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Preliminary Assessment of Maine Consumers' Educational Preferences for Fermenting Foods at Home

ABSTRACT

Because of growing consumer interest in home food fermentation, an online survey of Maine residents was developed for the purpose of learning the types of foods being fermented by consumers and of understanding the preferred educational media for this population. Notice of the survey was distributed to Cooperative Extension email lists and through a press release. Chi-square tests were used to analyze data on fermentation practices and demographic variables. More women than men responded to the survey ($P < 0.05$). Almost 60% of the 483 respondents had fermented at least one type of food or beverage at home ($P < 0.05$). Pickles and sauerkraut were the most commonly fermented foods. Lack of knowledge or time were the primary reasons respondents gave for not fermenting foods. Recipe websites and cookbooks were the predominant sources of information for home fermenters. The preferred formats for future educational programs were recipe websites, live hands-on workshops, and online videos. A combination of online, pre-tested recipes, along with low bandwidth videos and hands-on workshops in more populous regions, may best serve Maine residents in rural and urban locations.

INTRODUCTION

Interest in fermented foods and beverages such as yogurt, sauerkraut, kimchi, and kombucha has been growing in the United States, in part because these foods may offer the health benefits associated with probiotic bacteria *(24, 38, 39, 61)*. For example, yogurt may offer protection against certain cardiovascular diseases *(19)*. Fermenting fruits and vegetables has been reported to raise nutrient density, enhance the bioactivity of phytochemicals, and reduce antinutrients, in addition to providing the benefits of both prebiotics and probiotics *(55)*. Consumption of fermented foods and beverages is encouraged in some national dietary guidelines *(5, 17)*. Fermentation, as a method of food preservation, could also be important in communities where food insecurity is a problem. In Maine, 12.8–16.6% of residents may be considered food insecure *(2)*.

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Increased interest in home food preservation by means of fermentation calls for an examination of existing educational resources on this topic, as well as concerted efforts to deliver science-based guidance in the format most acceptable to home fermenters. Improper fermentation practices present food safety risks that some resources may not adequately explain to lay audiences. Between 2009 and 2015, 12% of recorded outbreaks of foodborne diseases in the United States were attributed to foods prepared in the home *(12)*. Data also revealed that consumers do not perceive their homes as a place where they are likely to acquire a foodborne disease *(51)*, highlighting the need for a safety focus in educational program delivery. Fermented foods can also pose risks that are unrelated to microbial foodborne illness.

Vegetables are preserved during fermentation through hurdle effects, including the addition of sodium chloride (NaCl) and the development of low pH levels during the fermentation process *(27)*. Traditionally fermented foods often contain high levels of sodium, which is contraindicated for consumers with hypertension *(15)*. Persons with hypertension or kidney disease may therefore desire foods with lower sodium concentrations *(26)*, but the food safety consequences of low-brine fermented vegetables are not well known. Replacement of sodium chloride by other chloride salts can have effects on food quality and safety *(4)*, but such replacement may be preferable to NaCl content reduction alone *(67)*.

Thus far, reports of illness due to consumption of home-fermented foods are rare. Two people contracted botulism in New York as a result of consuming home-fermented tofu *(9)*, and mycotoxins are a concern in Africa *(5)*. Outbreaks attributed to commercially fermented foods are also rare, although a 2013 outbreak involved more than 200 consumers who were sickened by Chobani yogurt contaminated with the fungus *Mucor circinelloides* *(33)*. Immunocompromised persons may develop opportunistic fungal infections from foods containing *Mucor* species either as a result of intentional fermentation or spoilage *(56)*.

The risk of pathogen contamination in fresh produce has been well documented *(43)*. Thus, understanding the safety hazards of fermented vegetable products may prevent future occurrences of foodborne illness. Academic research investigating a number of vegetable systems has demonstrated that fermentation may be insufficient to inactivate vegetative pathogens. *Listeria monocytogenes* has been shown to survive fermentation in fermented dill pickles *(31)*; kimchi *(28)*, green olives *(3, 6)* and cauliflower *(44)*. Pathogenic *Escherichia coli* may persist in olives *(3, 57)* and sauerkraut *(30)*. Murine norovirus-1 retained infectious capability for over 90 days in sauerkraut *(22)*. These pathogens may be introduced to food during production or could be the result of cross-contamination during preparation. In either case, adequate sanitation is key for illness prevention.

