Comparing Online Soybean Processing Module Including a Laboratory Component to On-Campus Module

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Abstract

Hands-on learning activities enhance course outcomes in college courses based on increased exam scores and student satisfaction; however, online courses pose challenges for creating hands-on learning opportunities. The objective of this study was to compare online and on-campus students' perception and performance on a soybean processing and products module with a laboratory component. The modules included identical lectures and discussion board questions. Students then participated in a hands-on laboratory exercise at home or on-campus investigating the effect of added soy protein at various levels on muffins physical and sensory properties. Baking kits were mailed to online students. All students were given detailed written instructions on how to prepare muffins for the exercise. Upon completion of the laboratory exercise, students wrote a scientific abstract on their findings. At the end of the module, all students (n=194) completed an assessment survey about their perception of the module. Seventy-two percent of online students met or exceeded expectations on the abstract assignment while 92% of on-campus students met or exceeded expectations. In both courses, ninety percent of students agreed or strongly agreed the laboratory improved their ability to apply knowledge to practical issues. Regarding knowledge gained, students reported an increased awareness of products that contain soy and methods for processing soybeans into ingredients. A common response was that students would be more likely to try soy products in the future because they were less concerned with off flavors and interested in the nutritional benefits of soy products.

Keywords: soybean products, online learning, laboratory exercise

In the fall of 2019, 36% of all undergraduate students at United States (U.S.) universities were enrolled in at least one online course, and 15% of all undergraduate students were enrolled exclusively in online courses (Irwin et al., 2021). During the COVID-19 pandemic, online course enrollment increased further as universities closed physical campuses. In the fall 2020 semester, 61% of undergraduates reported a change in class format from in-person to online or hybrid models.

During the COVID-19 pandemic faculty rapidly adapted course material for online courses. Laboratory components pose unique challenges when adapted for online learning, however, the inclusion of hands-on learning is important. Hands-on activities increase retention of learning outcomes and develop soft skills desired by potential employers (Hollis & Eren, 2016). In a 2005 survey by Purdue University, food science industry members rated the importance of the core competencies given by the Institute of Food Scientists (IFT). Success Skills plus Applied Food Science Knowledge were rated as most important content categories (Morgan et al., 2006). Success skills include oral and written communication, critical thinking, professionalism, information acquisition, teamwork, and organization (Hartel, 2001). In addition to these success skills, employers also expect graduates to be able to apply food science principles to practical issues. The demand for graduates with these skills presents an opportunity for undergraduate programs to improve the career readiness of their graduates. Online courses that include hands-on activities designed for a home environment provide experiences that are typically gained in on-campus courses. Educational programs that implement these activities better serve students by preparing them to meet industry demands.

One approach for hands-on activities that also encourages application of food science principles is problem-based learning. Instructors that implement problem-based learning present students with an issue and encourage them to explore solutions (Yew & Goh, 2016). A current problem the food industry faces is developing products that meet demand for protein-rich convenience foods (Sloan, 2020). Brands that feature high protein foods have experienced an increase in sales. For example, total sales for the high-protein bakery brand, Kodiak Cakes, grew from $6.7 million in 2014 to $160 million (Peckenpaugh, 2020). A 2021 Food and Health study found that 62% of Americans ages 18-80 are trying to consume more protein (International Food Information Council, 2021). In addition to demanding more protein, consumers are more informed when choosing a protein source. Consumption of plant-based, complete proteins is important to 67% of adults that purchase protein foods (USB 2019). To meet the demand, food companies must develop plant-based, protein-rich foods that maintain quality characteristics of non-fortified products.

Soy protein is of interest in baked goods with added protein because it is a highly digestible plant-based protein (Annor et al., 2014). Soy protein has a Protein Digestibility Corrected Amino Acid Score (PDCAAS) of 1.0, similar to meat, dairy, and eggs (Hughes et al., 2011). Quick breads such as muffins are inexpensive and easy to prepare, and these qualities allow online undergraduate students to prepare multiple treatments with added soy protein and observe differences at home. The objectives of this study were to 1) develop an online module with a laboratory component covering the addition of soy to foods and 2) compare students' perceptions and performance with a similar on-campus module in an undergraduate food processing course.

