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Research in Brief

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Leveraging the COVID-19 Fermentation Trend to Enhance Nutrition and Food Safety Extension Efforts

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Abstract. Our program aimed to increase knowledge related to fermented foods. Over 400 stakeholders registered for a webinar series that focused on defining fermented foods, health benefits of fermenting foods, and the safety of fermented foods. Participants indicated increases in knowledge and overall satisfaction with the content of the fermentation curriculum. The impact of the COVID-19 pandemic on the program outcomes are discussed.

INTRODUCTION

Fermented foods have been increasing in popularity in the United States over the last several years, and consumers are now interested in incorporating a variety of fermented foods in their diets (Everett, 2019; Prince, 2018). The fermented foods and ingredients market is expected to grow at a Compound Annual Growth Rate (CAGR) of 5–8% through 2023 (currently >$600 billion) (Nielson-Stowell, 2017). The COVID-19 pandemic has accelerated growth in the fermented food sector. Consumption of kombucha in the United States has increased by 10.1% during the pandemic (Domonoske & Schneider, 2020; Nielson-Stowell, 2020). U.S. sauerkraut sales reportedly surged by 960% in March 2020 compared to the previous year, and kimchi sales grew by 952% year over year as measured in the week of February 16, 2020 (Manskar & Raskin, 2020). Many U.S. fermented food producers indicate significant increases in sales since March 2020 (Nielson-Stowell, 2020). News coverage of research indicating a potential correlation between the consumption of sauerkraut and a decrease in COVID-19 severity has further spurred interest in fermented foods during the pandemic (Bousquet et al., 2021; Fonseca et al., 2020).

This increase in consumer demand for fermented foods heightens the need to understand consumer and small-scale processor knowledge of the nutrition and safety of these foods. Food fermentation practices are extremely prevalent in U.S. households, and fermented foods are a popular item produced by small-scale processors entering the food industry (Holmes, 2020; Prince, 2018; Snyder et al., 2020). Online communities and a number of in-person classes taught around the country evidence the high level of interest and practice. In-home fermentation has also gained traction as a result of the COVID-19 pandemic, a notable example being the popularity of bread making (Holmes, 2020). As fermented food consumption and production have increased during the COVID-19 pandemic, it is important to provide accurate information on safe production and nutritional benefits to those manufacturing fermented foods at home or commercially.

PURPOSE

Small-scale processors and consumers who would like to rely on U.S. Department of Agriculture (USDA) and university Extension sources for reliable, appropriately tested, and "approved" fermentation recipes and processes are frustrated by the limited processes and recommendations. There is no shortage of information available online related to production methods (recipes) and health benefits of fermented foods. However, there is concern in the Extension community regarding the accuracy of that information. The authors of most of these materials are not trained food safety specialists or microbiologists and do not provide any data to support the nutritional and bioactivity claims of the final product. Extension programming focuses on providing home food preservers with safe methods and recipes as well as providing accurate information related to the health benefits associated with the consumption of fermented foods. This study evaluated the utility of online curriculum and tools for increasing knowledge related to fermented foods.

PROGRAM DESCRIPTION

PROGRAM DESIGN

In 2018, California Extension launched a project entitled "Evaluating And Testing Lacto-fermentations Across the Country" (EATLAC). The goal of the project is to expand knowledge of fermentation and provide accurate information related to the production of fermented foods.

The project combines laboratory research with a robust Extension and outreach component targeted to small-scale fermented fruit and vegetable processors and consumers. The team established a project website, newsletter, Facebook account, and Instagram account to engage with stakeholders. In February 2021, the "EATLAC webinar series: the science of fermentation" was hosted live via Zoom. The anticipated outcome was to increase the knowledge of consumers, processors, regulators, and Extension educators regarding the definition, health benefits, and safety of fermented foods.