Chemical safety issues, including formation of biogenic amines, in fermented products may also exist for sensitive individuals. Researchers have reported the potential for the carcinogen ethyl carbamate to form in fermented beverages *(29)*. While few in number, serious cases of acidosis have been associated with the consumption of homemade kombucha *(7, 60)*. Formation of biogenic amines during fermentation may be inhibited by sodium chloride *(59)*. Thus, the trend for reducing sodium in processed foods might increase the risk of formation of biogenic amines, such as histamine and tyramine *(23)*, which could be problematic for histamine-sensitive individuals. Fortunately, several processing controls can prevent or limit biogenic amine production in fermented products, but increased levels of salt may favor biogenic amine production in some foods *(14)*. Optimal salt concentrations and storage temperatures to minimize biogenic amine levels varied with different cabbage varieties *(11)*. Refrigeration and the use of *Leuconostoc mesenteroides* as a starter culture minimized amine formation in sauerkraut containing only 0.5% NaCl *(48)*. Naila et al. *(41)* warned that while attempting to control the formation of biogenic amines, processors should investigate other potential food safety issues. Refrigeration alone is not an adequate single barrier to prevent biogenic amine production. Excess ethanol production in fermented beverages such as kombucha can be a concern even in tightly controlled commercial fermentations *(64)*, and consumers may be unaware of steps needed to control ethanol production at home. Migration of heavy metals from ceramics to food is enhanced in high acid systems, which is characteristic of fermented vegetables and beverages *(35, 40)*. The use of such vessels for fermentation, particularly those that are antique or imported, may lead to toxicity from excess lead in the finished product *(8, 50)*. Therefore, proper home fermentation information for consumers is important.

Utilizing the Internet for administering surveys has many advantages, such as rapid response times, minimal cost, and ease of data analysis *(13)*. In 2013, Maine's incidence of computer ownership (89.1%) and high-speed Internet use (79.2%) were higher than the national averages of 88.4% and 78.1%, respectively *(20)*. Although administration of a survey solely on the Internet might skew respondent preferences toward web-based educational activities, survey responses will assist in the development of pilot educational programs. The growing interest in fermented foods and the concomitant lack of information about consumer home fermentation practices provided the rationale for this survey research. The study's objectives were to identify the types of foods being fermented by Maine residents, assess barriers to fermentation, current and preferred sources of fermentation information, and determine whether consumers were concerned about preparing reduced-sodium fermented foods.

MATERIALS AND METHODS

The University of Maine Institutional Review Board judged the survey exempt from further review on June 26, 2017. The online survey was field tested in June 2017 with twelve participants of the University of Maine Master Food Preserver Program. Each participant accessed the online survey and completed the survey at the Cooperative Extension Office in Cumberland County. Each participant had an opportunity to provide feedback about the survey content and format. Based on the feedback from the pilot test, three additional commonly fermented foods were added to the survey list. The minimum number of responses expected was 300. Study inclusion criteria were being a Maine resident at least eighteen years old. A notice of the survey was distributed to Cooperative Extension's Constant Contact email listserv (7,660 subscribers) and Facebook page (6,170 followers). A press release on the survey was published in several newspapers, including the Penobscot Times, Sun Journal (Lewiston/Auburn), and The Irregular (Kingfield); the Morning Ag Clips daily e-blast, and WABI-TV (Bangor). Additional notices were promoted on the Maine Organic Farmers and Gardeners Association Web Forum and the Facebook page of a farmer-owned local grocery outlet. The 12-question survey was available June 27 through July 16, 2017. The survey instrument was created with Qualtrics software (July 2016 – July 2017, Provo, UT). The order of options was randomized in three questions to help prevent respondents from just checking off the first items. The questionnaire was designed to be easily viewed on smartphones and tablets. Demographic questions queried about age, gender, employment status, number of persons in household and county of residence. Maine has predominantly white residents *(66)*, so questions about race and Hispanic ethnicity were not asked. The number of different food products made at home by respondents was tallied, and Kruskal-Wallis analysis of variance was performed to examine associations between demographic traits and the number of foods fermented at home. Associations between nominal data sets were compared as cross-tabulations, using the Pearson chi-square test. A significance level of 0.05 was selected for all statistical procedures. Quantitative data were analyzed by SPSS software (version 24, IBM Analytics, Armonk, NY), and comments were evaluated with NVivo Pro 11 software (QSR International Pty. Ltd., Burlington, MA).