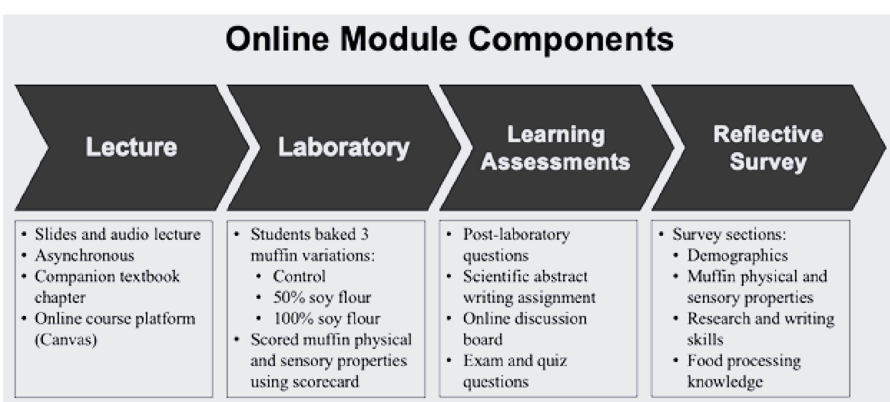
Methods

The online module was first implemented in fall 2020 in the online Kansas State University Fundamentals of Food Processing (FDSCI 305) course and repeated across four additional semesters (spring 2021, summer 2021, fall 2021, and spring 2022). The K-State FDSCI 305 course is taught at the sophomore level; however, the course is open to all undergraduate students. A total of 94 students were enrolled across all five semesters. Students accessed course materials via the online learning platform Canvas (Instructure, Inc., Salt Lake City, UT).

The module consisted of an audio lecture with slides that covered background information on soy products processing, a companion textbook chapter (see lecture section), a hands-on laboratory exercise, a discussion board question, and exam and quiz questions (Figure 1). At the end of the module in both semesters, students voluntarily completed a student reflective survey to assess module efficacy.

Figure 1.

Summary of module components



Lecture

Instructors (authors) provided students with a prerecorded audio lecture with slides on Canvas. A companion textbook chapter from Food Processing: Principles and Applications titled “Crops — Legumes” by Annor, Ma, & Boye (2014) was used to develop the lecture. Topics covered included soybean production, composition, nutrition, and processing methods. The lecture also included an overview of common ingredients made from soybeans, including soybean oil, soy flour, soy milk, and soy protein. To connect the lecture to the laboratory exercise (preparation of soy muffins), the advantages and disadvantages of soy as an ingredient in foods were discussed.

Laboratory Exercise

Online students completed a hands-on laboratory exercise in their home kitchens. The purpose of the exercise was to encourage students to explore soy protein as an ingredient for increasing the protein content in muffins and to evaluate the effect on muffin physical and sensory properties. Laboratory instructions were provided to students including formulations, muffin preparation steps, a muffin score card, post-laboratory questions, abstract writing instructions, abstract grading rubric, and supporting material.

Students were informed about the increased demand for protein-rich baked goods and explored muffins enriched with defatted soy flour to fill this demand. Students investigated the effect of defatted soy flour (Prolia® FLR-200/70), donated by Cargill (Minneapolis, MN), on physical and organoleptic properties of muffins. Baking kits containing three muffin mixes (Table 1) were prepared by the teaching assistants and mailed to students to reduce the chances of experimental error. Each mix contained a commercial muffin base (Muffin Base 10 2.0; Product #139037) donated by Corbion (Lenexa, KS) plus added flour and granulated sugar. For the control mix, 100% of the added flour was all-purpose flour. The added flour in the 50% soy flour mix contained 50% soy flour and 50% all-purpose flour. The added flour in the 100% soy flour mix contained 100% soy flour. Students followed the laboratory instructions to prepare muffins in their home kitchens using their own oil, eggs, and water (Tables 2 and 3).

Table 1.

Muffin mix formula variations with gravimetric measurements

	Weight (g)		
Ingredients	**Control**	**SF50**	**SF100**
Soy Flour	0.0	50.6	101.2
AP Flour	101.2	50.6	0.0
Sugar	124.6	124.6	124.6
Muffin Base[1]	59.4	59.4	59.4

Note. [1]Muffin Base Ingredients: Enriched Wheat Flour (Wheat Flour, Niacin, Reduced Iron, Thiamine Mononitrate, Riboflavin, Folic Acid), Modified Corn Starch, Corn Syrup Solids, Whey (Milk), Soybean Oil, Sodium Aluminum Phosphate, Salt, Sodium Bicarbonate and 2% or Less of Each of the Following: Propylene Glycol Esters of Fatty Acids, Xanthan Gum, Mono- and Diglycerides, Sodium Stearoyl Lactylate (SSL), Sodium Carboxymethyl Cellulose, Diacetyl Tartaric Acid Esters Of Mono-Diglycerides (DATEM), Artificial Flavor.

Table 2.

Muffin mix formula variations with gravimetric measurements

	Amount		
Ingredients	**Control**	**SF50**	**SF100**
Muffin Mix[a]	1 package	1 package	1 package
Oil[b]	1/2 cup	1/2 cup	1/2 cup
Eggs[b]	2 whole eggs	2 whole eggs	2 whole eggs
Water[b]	1/3 cup	1/3 cup	1/3 cup

Note. [a]See Table 3.1 for muffin base ingredients,
[b]Purchased and measured by students

Table 3.

