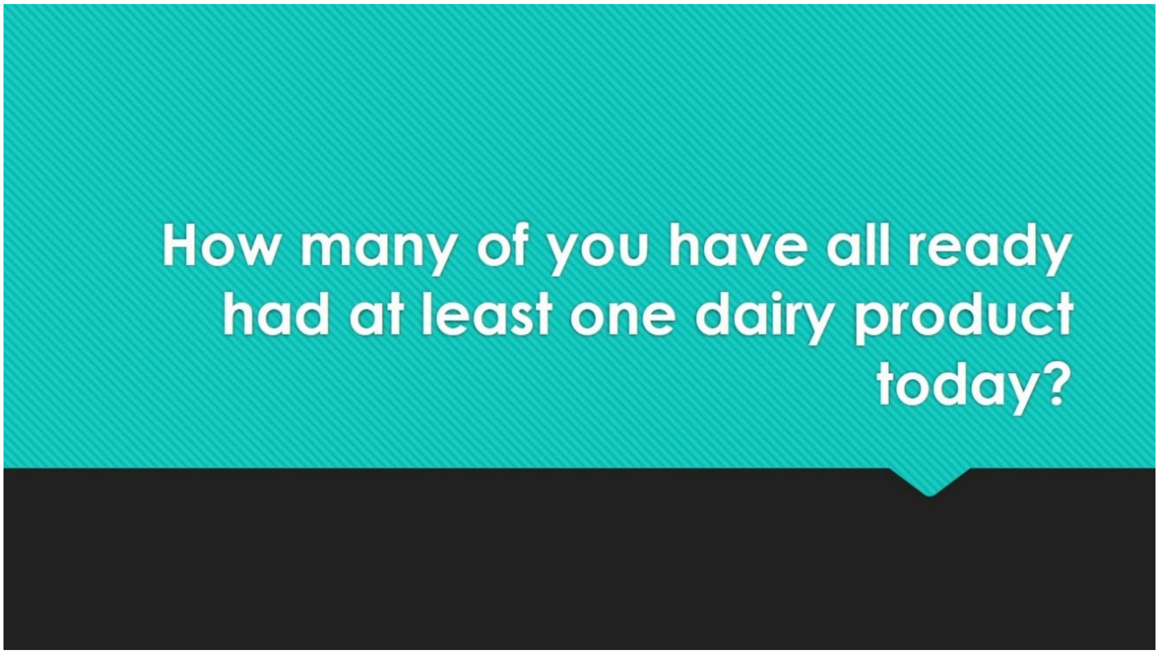
Finally, we would greatly appreciate your feedback on the HRPP approval process. Please take a few minutes to complete our survey at https://www.surveymonkey.com/s/PPM2FBP.