RESULTS AND DISCUSSION

Fourteen questionnaires were not answered, and 30 persons answered only the question, "Do you currently ferment foods at home?" (16 said that they did not, and 14 said that they did). Those 44 questionnaires were not included in the data analyses. The remaining questionnaires (n = 483) were 97% complete, with only a single question not responded to in most cases. For example, only 20 people who fermented food at home failed to answer one question, and the majority of those individuals (n = 17) did not answer Question 8 — "Are there specific topics that you would like to know more about?" Five people did not answer any of the demographic questions.

It was expected that persons who were interested in fermenting foods would respond to the survey and that the results would therefore not be representative of the entire Maine adult population. Twelve persons who indicated that they were not sure whether they fermented foods at home subsequently identified foods or beverages that they had made *(Table 1)*, so the responses of these individuals were added to those from the people who had answered that they were fermenting foods. Of the 483 surveys analyzed in this study, 187 were from people who did not ferment foods. Respondents who did not answer "no" to the fermentation question were asked to indicate which products they made at home. The number of reported foods made ranged from 1 to 13, with a median of 3. Pickles, sauerkraut, yogurt, and sourdough were produced by over 100 respondents *(Table 1)*. However, we do not know whether respondents produced pickles by fermentation or simply with vinegar.

Nearly half (47.5%) of respondents were at least 55 years old, and 20% were aged 65 years or older *(Table 2)*. A majority (71%) were women, and more than half of all respondents were employed full-time. Reported household size varied, but two-person households were most common. One-third of survey respondents (n = 157) were living in Penobscot County, and 114 reported that they lived in Cumberland County *(Table 3)*. These counties are the primary counties served by the authors in Cooperative Extension and ranked third and first in population, respectively, according to the 2010 Census *(65)*. Three people were not sure which county they lived in, and seven did not want to specify their county of residence.

Of the 226 respondents aged 55–84 years, 42% reported being retired, but only 53 of those individuals fermented food at home. Retired persons could have increased interest in food fermentation because of limited food budgets and food insecurity, interest in health-promoting foods, or availability of more time for food preservation. Consumers who are concerned about food safety are more likely to have clean kitchens *(10)*.

Although the majority of respondents reported fermenting foods at home, about 37% (187/483) did not ferment at home *(Table 1)*. People who ferment foods and beverages outnumbered those who did not ferment in all age categories except for 18–24 and 65–74 years ($\chi^2 = 18.39$, $P = 0.010$). Gender, employment status, household size, and county were not significantly associated with respondents' being home fermenters, based on results of Pearson chi-square calculations. Respondents who did not ferment foods varied in the reasons for not doing so, but 49% of non-fermenters said that they did not know how to get started with this type of processing *(Table 4)*. Food safety was selected by only a handful of respondents as a reason for not fermenting foods.

Based on the survey responses, consumers seek food information from numerous resources, and the survey asked respondents to select all fermented food information

TABLE 1. Home fermentation practices

Survey question	Question type	Responses	Number of responses (% of total responses)
Do you currently ferment foods at home?	Choose one answer		483
		Yes[a]	306 (63.3)
		No	187 (38.7)
Please tell us all foods that you ferment at home.	Mark all that apply[b]	**Foods fermented at home (n = 1092)**[b]	
		Pickles	195 (17.9)
		Sauerkraut	147 (13.5)
		Yogurt	136 (12.4)
		Sourdough	116 (10.6)
		Kombucha	98 (9.0)
		Alcoholic beverages (e.g., beer, wine, cider)	91 (8.3)
		Kimchi	82 (7.5)
		Vinegar	73 (6.7)
		Cheese	50 (4.6)
		Dairy kefir	50 (4.6)
		Other vegetables (e.g., beans, beets, carrots)	26 (2.4)
		Water kefir	26 (2.4)
		Kvass	5 (0.5)
		Tempeh	4 (0.4)

[a] Twelve persons answered that they did not know if they fermented at home, but then indicated the types of food that they did ferment.
[b] More than one answer could be selected.

sources that they currently use *(Table 5)*. Recipe resources, whether online or from books, were the most frequently chosen sources of information. Pinterest was mentioned by two people, and Facebook was a fermentation resource for just one individual. In a 2005 telephone survey about home canning, 51% of consumers relied on friends or family for guidance on canning, and only 3% used the Internet *(16)*. The sources of information most commonly cited by the fermented food survey respondents (recipe websites, cookbooks, friends and family members) may be unlikely sources of information about food safety risks or the importance of following a proven recipe and proper sanitary procedures. Tested, safe recipes and food safety practices were selected as desirable information by 305 and 193 people, respectively. Health-related information was the next most popular category of preferred information. Technical information such as equipment, ingredients, and scale-up was also desired.