DEVELOPMENT OF WEBINAR CONTENT

A fermentation microbiologist and a food safety specialist developed an outline of learning outcomes prior to developing webinar slides. Webinar 1 was entitled "What is a fermented food?", and content was based on current scientific literature and course material from an undergraduate Food Microbiology course (Ganzle, 2019; Golomb et al., 2013; Marco et al., 2021; Staley, 1997; Xue et al., 2021; Zaragoza et al., 2017). The learning objectives for Webinar 1 included (a) the definition of fermented food, (b) the types of fermented food, (c) the basics of the fermentation process, and (d) the microbiology of fermented food.

Webinar 2 was entitled "Benefits of fermenting food," and content was based on current scientific literature and course material from a graduate Food Microbiology course (Crakes et al., 2019; David et al., 2014; Derrien & van Hylckama Vlieg, 2015; Heeney et al., 2019; Hirao et al., 2014; Kim et al., 2011; Lang et al., 2014; Marco et al., 2020; 2021; Merenstein et al., 2020; Mozaffarian et al., 2011; Nielsen et al., 2018; Plé et al., 2015). The learning objectives for Webinar 2 included (a) fermentation as a preservation technique, (b) beneficial changes to food because of fermentation, (c) health benefits associated with fermented food consumption, and (d) the definitions of prebiotic and probiotic.

Webinar 3 was entitled "Safety of fermenting food," and content was based on existing scientific literature and university Extension resources (Breidt & Caldwell, 2011; Breidt et al., 2007; 2012; 2018; Cho et al., 2014; Inatsu et al., 2004; Johanningsmeier & McFeeters, 2015; Medina et al., 2016; Snyder et al., 2020). The learning objectives for Webinar 3 included (a) potential hazards in fermented foods, (b) ways fermentation controls for potential hazards, and (c) keys for ensuring a safe fermented food. In addition to webinar presentation content, organizers developed three short supplementary videos to provide practical guidance for producing home-fermented products based on current university Extension recommendations (U.S. Department of Agriculture[USDA], 2015). The videos "Tips for fermenting fruits and vegetables," "Tips for making sauerkraut," and "Troubleshooting fruit and vegetable fermentations" were shown at the conclusion of webinars 1, 2, and 3, respectively. Webinar recording links were posted online within a week of the live event. The short videos were included in the webinar recording and posted as separate content.

RECRUITMENT OF PARTICIPANTS

The webinar had an online registration page. The page asked participants to provide a name, email address, and company or institutional affiliation. To recruit participants, webinar organizers shared advertisements via social media, including on the EATLAC Facebook page and Instagram account and via collaborators' social media profiles. The EATLAC newsletter, which is sent to a listserv of EATLAC project partners and contacts, highlighted the webinar series. Additionally, the advertisement was shared with university Extension Master Food Preserver program leads in multiple states.

WEBINAR EVALUATION

To determine if the webinar content aligned with participant expectations, the webinar series participants were asked to answer the question "Did the webinar meet your expectations?" and respond with (1) Did not meet my expectations, (2) Met some of my expectations, (3) Neutral, (4) Met most of my expectations, or (5) Met all of my expectations. To assess participant satisfaction with the webinar, participants answered the question, "How satisfied were you with this webinar?" as (1) Extremely dissatisfied, (2) Somewhat dissatisfied, (3) Neutral, (4) Somewhat satisfied, or (5) Extremely satisfied. Surveyors used Qualtrics® XM (https://www.qualtrics.com) to administer the survey after the conclusion of each webinar.

LEARNING OUTCOME EVALUATION

In order to determine what webinar participants learned, we developed a retrospective pre-/post-test based on learning objectives for each webinar. The questions were embedded in the webinar evaluation survey. Participants were asked to gauge their understanding of key concepts before and after the webinar as either "No understanding" (scored 1), "Minimal" (scored 2), "Moderate" (scored 3), "Good" (scored 4), or "Very Good" (scored 5). The minimum, maximum, mean, standard deviation, and variance were calculated for the pre- and post-test. The difference in the self-reported knowledge after attending the webinar was calculated by subtracting the mean of the scores for the pre-test from the mean of scores from the post-test. A paired-samples t-test was used to analyze pre-/post-test data and compare mean differences in

self-reported level of understanding for each knowledge area evaluated.