Muffin mixing and baking instructions

1. Preheat oven to 375°F (190.6°C). Line a standard muffin tin with 6 paper muffin cups/liners or spray with Pam/no-stick cooking spray or grease with shortening.
2. In a large mixing bowl combine control muffin base, oil, and egg and mix for 1 minute. Below is an image of what the batter should look like at this stage.
3. Add cold tap water and mix for 1 minute. Below is an image of what the batter should look like at this stage. Take pictures of each batter after mixing (3 pictures total) (6 pts.). Insert your pictures on page 12

4. Spoon batter evenly into prepared pan filling cups ¾ full.
5. Bake the muffins for about 20 minutes. If you have a thermometer, you should test for doneness using the thermometer first. Muffins are done at around 200°F. From a food quality standpoint, muffins should be a pale golden brown and a toothpick inserted into the middle of a center muffin should come out clean. Commercial food facilities rely on both methods to ensure a safe and satisfactory product. From a food safety standpoint, baking at 190.6°C for at least

Table 3 Cont.

Muffin mixing and baking instructions

17 minutes will reduce *Salmonella* by ≥5 logs (Channaiah et al. 2017).

6. Remove muffins from oven and let cool completely.
7. Repeat with variations SF50 and SF100.
8. Take pictures of the muffins for each variation (2 pictures total) (8 pts.). See example below. Insert your pictures on page 13.

Side view

Top view

Control SF50 SF100

After preparing the muffins, students evaluated physical and organoleptic properties according to a muffin score adapted from Foods: Experimental Perspectives (McWilliams, 2001). The scorecard was divided in two sections: external and internal qualities. External qualities included volume, contour, and crust color while external qualities included crumb color, cell uniformity and size, thickness of cell walls, texture, flavor, and aftertaste. Within each section muffin quality descriptions with corresponding numerical scores were given. The last section of the scorecard includes a rating for overall acceptability from 1 (very unacceptable) to 5 (very acceptable). Upon completing the lab, students were assigned post-laboratory questions to guide their reflection of the hands-on exercise. As a resource for answering the post-laboratory questions, the laboratory instructions included background information on muffin quality parameters and a muffin commercial item description (CID) from the United States Department of Agriculture's (USDA) Agricultural Marketing Service (AMS) (2021).

Student Learning Assessment

Students wrote a scientific abstract to present their findings and make a recommendation on a level of soy flour for further research. The laboratory instructions provided students with information on writing scientific abstracts and the grading rubric (Table 4). A sample abstract from a relevant paper was included with annotations explaining different sections of an abstract to assist students in writing their abstracts. Abstracts were graded using the rubric with the following sections: introduction, objectives, materials and methods, results, professional writing, and length. Student understanding also was assessed with post-laboratory questions, a discussion question assignment, ten-question quiz, essay exam question (Tables 5 and 6).

On-Campus Module Summary

Student data for the on-campus module was collected in the Spring 2021 and Spring 2022 on-campus Fundamentals of Food Processing courses. Students attended an in-person lecture with the same slides, content, and verbal explanations as the online lecture. The laboratory exercise was modified to include more treatments to accommodate a large class and to utilize lab equipment not typically available in a home setting such as digital calipers and scales. Post-laboratory questions, discussion questions, quiz questions, and the exam essay question were kept consistent between online and on-campus modules. Students responded to similar reflective surveys anonymously online. The main difference between the surveys was Question 13 which references the students' ability to work independently (in the online class) or as a group (in the on-campus class).

Student Reflective Survey

A survey was modified from Heerman et al. (2020) to assess students' perception of the soybean module and at-home laboratory exercise. The study was reviewed and approved by the Institutional Review Board under IRB number 10248. Informed consent was obtained from each subject prior to completing the reflective survey. All students enrolled in Fundamentals of Food Processing completed the module assignments (exam and quiz questions, laboratory exercise, report) as part of the course, while participation in the reflective survey was optional and anonymous. The survey was distributed to online and on-campus students using a link to the online survey platform Qualtrics (Provo, UT; Seattle, WA). Students who completed the survey earned five bonus points towards their class grade. To maintain anonymity, bonus points were awarded based on submission of a screenshot of the "End of Survey" webpage. Bonus points may have created some bias but was consistent for both modules. At the end of the survey a debriefing statement was provided.

Table 4.