Only persons who responded that they fermented foods at home, and those who said they were not sure, were shown the question regarding the importance of making low-sodium fermented foods. Twenty-six percent of respondents (26%, 77/295) said that this issue was not at all important to them *(Fig. 1)*, and only 20% (59/295) responded that this topic was very or extremely important to them. The importance of low-sodium foods was not significantly associated with self-reported demographic characteristics of respondents. The safety of lactic-acid fermented foods relies primarily on the production of lactic acid by diverse lactic acid bacteria. The microbiota that drive this process may be nascent (i.e., spontaneous fermentation, as in the production of sauerkraut from cabbage) or added as a starter culture, (as

TABLE 2. Demographic characteristics of Maine survey respondents (n = 483)

Survey question	Responses	Number of responses			Percentage of total responses	2010 Maine Census Data (%)[a]
		Non-fermenters	Fermenters	Total		
Please tell us your age. (Choose one answer.)[b]	18–24	10	2	12	2.5	8.7
	25–34	24	36	60	12.6	10.9
	35–44	30	55	85	17.8	12.9
	45–54	27	61	88	18.4	16.5
	55–64	45	86	131	27.4	14.5
	65–74	40	41	81	16.9	8.5
	75–84	5	10	15	3.1	5.2
	Prefer not to say	3	3	6	1.3	-
		Non-fermenters	Fermenters	Total		
Please tell us which gender you identify with. (Choose one answer.)[c]	Female	133	205	338	70.7	48.9
	Male	43	79	122	25.5	51.1
	Prefer not to say	7	11	18	3.8	-
		Fermenters	Non-fermenters	Total		
What is your current employment status? (Choose one answer.)	Employed full time	91	160	251	52.5	
	Employed part time	21	49	70	14.6	
	Unemployed, looking for work	2	1	3	0.6	
	Unemployed, not looking for work	7	11	18	3.8	
	Retired	43	54	97	20.3	
	Student	11	6	17	3.6	
	Disabled	5	5	10	2.1	
	Prefer not to say	4	8	12	2.5	
		Fermenters	Non-fermenters	Total		
How many people live in your household? (Choose one answer.)	One	37	41	78	16.3	28.6
	Two	85	143	228	47.7	38.4
	3–4	51	85	136	28.4	26.6
	5–6	6	16	22	4.6	5.7
	Seven or more	0	6	6	1.3	0.7
	Prefer not to say	5	3	8	1.7	

[a]U.S. Census Bureau, 2010 Census of Population and Housing Summary Population and Housing Characteristics, CPH-1-21, Maine U.S. Government Printing Office, Washington, D.C., 2012.

[b]Chi-square test of association between fermenting and age = 18.39, $P = 0.01$.

[c]Survey participation based on gender was significant (Pearson chi-square = 334.46, $P = 0.00$).

TABLE 3. Survey respondents' counties of residence

In which Maine county do you reside? (n = 479)	Number of responses (percentage of total responses)		
	Fermenters	Non-fermenters	Sum
Androscoggin [a]	10 (2.1)	3 (0.6)	13 (2.7)
Aroostook	2 (0.4)	2 (0.4)	4 (0.8)
Cumberland	71 (14.8)	43 (9.0)	114 (23.8)
Franklin	4 (0.8)	5 (1.0)	9 (1.9)
Hancock	14 (2.9)	6 (1.2)	20 (4.2)
Kennebec	11 (2.3)	7 (1.5)	18 (3.8)
Knox [b]	5 (1.0)	0 (0)	5 (1.0)
Lincoln	7 (1.5)	3 (0.6)	10 (2.1)
Oxford	11 (2.3)	5 (1.0)	16 (3.3)
Penobscot	80 (16.7)	77 (16.1)	157 (32.8)
Piscataquis	19 (4.0)	6 (1.2)	25 (5.2)
Sagadahoc	7 (1.5)	2 (0.4)	9 (1.9)
Somerset	16 (3.3)	6 (1.2)	22 (4.6)
Waldo	15 (3.1)	8 (1.8)	23 (4.8)
Washington	3 (0.6)	2 (0.4)	5 (1.0)
York	15 (3.1)	4 (0.8)	19 (3.3)
Not sure	1 (0.2)	2 (0.4)	3 (0.6)
Prefer not to say	4 (0.8)	3 (0.6)	7 (1.5)

[a] This county shares an Extension office with Sagadahoc County.
[b] This county shares an Extension office with Lincoln County.