RESULTS

WEBINAR PARTICIPATION

A total of 478 individuals registered for the webinar series. Most participants provided a name, email, and company or institutional affiliation. Among those registered, 259 individuals provided information on their affiliation (54.2% of registrants). Of those reporting, 92 were from industry (35.5%), 97 were from academic institutions (37.5%), 37 were regulatory or government (14.2%) and 33 identified as consumers (12.7%). The other 219 individuals (45.8%) did not provide information on their company or institution. The number of participants in live Webinars 1, 2, and 3 were 125, 131, and 99 respectively. The recording of Webinar 1 ("What is a fermented food?") was viewed 503 times as of February 22, 2022. The short video accompanying webinar 1 ("Tips for fermenting fruits and vegetables") was viewed 241 times during the same period. The recording of Webinar 2 ("Benefits of fermenting food") has been viewed 173 times as of February 22, 2022. The short video accompanying Webinar 2 ("Tips for making sauerkraut") was viewed 73 times during the same period. The recording of Webinar 3 ("Safety of fermented food") has been viewed 233 times as of February 22, 2022. The short video accompanying Webinar 3 ("Troubleshooting fruit and vegetable ferments") was viewed 53 times during the same period.

WEBINAR EVALUATION AND ASSESSMENT OF LEARNING OUTCOMES

Fifty-eight individuals completed the evaluation survey for Webinar 1 (46.4% of webinar participants). The response rate for Webinar 2 was 34.4% (45 responses). Thirty-three individuals completed the evaluation survey for Webinar 3 (33.3% of webinar participants). The authors used paired t-tests (significance level α=0.05) to determine changes in knowledge between pre-test and post-test data. Statistically significant increases in knowledge were observed for all evaluated content areas as a result of the educational intervention. Tables 1–4 describe the webinar evaluation and assessment of learning outcomes in participants.

DISCUSSION

The EATLAC webinar series "The science of fermentation" reached a wide range of stakeholders—including consumers, industry employees, regulatory personnel, and academics—with interest in fermented foods. Moreover, stakeholder engagement came from across the United States and abroad. However, one limitation of this work is the lack of demographic information such as age, race, and education level collected during program evaluation. This information may allow for a deeper understanding of the diversity of those engaged by the program. The majority of participants (>80%) reported the webinar series met most or all of their expectations and were somewhat or extremely satisfied with the webinars. As with many online evaluation tools, the response rate to post-webinar evaluation surveys ranged from 33–46% of total live participants. Overall, the participants that completed the retrospective pre-/post-test indicated increases in knowledge in all content areas evaluated. While 478 individuals registered for the webinar series, approximately 100 participants attended each Zoom webinar. However, by recording and posting content on YouTube, these materials

Table 1. Webinar Evaluation

Webinar 1	
What is a fermented food?	
Did the webinar meet your expectations?	Did not meet my expectations: 6.45% Met some of my expectations: 6.45% Neutral: 8.06% Met most of my expectations: 35.48% Met all of my expectations: 43.55%
How satisfied were you with this webinar?	Extremely dissatisfied: 1.69% Somewhat dissatisfied: 1.69% Neutral: 3.39% Somewhat satisfied: 28.81% Extremely satisfied: 64.41%
Webinar 2	
Benefits of fermenting food	
Did the webinar meet your expectations?	Did not meet my expectations: 2.22% Met some of my expectations: 6.67% Neutral: 4.44% Met most of my expectations: 51.11% Met all of my expectations: 35.56%
How satisfied were you with this webinar?	Extremely dissatisfied: 0.00% Somewhat dissatisfied: 2.33% Neutral: 2.33% Somewhat satisfied: 44.19% Extremely satisfied: 51.16%
Webinar 3	
Safety of fermented food	
Did the webinar meet your expectations?	Did not meet my expectations: 3.03% Met some of my expectations: 0.00% Neutral: 6.06% Met most of my expectations: 36.6% Met all of my expectations: 54.55%
How satisfied were you with this webinar?	Extremely dissatisfied: 6.06% Somewhat dissatisfied: 6.06% Neutral: 6.06% Somewhat satisfied: 24.24% Extremely satisfied: 57.58%

Table 2. Learning Outcomes in Participants in Webinar 1 ("What is a Fermented Food?")