Grading rubric for soy muffin lab abstract

Abstract Criteria (21 points total)	Exceeds Expectations	Meets Expectations	Below Expectations	No Expectations Met
Introduction (3 points)	Clear, concise, engaging; describes, connects the topic to literature and objectives (3 points)	Clear, but not engaging; Attempts to connect to literature (2 points)	Unclear; does not connect to literature (1 point)	Missing (0 points)
Objectives (3 points)	Clear, concise, and relevant; provides purpose of the study (3 points)	Clear but not concise; might contain irrelevant information; lacks specifics (2 points)	Unclear; contains irrelevant or unimportant information (1 point)	Missing (0 points)
Materials and Methods (4 points)	Identifies materials and methods used to answer the research question (3.5-4 points)	Somewhat identifies materials and methods used to answer the research question (3 points)	Minimally, identifies materials and methods used to answer the research question (2.5-1 points)	Missing (0 points)
Results (5 points)	Clear; provides explanation of what was expected, discovered, accomplished, collected, produced (4.5-5 points)	Attempts to present findings but might be unclear; some information missing (3-4 points)	Unclear or misinterpretation of the results (1-2.5 points)	Missing (0 points)
Professional Writing (5 points)	Few grammatical errors or typos; mixed verb tense (4.5-5 points)	Few grammatical errors or typos; mixed verb tense (3-4 points)	Many grammatical errors, typos but do not impeded understanding, inappropriate verb tense (1-2.5 points)	Grammatical errors, typos impede understanding, inappropriate verb tense (0 points)
Length (1 point)	275-300 words (1 point)	275-250 words (0.50 points)	Less than 250 words (0.25 words)	Only 100 words or less (0 points)

Table 5.

Post Laboratory Learning Assessment Questions

Post Laboratory Questions

1. Explain the difference between a variation and a replication.
2. Create a flow diagram of how a muffin processing line might look in a commercial setting. This can be handwritten and attached as a picture, created in excel and attached as a separate document, or pasted below. Make sure you include receiving of ingredients AND packaging material and storage of ingredients AND packaging material.
3. List 2 advantages and 2 disadvantages of soy as an ingredient in food.
4. What are the variations in this experiment? This will be different levels of the independent variable.
5. What is being measured in this experiment? List at least 3 measurements.

Use the Pre-Lab Information and Supporting Material to answer the following questions. Circle the answer.

6. T or F Muffins made with bread flour are likely to have tunnels because of the high gluten potential.
7. T or F Excessive baking soda results in a muffin with a soapy, bitter flavor and a yellow color and coarse texture.
8. T or F Wrapping muffins before cooling will increase the shelf life by increasing the moisture content.
9. T or F According to the information and your observations, the protein content in soy flour causes more Maillard browning reactions to occur.
10. T or F Adding ham, cheese, or dried fruits to muffin batter will decrease the shelf life of muffins.
11. T or F The CID for muffins does not require the use of Grade A Pasteurized milk.
12. T or F There are specific age requirements for both fresh and frozen muffins that are determined by time and temperature parameters.

Table 6.

Discussion, Essay, and Quiz Learning Assessment Questions

Discussion Questions	
After watching the soybean lecture and completing the soy muffins lab, how has your perception of soybeans or soy as an ingredient changed? What benefits do you see for consuming soybeans and soy products? Are there any barriers for you personally consuming soy?”	
Essay Question	
Identify one product made from soybeans. Describe the processing steps required to make the product. List two nutritional benefits of consuming soy. List one barrier to soy consumption discussed in the lecture.	
Quiz Questions	
A product extracted from soybeans similar to eggs that serves as a binding agent:	
A. Soybean oil	C. Lecithin
B. Soy protein	D. Soybean meal
Fermentation assists with the following:	
A. Deactivating the antioxidant activity	C. Improving nutrient digestibility
B. Decreasing the phenolic compound concentration	D. All of the above
True or False: Soybeans may turn a purple color due to drought and a specific fungus problem.	
Match the soy product with a specific food application.	
1. Traditional foods	A. Miso
2. Okra	B. High fiber breads
3. Non-traditional foods	C. Soynut butter
4. Lecithin	D. Emulsifying agents
	E. Isoflavones
Match the term with the definition.	
1. Canning	A. Commerical Sterile
2. High-pressure cooking	B. Hydrostatic Pressure
3. Extrusion	C. Twin-screw pushes product through a die
4. Soaking	D. Softens cotyledon

Results and Discussion

Student Learning Assessment

Scientific Abstract Assignment

All abstract assignments were graded by the same course teaching assistant and author. Some bias may have been introduced due to the lack of an independent grader, however, the grader remained consistent for all students and a rubric was used to standardize scoring. In the online course 72-93% of students met or exceeded expectations on every rubric section (Figure 2). In the on-campus course 92-98% or more of students met or exceeded expectations on every rubric section. Students in the online course scored lowest on the length rubric section with 72% of students meeting or exceeding expectations. In both sections the professional writing section had the highest scores.

Students in the online course may have scored lower as they had written and received feedback on one scientific laboratory report prior to the muffin laboratory exercise. The on-campus students had written three scientific laboratory reports prior to the muffin exercise. Therefore, on-campus students had more opportunities to improve their scientific writing skills prior to this assignment.