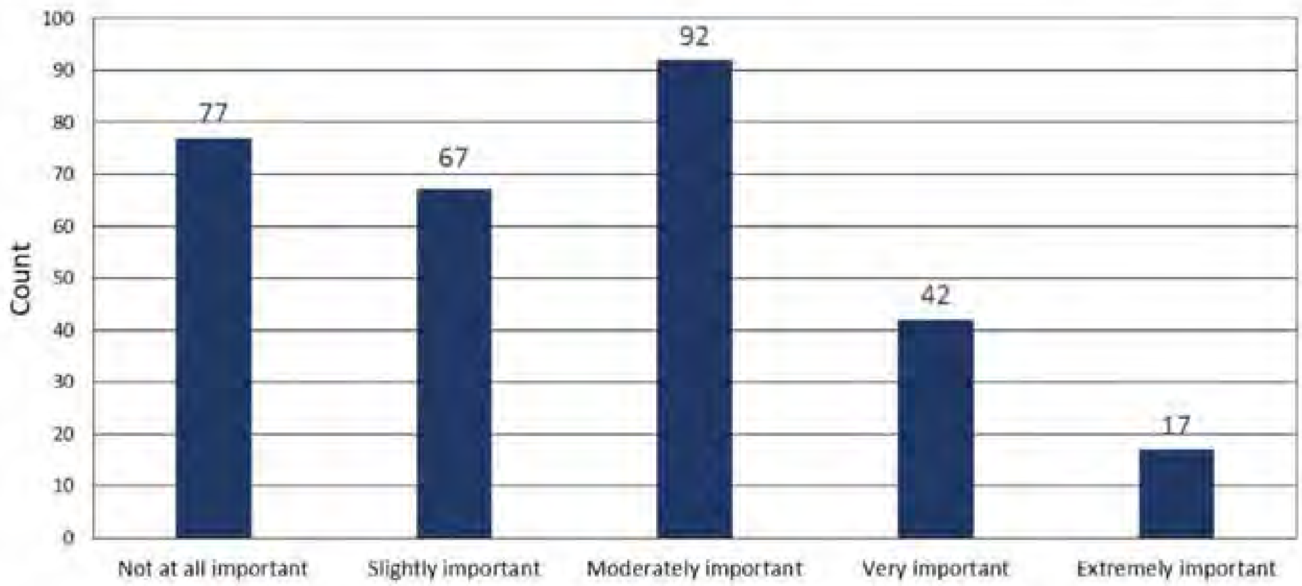
TABLE 4. Reasons why survey respondents said that they do not ferment

What is the one main reason that you do not ferment foods at home? (n = 359)	Number of responses (percentage of total responses)		
	Fermenters	Non-fermenters	Sum
Do not know how to get started	21 (5.8)	91 (25.3)	112
Lack of time	65 (18.1)	32 (5.9)	97
Other reasons including currently fermenting	41 (11.4)	13 (3.6)	54
Buying already-made foods is more convenient	25 (6.9)	28 (7.8)	53
Concerned about food safety	19 (5.3)	12 (3.3)	31
Do not like fermented foods	1 (0.3)	9 (2.5)	10
Too expensive	1 (0.3)	1 (0.3)	2