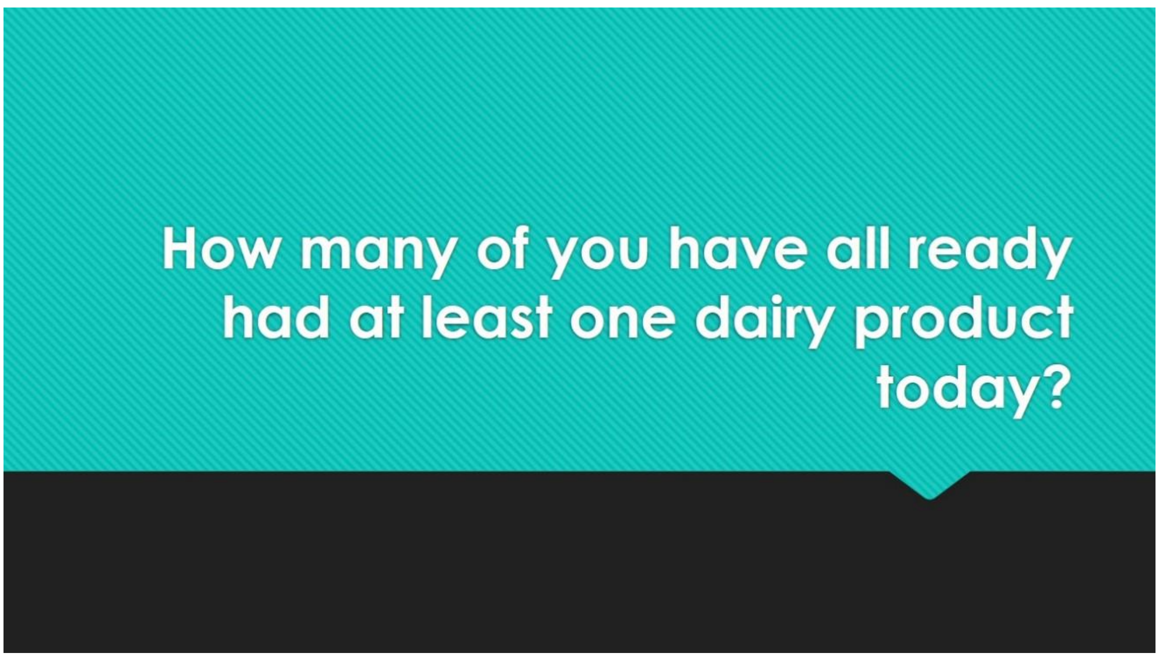
Sincerely,

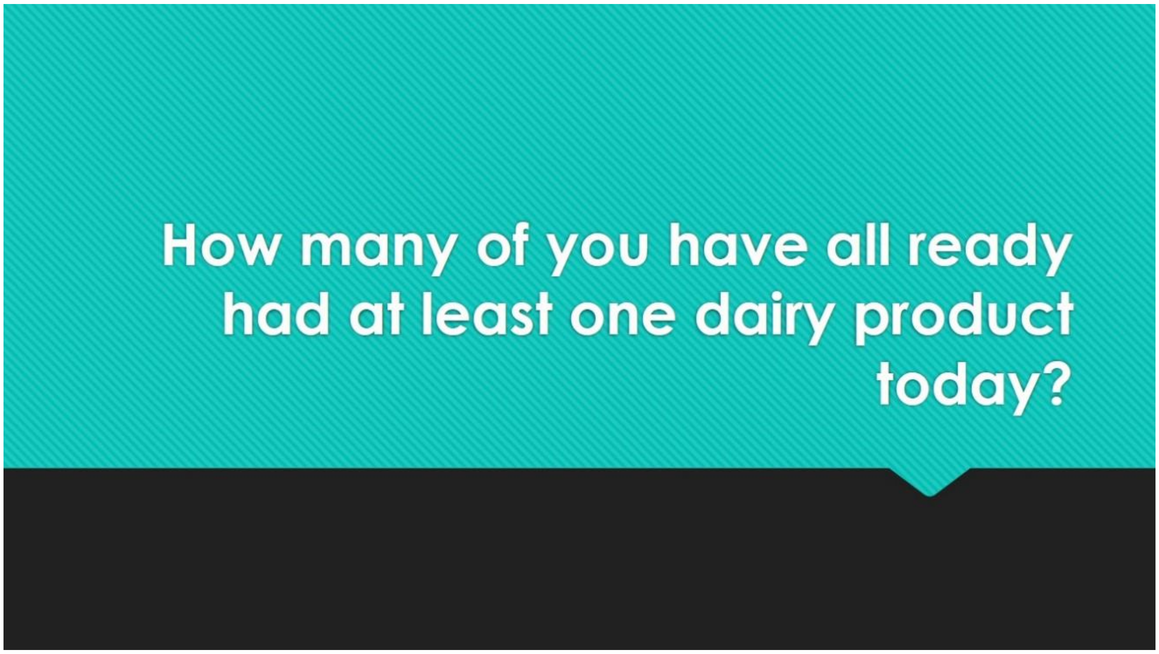
Ashley Massey

Assistant Compliance Administrator

cc: Mark Wes Schilling, Advisor


How many of you have all ready had at least one dairy product today?


How many of you have all ready had at least one dairy product today?



HOW SWEET IT IS! *Student Handout*

Introduction:

Sucrose (Figure 1) (drawn on board), or common table sugar, is a carbohydrate and is a major source of calories and energy in the human diet. Because of the interest in low-calorie and low-sugar foods that has developed over the last few decades, interest has grown in using low-calorie or no-calorie sweeteners. Stevia (Figure 2) (drawn on board), is unique among food ingredients because it's most valued for what it doesn't do. It doesn't add calories. Unlike other sugar substitutes, stevia is derived from a plant. Sucralose (Figure 3) (drawn on board), is another sweetener on the market and is known by the trade name Splenda®. Sucralose is made through a process that converts sucrose to a non-caloric, non-carbohydrate sweetener by replacing three –OH groups on the sucrose molecule with three Cl atoms. Saccharin (Figure 4) (drawn on board), the world's oldest low-calorie sweetener, is known by the trade name Sweet'N Low®. Saccharin is a synthetic compound derived from toluene. Table sugar is refined from sugarcane and sugar beets and is considered the standard when measuring the sweetness of compounds. Compared to sucrose, artificial sweeteners exhibit much more intense sweetness. Saccharin is 300-times sweeter than sucrose, while sucralose is 600-times sweeter than sucrose and stevia is 200-times sweeter than sucrose.

Purpose:

To identify common food sweeteners, sucrose, stevia, saccharin, and sucralose, by comparing sweetness intensity rankings of solutions of each compound.

Materials:

1. 4 Sweetener solutions (A, B, C and D)
2. Cup of water
3. Saltine® crackers
4. Napkin

Intensity Ranking:

Sample each solution, from A to D. Rank (1 being least intense and 4 being most intense) the sweetness of each solution.

Sample

Sweetness Intensity   Ranking Comments

A __________   __________________________

B __________   __________________________

C __________   __________________________

D __________   __________________________

Post-Laboratory Questions:

1. Identify solutions A, B, C and D as sucrose, stevia, saccharin, or sucralose based on your sweetness intensity rankings.

A. ________________________

B. ________________________

C. ________________________

D. ________________________

2. Other than sweetness intensity, what differences did you detect among the samples?

____

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3. Can you change sucrose for another sugar seen today in a recipe equally? (cup for cup) Why or why not?

____

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