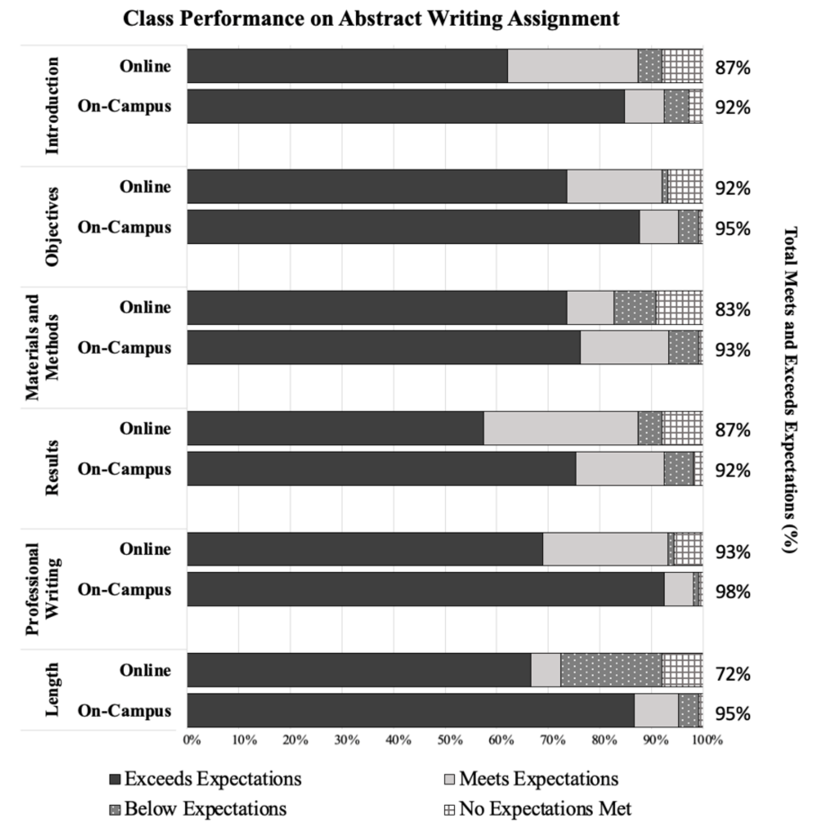
Discussion Boards

After completing the lecture and laboratory activity, students participated in an online discussion board on Canvas. Table 6 lists the questions and summarizes student responses. Overall, students reported an increased awareness of food products that contain soy and methods for processing soybeans into ingredients. Students also reported an improvement in the perception of the taste of soy products. A common response was that students would be more likely to try soy products in the future because they were less concerned with off flavors and interested in the nutritional benefits. The discussion board results are consistent with research that indicates taste has the largest impact on demand for soy products (Chang et al., 2012). Defatted soy flour was used in the muffins because the flavor is less beany and more neutral. The laboratory exercise was likely students’ first experience with defatted soy flour, and many students were surprised at the mild flavor of the soy muffins. As a results, they were more likely to try soy products in the future.

Many students indicated that the exercise removed barriers to future soy consumption such as lack of familiarity with the product and preparation, however, a few students listed concerns about estrogen consumption and possible

Figure 2.

Comparison of online and on-campus class performance on abstract writing assignment



hormonal effects. Concerns about estrogenic effects present an opportunity for discussion in future implementations of the module. Consumption of phytoestrogens have been found to have benefits for the cardiovascular, immune, and nervous systems and risks that necessitate further research (Petrine & Del Bianco-Borges, 2021).

Student Reflective Survey Results

Demographics

Eighty-nine students in the online course (95% response rate) completed the reflective survey (n=89) (Figure 3). One hundred and five students in the on-campus course (95% response rate) completed the reflective survey (n=105). Distribution of grade levels between the two course modes was similar. Juniors and seniors accounted for 71% or more of students in both courses. Seven percent or less of students in either course were freshmen. While 14% of students in the online course were sophomores, the on-campus course contained 26% sophomores.

Distribution of majors was more varied between the two course delivery methods (Figure 4). In both courses Animal Sciences & Industry majors were most represented, with 40% online and 55% on-campus. The animal science students were likely juniors and seniors because animal science students typically take the required food processing elective as upperclassmen. For the online course 42% of students were food science majors and 28% of students in the on-campus course were food science majors. The remaining students were Bakery Science & Management

Figure 3.