TABLE 5. Fermented food information sources and interests

	Number of responses	Percentage of total responses to this question
Where do you currently get information on fermenting foods?		
Recipe websites	197	27.1
Cookbooks and other books	187	25.8
YouTube videos	75	10.3
Culture supplier	62	8.5
University of Maine Cooperative Extension	54	7.4
Friends and family members	34	4.7
Maine Organic Farmers & Gardener Association	33	4.5
Lifestyle blog	31	4.3
Workshops or classes at retail stores	24	3.7
Life experience	5	0.7
Other	25	3.4
What types of assistance or information about making fermented foods would you like to have available to you? (n = 821)		
Recipe website	195	23.8
Live hands-on workshop	158	19.2
Online video	147	17.9
A series of classes	112	13.6
Online handout	106	12.9
Recipe cards at stores and farmers' markets	85	10.3
Other	18	2.2
Are there specific topics that you would like to know more about? (n = 1337)		
Tested and safe recipes	305	22.8
Food safety practices	193	14.4
Probiotic benefits	183	13.7
Fermented food nutrition information	168	12.6
Equipment selection	142	10.6
Where to find ingredient suppliers	141	10.5
Making low-sodium fermented foods	132	9.9
Scaling up to commercial production	54	4.0
Other	19	1.4

in the production of yogurt from milk with added culture). As these bacteria multiply, they produce acid that lowers the pH of the environment as well as other products, including antimicrobial compounds and CO_2, that contribute to the anaerobic status of the environment. The creation of an acid environment prevents the growth of most foodborne pathogens and spoilage microorganisms *(59)*. In vegetable and meat fermentations, the addition of salt contributes to



Survey responses to "How important is making low-sodium fermented foods to you? (n = 295)

Figure 1. Survey respondents' interest in low-sodium fermented foods.

safety *(42)*. Historically, fermentation has been utilized as a means of preserving food and increasing safety. However, proper fermentation equipment is still a vital tool in instances of infrastructure or economic insufficiency. For risk to be reduced, it is essential that acids and/or salts be present at the appropriate levels and that fermented foods be produced by use of proper sanitation and hygiene practices *(42, 58)*.

Consumers fermenting foods at home are unlikely to have the equipment required to weigh ingredients accurately, or to monitor pH level. Educating consumers about the relatively low cost of such equipment and their correct use when preparing fermented foods should be addressed in future training activities. Microbiota associated with unprocessed foods can vary depending on the season, handling, age and other factors *(25, 45, 66)*. Changes in endogenous microbiota can have consequences in spontaneous fermentations, which rely on these populations to drive the process. Target pH values for fermented foods are most often defined by use of the U.S. Food and Drug Administration (FDA) requirement of pH 4.60 for an acidified food, while some process authorities require a pH level of 3.70 or below as a critical safety factor to ensure that fermentation is complete. While the 4.60 or below pH level is the canned food requirement known to prevent the germination of *Clostridium botulinum* spores, it may not be sufficient to inactivate some foodborne pathogens, such as *Salmonella, L. monocytogenes*, and Shiga toxin-producing *E. coli* O157:H7 *(6)*.

L. monocytogenes, a soil-borne pathogen, has been found to be resistant to salt and may survive at pH values as low as 4.3 *(53)*. The potential for cross-contamination of a variety of foods with *Salmonella* during cooking operations has been well documented *(32)*. While *Salmonella* is considered to be sensitive to salt concentrations in excess of 5% *(62)*, salt levels below 3% have been shown to increase its resistance to acid stress *(34)*, and its survival in fermented foods such as olives and cauliflower has been demonstrated *(3, 44)*. Mammalian mucous membranes and skin are the primary reservoirs for *Staphylococcus aureus*, a pathogen that grows at salt concentrations of 10% and at pH levels as low as 3.9 *(54)*. If allowed to grow to sufficiently high populations, *S. aureus* may produce an emetic toxin that is highly resistant to heat and denaturation. Pathogen survival, and more important, toxin production, has been demonstrated in a number of fermented foods, including yogurt *(18)*, cow and goat cheeses *(1, 52, 63)*, and fermented meats *(49)*. Recently, a preliminary inoculation study was completed on sauerkraut produced with salt concentrations of 1.0, 1.5, 2.0 and 2.5% (w/w) *(30)*. The results showed that even at high inoculation concentrations (10^5), *L. monocytogenes* was not detected after 6 days of fermentation. However, STEC (Shiga toxin-producing *E. coli*) and *Staphylococcus aureus* were able to survive these salt conditions over fermentation times for some treatments between 18 and 21 days. All of these hazards are preventable by proper processing and sanitation, but consumer adherence requires accessible education.