	Pre-test		Post-test		
Knowledge area	**Mean level of understanding**	**SD[a]**	**Mean level of understanding**	**SD**	**Change in level of understanding after attending webinar**
Definition of fermentation	3.72	± 0.93	4.44	± 0.69	+0.72*
General steps needed to set up a fermentation	3.66	± 1.10	4.28	± 0.77	+0.62*
Different types of microorganisms needed to make fermented food	3.20	± 1.07	4.13	± 0.86	+0.92*
Sources of fermentation microbes	3.16	± 1.10	4.10	± 0.88	+0.50*
Role of spoilage microorganisms in causing a failed fermentation	3.16	± 1.03	3.90	± 0.92	+0.74*

[a] SD – standard deviation

*Denotes significant difference ($p \leq 0.05$) comparing pre-test and post-test self-reported level of understanding after attending webinar 1, n = 58.

Table 3. Learning Outcomes in Participants in Webinar 2 ("Benefits of Fermenting Food")

	Pre-test		Post-test		
Knowledge area	**Mean level of understanding**	**SD[a]**	**Mean level of understanding**	**SD**	**Change in level of understanding after attending webinar**
Established benefits (and risks) of fermenting food	3.50	± 0.92	3.93	± 0.94	+0.43*
Health benefits associated with fermented food consumption	3.48	± 0.92	3.9	± 0.90	+0.43*
Ways in which microbial growth and activity make foods healthier	3.14	± 0.99	3.86	± 0.94	+0.72*
Definition of probiotics and relation to fermented food	3.34	± 1.02	4.14	± 0.87	+0.80*

[a] SD – standard deviation

*Denotes significant difference ($p \leq 0.05$) comparing pre-test and post-test self-reported level of understanding after attending webinar 2, n = 45.

Table 4. Learning Outcomes in Participants in Webinar 3 ("The Safety of Fermented Food")

	Pre-test		Post-test		
Knowledge area	**Mean level of understanding**	**SD[a]**	**Mean level of understanding**	**SD**	**Change in level of understanding after attending webinar**
Biological hazards associated with fermented fruits and vegetables	3.52	± 0.89	4.09	± 0.90	+0.57*
Role of fermentation in the control of biological hazards	3.36	± 0.98	4.15	± 0.86	+0.79*
Importance of high acidity (low pH) in controlling biological hazards	3.88	± 0.84	4.45	± 0.74	+0.57*
Role of salt in fermentation	3.85	± 0.89	4.42	± 0.70	+0.57*
Common spoilage issues encountered in fruit and vegetable fermentation	3.55	± 1.05	4.15	± 0.89	+0.60*

[a] SD – standard deviation

*Denotes significant difference ($p \leq 0.05$) comparing pre-test and post-test self-reported level of understanding after attending webinar 3, n = 33.

have been collectively viewed over 1,000 times each, which exceeds the original webinar registration numbers. Moreover, these materials are likely to continue to be utilized in the future. The EATLAC webinar series provided a unique opportunity to tap into two COVID-19 pandemic related impacts, enhanced stakeholder usage of online meeting platforms and increased stakeholder interest in fermentation.

REFERENCES

Bousquet, J., Anto, J. M., Czarlewski, W., Haahtela, T., Fonseca, S. C., Iaccarino, G., Blain, H., Vidal, A., Sheikh, A., Akdis, C. A., Zuberbier, T., & ARIA group. (2021). Cabbage and fermented vegetables: From death rate heterogeneity in countries to candidates for mitigation strategies of severe COVID-19. *Allergy*, *76*(3), 735–750. https://doi.org/10.1111/all.14549

Breidt, F., Jr., & Caldwell, J. M. (2011). Survival of Escherichia coli O157:H7 in cucumber fermentation brines. *Journal of Food Science*, *76*(3), M198–203. https://doi.org/10.1111/j.1750–3841.2011.02045.x