Class demographics from reflective Survey: year in school

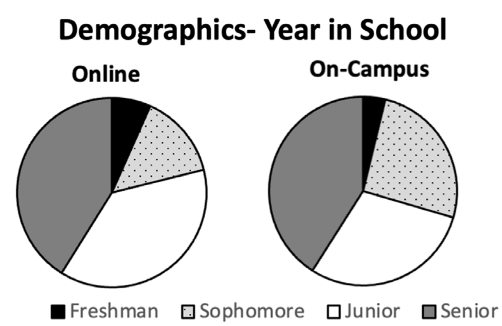
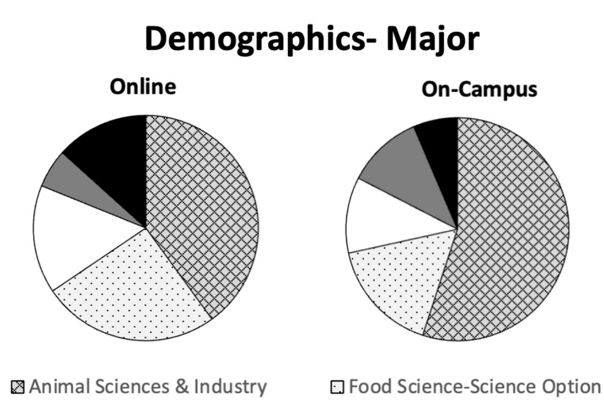


Figure 4.

Class demographics from reflective survey: major



majors and other majors. Historically, students in other majors are typically in the College of Agriculture.

Muffin Physical and Sensory Properties

A majority of responses in the "Muffin Physical and Sensory Properties" section was positive for both online and on-campus courses (Figure 5). The "Muffin Physical and Sensory Properties" section features questions about the physical and organoleptic properties of muffins and how these properties are affected by the addition of soy flour. All questions in this section received 77% or more responses of "strongly agree" or "somewhat agree" for both course delivery methods. At least 92% of online and on-campus respondents strongly or somewhat agreed with questions four, five, and seven. Question six received the most negative responses in both the online and on-campus courses with 9% and 8% negative responses respectively. Question five asked if the exercise introduced respondents to standard preparation procedures for muffins. Students may have responded negatively to this question if they had prior experience with muffin preparation and the exercise was not an introduction. For students already familiar with basic muffin preparation, the module expanded on prior knowledge by including commercial item descriptions given by the USDA's AMS and including a video of a commercial muffin production line. Additionally, the muffin scorecard was introduced as a quality and sensory evaluation method. For both course delivery methods, over 96% of students indicated that this was their first experience using a muffin scorecard. Overall, students indicated that the exercise improved their understanding of muffin physical and organoleptic properties with and without added soy.

On-campus students responded more positively overall for each question; however, responses in both course delivery methods were very positive. The efficacy of the online module at teaching about muffin physical and sensory properties was similar to the on-campus course, and both were well received by students.

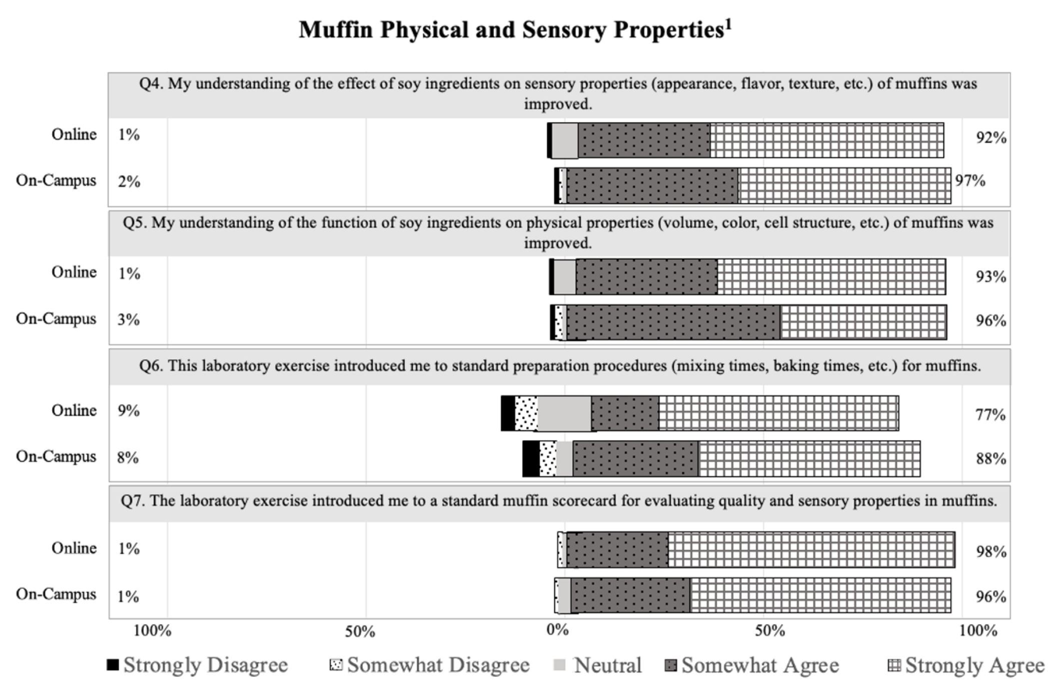
Active learning, where students are engaged in the learning process as opposed to passively listening, improves understanding and retention of course material (Hollis & Eren, 2016). The online laboratory exercise successfully created an active learning opportunity similar to an on-campus laboratory exercise by allowing students to carry out every step of the baking process. Students scored the final product based on physical (texture, color, shape) and sensory properties (taste, smell, mouthfeel). An immersive experience such as the muffin laboratory adds value to the online course.