Online education is a cost-effective tool for educators in rural states. A U.S. survey of consumer media preference for food safety information reported that the Internet was the preferred information source and that websites were preferred to all social media platforms *(36)*. The Preserve the Taste of Summer program combined online food preservation lessons with optional hands-on workshops *(21)*, and the program reached well beyond the instructor's home state of Iowa. Although only 29.2% of program participants reported "high knowledge" of proper techniques to produce pickles after completing the training, other topics, such as canning at high altitude and water bath canning, had increases of knowledge of 74.1% and 57%, respectively *(21)*. According to survey responses in this study, Maine consumers are searching for fermentation information online, and an online education tool may work for this state as well. Eighteen percent of respondents prefer online videos, while 19% prefer live, hands-on workshops. Therefore, a combination of online videos, fact sheets, and in-person workshops may be the best approach to educating Maine residents about tested recipes, proper fermentation and food safety techniques, depending on consumers' preferred learning styles. Providing a list of recommended websites and books may also be beneficial to consumers since information posted online may not be from credible sources.

Strengths of this survey research were the inclusion of residents of most Maine counties and participant willingness to learn more about fermenting foods. Knowing which types of foods are fermented by consumers will allow Cooperative Extension to design curricula aimed at reducing risks of foodborne illness as a result of producing fermented foods at home, for which widely-accepted guidelines are not available in the U.S. For example, the National Center for Home Food Preservation provides guidance for making pickles and sauerkraut *(42)*; therefore, research could focus on lesser-known foods such as kombucha, kefir, and kvass. The effectiveness of curricular materials could then be tested with consumers in Maine and elsewhere. Basic proper hygiene and sanitation practices and selection of safe fermentation vessels will be essential parts of the curriculum. However, a meta-analysis of studies of consumer food safety behaviors concluded that men and young adults (defined as 19–29 years old) are less likely to practice hygienic food preparation *(46, 47)*. According to our findings, Maine women and persons over the age of 30 years are more likely to ferment foods at home. Thus, testing knowledge of hygiene among this population may be less critical.

A limitation of this study is that survey respondents self-selected to take part in the research, and we did not inquire about seasonal fermentations. For example, pickles may be made only in late summer to take advantage of local produce, whereas dairy products might be fermented year-round. Another drawback is the reliance upon the Internet to administer the survey, since some individuals may live "off the grid" in rural Maine and may not have regular access to the Internet. Malsheimer and Germain *(37)* concluded that only a small percentage of survey respondents would take part in face-to-face workshops. Therefore, online demonstrations may be more cost-effective and productive than hands-on workshops, despite the potential exclusion of some residents without Internet access.

CONCLUSIONS/RECOMMENDATIONS

Maine residents are interested in fermenting foods at home. Data indicate that home fermenters are demographically diverse, with significant representation across ages 25–74 years.

Future research should seek to understand the increased interest in fermented foods among older adults, particularly retired persons. Survey respondents requested accessible information on food safety, health benefits of fermented foods, and trustworthy recipes. Food safety was not a top priority for most respondents, which reinforces the need to expand understanding of the importance of proper sanitation and food handling practices. Recipe websites were the most preferred source of information, which indicates that online delivery of educational materials may have greater potential for producing engagement and adherence than traditional workshops. Development of web-based information, including instructional videos, may require a significant investment of time initially but could reduce demands on Extension personnel over time. All Internet materials should be optimized for viewing on smartphones and tablets, as well as traditional computers. Considering the generational divide present among the target audience, a nuanced assessment of preferences for specific digital communication modalities would be useful for targeting future educational efforts.

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REFERENCES

1. Akineden, Ö., A. A. Hassan, E. Schneider, and E. Usleber. 2008. Enterotoxigenic properties of *Staphylococcus aureus* isolated from goats' milk cheese. *Intl. J. Food Microbiol.* 124:211–216.
2. Anonymous. 2017. Hunger pains: widespread food insecurity threatens Maine's future. Preble Street and Good Shepherd Food Bank of Maine, Portland and Auburn, ME. Available at: https://www.gsfb.org/wp-content/uploads/2017/02/Food-Pantry-Report-2-6-171.pdf. Accessed 21 September 2018.
3. Argyri, A., E. Lyra, E. Z. Panagou, and C. C. Tassou. 2013. Fate of *Escherichia coli* O157:H7, *Salmonella* Enteritidis and *Listeria monocytogenes* during storage of fermented green table olives in brine. *Food Microbiol.* 36:1–6.
4. Bautista-Gallego, J., K. Rantsiou, A. Garrido-Fernandez, L. Cocolin, and F. N. Arroyo-López. 2013. Salt reduction in vegetable fermentation: Reality or desire? *J. Food Sci.* 78:R1095–R1100.
5. Bell, V., J. Ferrão, and T. Fernandes. 2017. Nutritional guidelines and fermented food frameworks. *Foods* 6:65. Available at: http://www.mdpi.com/2304-8158/6/8/65. Accessed 18 July, 2018.