Breidt, F., Jr., Hayes, J., & McFeeters, R. F. (2007). Determination of 5-log reduction times for food pathogens in acidified cucumbers during storage at 10 and 25 degrees C. *Journal of Food Protection*, *70*(11), 2638–2641. https://doi.org/10.4315/0362–028x-70.11.2638

Breidt, F., McFeeters, R. F., Perez Diaz, I. M., & Lee, C. (2012). Fermented Vegetables. In M. P. Doyle & R. L. Buchanan (Eds.), *Food Microbiology: Fundamentals and Frontiers* (4th ed., pp. 841–855). ASM Press.

Breidt, F. J., Andress, E. L., & Ingham, B. I. (2018). Recommendations for designing and conducting cold-fill hold challenge studies for acidified food products. *Food Protection Trends*, *38*(5), 322–328. https://www.foodprotection.org/files/food-protection-trends/sep-oct-18-breidt.pdf

Cho, S. H., Kim, J., Oh, K. H., Hu, J. K., Seo, J., Oh, S. S., Hur, M. J., Choi, Y. H., Youn, S. K., Chung, G. T., & Choe, Y. J. (2014). Outbreak of enterotoxigenic Escherichia coli O169 enteritis in schoolchildren associated with consumption of kimchi, Republic of Korea, 2012. *Epidemiology & Infection*, *142*(3), 616–623. https://doi.org/10.1017/s0950268813001477

Crakes, K. R., Santos Rocha, C., Grishina, I., Hirao, L. A., Napoli, E., Gaulke, C. A., Fenton, A., Datta, S., Arredondo, J., Marco, M. L., Sankaran-Walters, S., Cortopassi, G., Giulivi, C., & Dandekar, S. (2019). PPARα-targeted mitochondrial bioenergetics mediate repair of intestinal barriers at the host-microbe intersection during SIV infection. *Proceedings of the National Academy of Sciences of the United States of America, 116*(49), 24819–24829. https://doi.org/10.1073/pnas.1908977116

David, L. A., Maurice, C. F., Carmody, R. N., Gootenberg, D. B., Button, J. E., Wolfe, B. E., Ling, A. V., Devlin, A. S., Varma, Y., Fischbach, M. A., Biddinger, S. B., Dutton, R. J., & Turnbaugh, P. J. (2014). Diet rapidly and reproducibly alters the human gut microbiome. *Nature, 505,* 559–563. https://doi.org/10.1038/nature12820

Derrien, M., & van Hylckama Vlieg, J. E. (2015). Fate, activity, and impact of ingested bacteria within the human gut microbiota. *Trends in Microbiology, 23*(6), 354–366. https://doi.org/10.1016/j.tim.2015.03.002

Domonoske, C., & Schneider, A. (2020, March 16). *The Coronavirus Crisis: Here's What's Been Flying Off Store Shelves*. NPR. https://www.npr.org/2020/03/16/816404689/spiking-demand-for-sanitizer-canned-goods-leaves-stores-struggling-to-keep-up

Everett, H. (2019). *Restaurant menu trends: what to expect to see on more menus in 2019*. Upserve Restaurant Insider. Retrieved April 2 from https://upserve.com/restaurant-insider/restaurant-menu-trends/

Fonseca, S. C., Rivas, I., Romaguera, D., Quijal, M., Czarlewski, W., Vidal, A., Fonseca, J. A., Ballester, J., Anto, J. M., Basagana, X., Cunha, L. M., & Bousquet, J. (2020). *Association between consumption of fermented vegetables and COVID-19 mortality at a country level in Europe*. medRxiv. https://doi.org/10.1101/2020.07.06.20147025

Ganzle, M. (2019). Fermentation and beneficial microbes: Fermented Foods. In M. P. Doyle, F. Diaz-Gonzalez, & C. Hill (Eds.), *Food Microbiology: Fundamentals and Frontiers* (5th ed., pp. 855–902). ASM Press.