Research and Writing Skills

Students' responses in the "Research and Writing Skills" section varied more than the other sections. Questions in this section received between 44% and 97% positive responses overall (Figure 6). The question with the least positive responses was question nine, which asks respondents if the exercise introduced them to abstract-writing for the first time. Negative responses to this question are expected, as 71% or more of the respondents in both course delivery methods were juniors or seniors who may have read or written abstracts in previous courses; however, 79% of online respondents and 65% of on-campus respondents indicated that participation in the exercise improved their abstract writing skills. The positive

Figure 5.

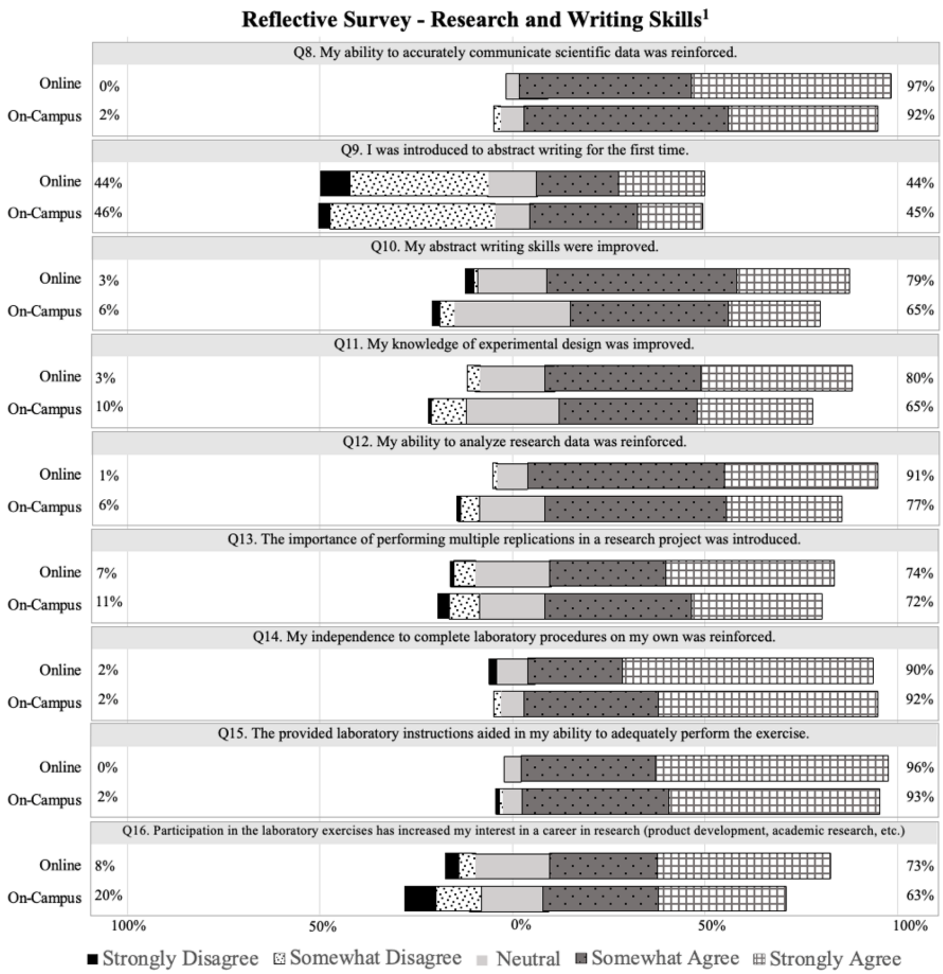
Student responses for "Muffin Physical and Sensory Properties" reflective survey section



Note. [1]Percentages on the left represent the total "strongly disagree" and "somewhat disagree" responses. Percentages on the right represent the total "strongly agree" and "somewhat agree" responses"

Figure 6.

