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Dishing up Science: Integrated Content Links History, Microbiology, and Nutrition

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INTRODUCTION

Childhood obesity is a public health epidemic (1), and research has suggested both home-cooked meals (2) and multicomponent, school-based education programs that incorporate nutrition across the curriculum (3–4) as beneficial in combatting this epidemic. Historical processes, such as food preservation before refrigeration and the use of herbs and spices to slow down bacterial growth, link nutrition with microbiology and history and can help integrate nutrition education with other subjects, though examples of museum programming for children may incorporate science topics less frequently (5). The U.S. Department of Agriculture recognizes food safety as an integral part of healthy eating within their dietary guidelines (6), creating a unique and important opportunity for microbiology education in the context of food safety while preparing food at home and transporting it to school. Although home-cooked meals are associated with higher diet quality and greater compliance with dietary guidelines (7), extra steps need to be taken to keep food safe (8). Given that teachers cite many barriers to teaching nutrition education, including core academic subjects taking up the majority of time and limited resources (9–12), developing interdisciplinary lessons that incorporate nutrition and food safety into other subjects is ideal. For instance, research at middle schools in Massachusetts pilot tested an interdisciplinary program called Planet Health, which integrated health goals into core content lessons in areas such as math and language arts. Overall, teachers found the integrated content easy to teach (13). Thus, the purpose of this project was to create easy-to-demonstrate experiments illustrating key microbiology processes in a simplified manner at a level that is appropriate for elementary school-aged students visiting a historic home. The activities were designed to be implemented by museum staff during a field trip or by teachers afterwards and could be modified depending on the grade level; for example, what may be a full experiment for fifth graders could be a teacher-led demonstration for first grade or for a larger class in which support is limited.

MATERIALS AND METHODS

Literature search

Historical food preservation and the science behind food preservation methods were researched using the Kean University Library, PubMed, and Google Scholar. Lessons with visual aids and a hands-on experiment were created. There were no safety concerns, since the students were not exposed to microorganisms. The researchers partnered with Liberty Hall Museum, located on Kean University's campus in Union, NJ, which creates programming for school groups and families with the help of students and faculty. Museum programs often include children of multiple ages; therefore, the activities were developed to be flexible so that elementary teachers and museum staff could adapt them as needed. Pilot testing occurred in the museum with museum staff, students, and teachers directly participating because the lessons were designed specifically for museums and their staff to use with teachers and students. The idea was to help museum staff show teachers how to connect concepts learned at the museum with lessons back in their classrooms. New Jersey learning standards were consulted to ensure that content and materials developed aligned with standards (14), and a microbiologist was consulted to confirm the content's relevancy. The specific standards to which these activities align are grades K to 2, making observations to collect data that can be used to make comparisons, grades 3 to 5, planning and carrying out investigations, grade 4, explaining how creativity and innovation lead to scientific advancement, and grade 5, understanding and explaining that plants and animals have both internal and external structures that serve different purposes such as growth, survival, behavior of organisms, and reproductive capacity (14).

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FIG 1. Sample cards (front/back) from herbs matching game. Thyme.

Results from the literature search found that common properties of colonial herbs and spices included protecting cells from oxidation, destroying bacterial cell membranes, inhibiting cancer cells, and inhibiting the bacterial cell's ability to synthesize DNA and proteins (15–16). Research found that essential oils derived from herbs and spices such as thyme, oregano, and cloves lead to a reduction in microorganism growth (17–21) and that these effects persist even after cooking and food preparation (16). Herbs and spices have phenolic compounds that contain antimicrobial properties which inhibit bacterial growth (22–23). These phenolic compounds are able to penetrate bacterial cell walls and membranes, causing the contents of the cytoplasmic membrane to leak out and clump together, destroying its structure (22–23). Temperature has also been found to inhibit bacterial growth, with colder temperature slowing down the growth rate of microorganisms (24). Lastly, using different solutions such as sugar and sodium chloride on fruits and vegetables helps to slow down browning due to water removal from osmotic dehydration (25).

Lesson design

The first lesson focused on medicinal uses of herbs and spices grown at Liberty Hall. An instructor's guide was developed to provide step-by-step instructions for teacher implementation of this activity in the classroom or for museum staff to use during educational programming (Appendix I). A group activity illustrated antimicrobial properties of herbs and spices in destroying bacteria (Fig. 1). Herb properties were illustrated with a gelatin experiment that compared a recipe made with salt to a conventional recipe. The instructor's guide provides detailed directions for the teacher to implement in the classroom or for museum staff to use during educational programming (Appendix II). After 45 min, the gelatin with salt added had not set. The control, made without salt, solidified (Fig. 2). This demonstrated a bacteria cell membrane that is no longer intact, for example, following treatment with herbs like thyme or clove. A lesson explaining early methods of food preservation was also developed.

The second experiment tested how well salt, acid, and sugar protected an apple from oxidation (browning). After 15 min, apple slices treated with salt showed less browning than the control without treatment (Fig. 3). Treatment with sugar syrup and lemon allowed more browning compared to that with salt but less than the control. This illustrated how creating a barrier between the fruit tissue and air, for example by canning, decreases oxidation and helps preservation. Adding a salt or sugar solution also disrupts osmosis, which inhibits microorganisms (25). Verbal feedback during pilot testing indicated that museum staff and teachers planned to use the experiments with their classes, and families and elementary school-aged students were enthusiastic about the activities and the learning experience they had.