Golomb, B. L., Morales, V., Jung, A., Yau, B., Boundy-Mills, K. L., & Marco, M. L. (2013). Effects of pectinolytic yeast on the microbial composition and spoilage of olive fermentations. *Food Microbiology, 33*(1), 97–106. https://doi.org/10.1016/j.fm.2012.09.004

Heeney, D. D., Zhai, Z., Bendiks, Z., Barouei, J., Martinic, A., Slupsky, C., & Marco, M. L. (2019). Lactobacillus plantarum bacteriocin is associated with intestinal and systemic improvements in diet-induced obese mice and maintains epithelial barrier integrity in vitro. *Gut Microbes, 10*(3), 382–397. https://doi.org/10.1080/19490976.2018.1534513

Hirao, L. A., Grishina, I., Bourry, O., Hu, W. K., Somrit, M., Sankaran-Walters, S., Gaulke, C. A., Fenton, A. N., Li, J. A., Crawford, R. W., Chuang, F., Tarara, R., Marco, M. L., Bäumler, A. J., Cheng, H., & Dandekar, S. (2014). Early mucosal sensing of SIV infection by paneth cells induces IL-1β production and initiates gut epithelial disruption. *PLOS Pathogens, 10*(8), e1004311. https://doi.org/10.1371/journal.ppat.1004311

Holmes, B. (2020, August 13). *The science of sourdough: How microbes enabled a pandemic pastime*. Scientific American: Knowable Magazine. https://www.scientific

american.com/article/the-science-of-sourdough-how-microbes-enabled-a-pandemic-pastime/

Inatsu, Y., Bari, M. L., Kawasaki, S., & Isshiki, K. (2004). Survival of Escherichia coli O157:H7, Salmonella Enteritidis, Staphylococcus aureus, and Listeria monocytogenes in kimchi. *Journal of Food Protection, 67*(7), 1497–1500. https://doi.org/10.4315/0362–028X-67.7.1497

Johanningsmeier, S. D., & McFeeters, R. F. (2015). Metabolic footprinting of Lactobacillus buchneri strain LA1147 during anaerobic spoilage of fermented cucumbers. *International Journal of Food Microbiology*, *215*, 40–48. https://doi.org/10.1016/j.ijfoodmicro.2015.08.004

Kim, E. K., An, S. Y., Lee, M. S., Kim, T. H., Lee, H. K., Hwang, W. S., Choe, S. J., Kim, T. Y., Han, S. J., Kim, H. J., Kim, D. J., & Lee, K. W. (2011). Fermented kimchi reduces body weight and improves metabolic parameters in overweight and obese patients. *Nutrition Research*, *31*(6), 436–443. https://doi.org/10.1016/j.nutres.2011.05.011

Lang, J. M., Eisen, J. A., & Zivkovic, A. M. (2014). The microbes we eat: Abundance and taxonomy of microbes consumed in a day's worth of meals for three diet types. *PeerJ - Life and Environment*, *2*, e659. https://doi.org/10.7717/peerj.659

Manskar, N., & Raskin, S. (2020, April 17). *Here's why sauerkraut and kimchi sales have surged during the coronavirus*. New York Post. Retrieved April 2, 2021 from https://nypost.com/2020/04/17/heres-why-sauerkraut-and-kimchi-sales-are-surging-thanks-to-coronavirus/

Marco, M. L., Hill, C., Hutkins, R., Slavin, J., Tancredi, D. J., Merenstein, D., & Sanders, M. E. (2020). Should there be a recommended daily intake of microbes? *The Journal of Nutrition*, *150*(12), 3061–3067. https://doi.org/10.1093/jn/nxaa323

Marco, M. L., Sanders, M. E., Gänzle, M., Arrieta, M. C., Cotter, P. D., De Vuyst, L., Hill, C., Holzapfel, W., Lebeer, S., Merenstein, D., Reid, G., Wolfe, B. E., & Hutkins, R. (2021). The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on fermented foods. *Nature Reviews Gastroenterology & Hepatology*, *18*(3), 196–208. https://doi.org/10.1038/s41575–020–00390–5

Medina, E., Pérez-Díaz, I. M., Breidt, F., Hayes, J., Franco, W., Butz, N., & Azcarate-Peril, M. A. (2016). Bacterial ecology of fermented cucumber rising pH spoilage as determined by nonculture-based methods. *Journal of Food Science*, *81*(1), M121–129. https://doi.org/10.1111/1750–3841.13158

Merenstein, D. J., Sanders, M. E., & Tancredi, D. J. (2020). Probiotics as a Tx resource in primary care. *Journal of Family Practice*, *69*(3), E1-e10.