Student responses for "Research and Writing Skills" reflective survey section



Note. [1]Percentages on the left represent the total "strongly disagree" and "somewhat disagree" responses. Percentages on the right represent the total "strongly agree" and "somewhat agree" responses"

responses to this question indicate that students found the abstract writing portion of the exercise valuable, regardless of prior experience writing abstracts. Furthermore, 97% and 92% on online and on-campus students, respectively, indicated that their ability to communicate scientific data was improved by participation in the exercise. The scientific abstract assignment was the main method used by students to communicate data. Fewer positive responses to the abstract writing questions as opposed to the scientific writing question could be attributed to a lack of confidence from the students in their abstract-writing skills. Regardless of self-reported improvement, 72% or more of students in the online course met or exceeded expectations in all rubric categories of the abstract assignment.

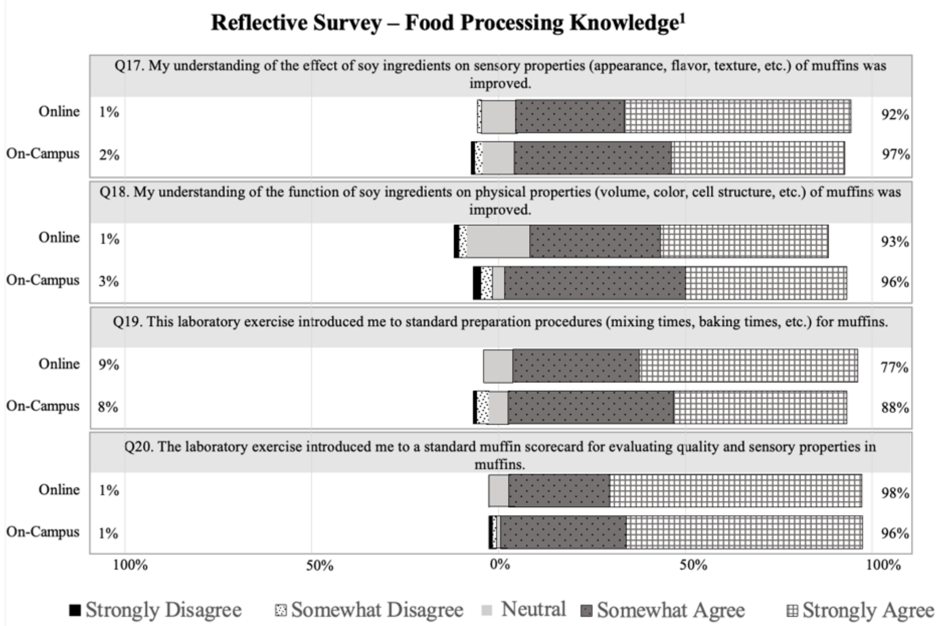
A key difference between the online and on-campus course is the ability of instructors to guide students through the laboratory. In on-campus laboratory activities, the instructors typically provide verbal instructions alongside written instructions to enhance students' experience. If students are unsure about a step, instructors are present to help. Online courses lack these opportunities for instructors to aid students, so thorough written instructions are essential. The instructions must guide students through the activity, providing adequate information without overwhelming students. Ninety-six percent of students in the online course responded that the provided instructions were useful in completing the exercise, compared to 93% of on-campus students. The provided laboratory instructions successfully allowed students to complete the laboratory exercise, whether instructors were present to provide additional guidance or not.

Food Processing Knowledge

Questions in this section asked about how the module impacted students understanding of food processing principles and applications with 80% or more positive responses in both course formats (Figure 7). Students in both courses agreed or strongly agreed (90%) that the exercise helped apply principles of food science to practical issues associated with food processing. Online courses typically lack opportunities to practice applying knowledge, and survey results indicate that activities such as the soy muffin laboratory exercise provide these essential opportunities (Hollis & Eren, 2016). Ninety-four percent or more students in both courses agreed or strongly agreed that the exercise increased understanding of the

Figure 7.

Student responses for "Food Processing Knowledge" reflective survey section



Note. [1]Percentages on the left represent the total "strongly disagree" and "somewhat disagree" responses. Percentages on the right represent the total "strongly agree" and "somewhat agree" responses"

advantages and disadvantages of adding soy ingredients to food. Survey results are consistent with responses to the discussion board questions, where many students were surprised at the possible uses of soy products in food and curious about including soy into their diet more frequently. The discussion board questions were likely useful in the module because understanding and retention of course material increases when students relate learning to their personal life (Schmidt, 2020).

Conclusion

Data from the student abstract scores, discussion board comments, and reflective survey results indicates that the module was effective in teaching students about soybean products processing and end uses. At the completion of the module, students were more aware of the advantages and disadvantages of adding soy ingredients to foods and were more open to trying soy products in the future. Students were exposed to the research process and communicated results in a scientific abstract. The laboratory exercise encouraged students to apply basic knowledge of food science principles to explore solutions to industry challenges. The soybean product processing module serves as a model for future online modules with hands-on activities to improve content knowledge and skills acquisition in food science and agriculture courses.

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