FIG 2. The effects of salt on the ability of the gelatin to solidify. Thyme essential oil has been shown to bind to cell membrane proteins and change what is allowed to pass through the membrane (permeability).

There are also beneficial microorganisms that help to preserve food, are beneficial for gut health, and could be discussed as part of future lessons; for example, *Lactobacillus*, commonly found in sauerkraut and yogurt, is used to preserve fermented foods and generate probiotics (26). Furthermore, canning can be used to help preserve fermented foods and slow down the spoiling process (27). Fermentation can be illustrated with school-aged children by mixing sugar, water, and yeast in a small cup and watching the liquid bubble over in the cup as the yeast breaks down the sugar to make carbon dioxide.

CONCLUSION

These experiments could be used by museum educators and teachers to connect nutrition, history, and science with basic supplies and no microorganism exposure while aligning with microbiology research and educational standards. The current project pilot tested these activities in the context of a museum program for schools, families, and teachers; future research should test efficacy within a classroom setting for teachers who prefer to use the materials after visiting the museum with their classes.

These activities could provide greater learning opportunities for students about microbiology and food safety. User-friendly content makes it simple for teachers and museum staff without a science background to be able to teach integrated nutrition content. Hands-on experiments to demonstrate food preservation techniques could allow school-aged students to learn about the important processes of microorganisms and food spoilage outside the confines of the science classroom, which helps them connect nutrition, microbiology, and history to their everyday world. However, these activities are simplified for the target audience and would not be appropriate for more advanced learning or older students regarding microbiology processes. This project illustrated new possibilities for teaching multidisciplinary/integrated nutrition content and meets a practical need by suggesting a way to eliminate major barriers cited by teachers for nutrition education (1–4). In addition, it provides an example of an opportunity for interdisciplinary collaboration between science educators, teachers, and museum staff focusing together on food safety and health.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

SUPPLEMENTAL FILE 1, DOCX file, 4 MB.

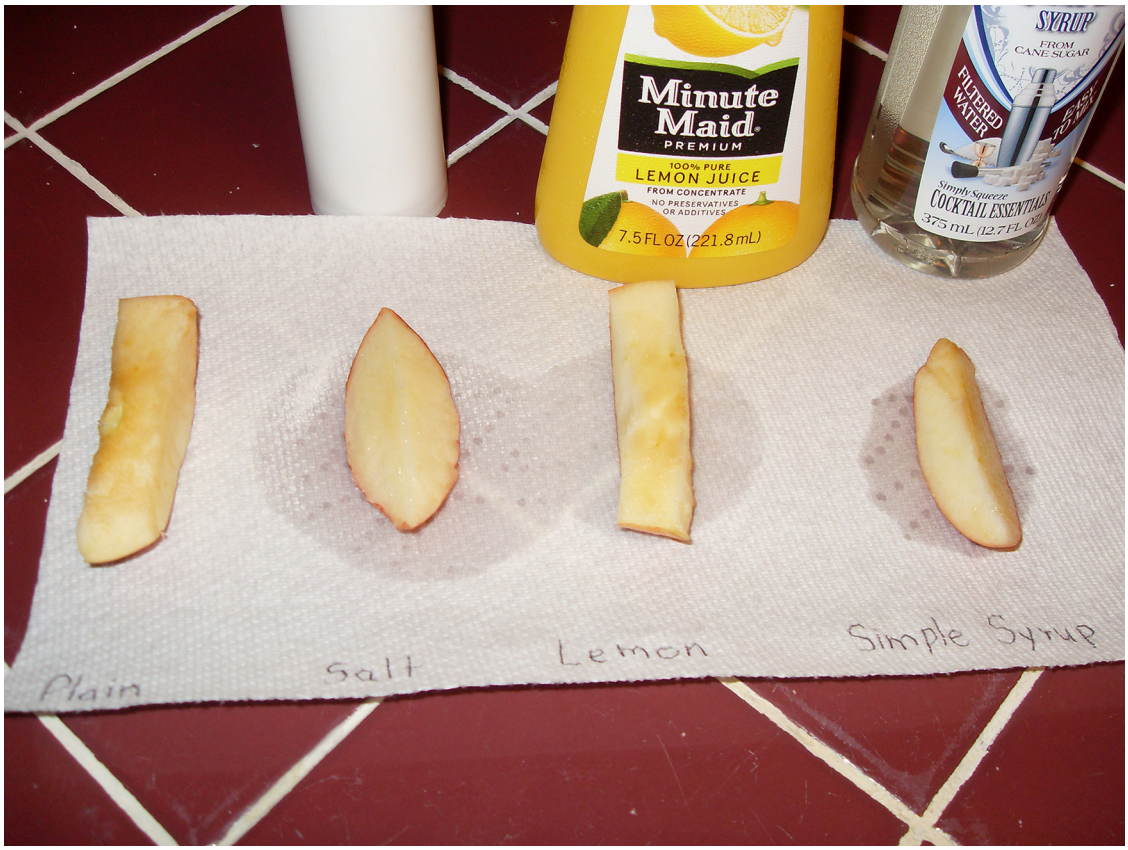

FIG 3. The effects of lemon, salt, and sugar on oxidation in apples.

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