Mozaffarian, D., Hao, T., Rimm, E. B., Willett, W. C., & Hu, F. B. (2011). Changes in diet and lifestyle and long-term weight gain in women and men. *New England Journal of Medicine*, *364*(25), 2392–2404. https://doi.org/10.1056/NEJMoa1014296

Nielsen, E. S., Garnås, E., Jensen, K. J., Hansen, L. H., Olsen, P. S., Ritz, C., Krych, L., & Nielsen, D. S. (2018). Lacto-fermented sauerkraut improves symptoms in IBS patients independent of product pasteurisation - a pilot study. *Food & Function, 9*(10), 5323–5335. www.doi.org/10.1039/c8fo00968f

Nielson-Stowell, A. (2017, December 12). *Global fermented food & ingredients market, analysis and forecast (2017–2023)*. The Fermentation Association. Retrieved May 3, 2021 from https://fermentationassociation.org/global-fermented-food-ingredients-market-analysis-and-forecast-2017–2023/

Nielson-Stowell, A. (2020, April 1). *Fermentation Booms During Pandemic*. The Fermentation Association. Retrieved April 2, 2021 from https://fermentationassociation.org/fermentation-brands-experience-sales-boom-during-coronavirus/

Plé, C., Breton, J., Daniel, C., & Foligné, B. (2015). Maintaining gut ecosystems for health: Are transitory food bugs stowaways or part of the crew? *International Journal of Food Microbiology*, *213*(Special Issue), 139–143. https://doi.org/10.1016/j.ijfoodmicro.2015.03.015

Prince, J. (2018). *Fermented flavors driving food, beverage innovation, Symrise says.* Nutritional Outlook. Retrieved April 2, 2021 from http://www.nutritionaloutlook.com/food-beverage/fermented-flavors-driving-food-beverage-innovation-symrise-says

Snyder, A., Breidt, F., Jr., Andress, E. L., & Ingham, B. H. (2020). Manufacture of Traditionally Fermented Vegetable Products: Best Practice for Small Businesses and Retail Food Establishments. *Food Protection Trends*, *40*(4), 251–263. https://www.foodprotection.org/files/food-protection-trends/jul-aug-20-snyder.pdf

Staley, J. T. (1997). Biodiversity: Are microbial species threatened?: Commentary. *Current Opinion in Biotechnology*, *8*(3), 340–345. https://doi.org/10.1016/S0958–1669(97)80014–6

Xue, Z., Brooks, J. T., Quart, Z., Stevens, E. T., Kable, M. E., Heidenreich, J., McLeod, J., & Marco, M. L. (2021). Microbiota assessments for the identification and confirmation of slit defect-causing bacteria in milk and cheddar cheese. *Food Microbiology*, *6*(1). https://doi.org/10.1128/mSystems.01114–20

Zaragoza, J., Bendiks, Z., Tyler, C., Kable, M. E., Williams, T. R., Luchkovska, Y., Chow, E., Boundy-Mills, K., & Marco, M. L. (2017). Effects of exogenous yeast and bacteria on the microbial population dynamics and out-

comes of olive fermentations. *mSphere*, *2*(1), e00315–00316. https://doi.org/10.1128/mSphere.00315–16

U.S Department of Agriculture [USDA] NIFA. (2015). *Complete Guide to Home Canning, Agriculture Information Bulletin No. 539. In: Guide 6 Preparing and Canning Fermented Foods and Pickled Vegetables.* https://www.healthycanning.com/wp-content/uploads/USDA-Complete-Guide-to-Home-Canning-2015-revision.pdf