6. Center for Food Safety and Applied Nutrition, Food and Drug Administration, U.S. Department of Health and Human Services. 2015. Qualitative Risk Assessment: Risk of Activity/Food Combinations for Activities (Outside the Farm Definition) Conducted in a Facility Co-Located on a Farm. Available at: https://www.fda.gov/downloads/Food/GuidanceRegulation/FSMA/UCM461400.pdf. Accessed 22 August 2018.
7. Centers for Disease Control and Prevention. 1995. Unexplained severe illness possibly associated with consumption of kombucha tea—Iowa, 1995. *MMWR.* 44:892-893,899-900. Available at: https://www.cdc.gov/mmwr/preview/mmwrhtml/00039742.htm. Accessed 11 August 2018.
8. Centers for Disease Control and Prevention. 2004. Childhood lead poisoning from commercially manufactured French ceramic dinnerware - New York City, 2003. *MMWR.* 53:584-586. Available at: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5326a4.htm. Accessed 23 August 2018.
9. Chai, E., E. Choi, C. Guitierrez, M. Holman, S. Johnkutty, W. Kamel, T. Mekles, R. Zarnegar, J. Ackelsberg, S. Baltzer, E. H. Lee, L. Li, A. Ramos, T. Rodriguez, D. Weiss, J. Yung, B. Zhao, S. W. Davis, G. E. Hannett, A. Rao, A. Toprani, and N. Sreenivasan. Botulism associated with home-fermented tofu in two Chinese immigrants — New York City, March–April 2012. *MMWR.* 62:529–532.
10. Chen, F., S. L. Godwin, and A. Kilonzo-Nthenge. 2011. Relationship between cleaning practices and microbiological contamination in domestic kitchens. *Food Prot. Trends* 31:672–679.
11. Cvetković, B. R., L. L. Pezo, T. Tasić, L. Šarić, Z. Kevrešan, and J. Mastilović. 2014. The optimisation of traditional fermentation process of white cabbage (in relation to biogenic amines and polyamines content and microbiological profile). *Food Chem.* 168:471–477.
12. Dewey-Mattia, D., K. Manikonda, A. J. Hall, M. E. Wise, and S. J. Crowe. 2018. Surveillance for foodborne disease outbreaks — United States, 2009–2015. *MMWR.* 67:1–10.
13. Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. Internet, phone, mail, and mixed-mode surveys: The tailored design method. John Wiley & Sons, Inc., Hoboken, NJ.
14. Doeun, D., M. Davaatseren, and M.- S. Chung. 2017. Biogenic amines in foods. *Food Sci. Biotech.* 26:1463–1474.
15. Dolmatova, E. V., K. Moazzami, and S. Bansilal. 2018. Dietary sodium intake among US adults with hypertension, 1999–2012. *J. Hypertens.* 36:237–242.
16. D'Sa, E. M., E. L. Andress, J. A. Harrison, and M. A. Harrison. 2007. Survey of home canning practices and safety issues in the U.S. National Center for Home Food Preservation. Available at: http://nchfp.uga.edu/papers/2007/canning_survey.html. Accessed 21 September 2018.
17. Ebner, S., L. N. Smug, W. Kneifel, S. J. Salminen, and M. E. Sanders. 2014. Probiotics in dietary guidelines and clinical recommendations outside the European Union. *World J. Gastroenterol.* 20:16095–16100.
18. Estrada, A.Z., M. S. Mendoza, L. M. de la Garza, and J. O. Ferado. 1999. Behavior of enterotoxigenic strains of *Staphylococcus aureus* in milk fermented with a yogurt starter culture. *Rev. Latinoam. Microbiol.* 41:5–10.
19. Fernandez, M. A., S. Panahi, N. Daniel, A. Tremblay, and A. Marette A. 2017. Yogurt and cardiometabolic diseases: a critical review of potential mechanisms. *Adv. Nutr.* 8:812–829.
20. File, T., and C. Ryan. 2014. Computer and Internet use in the United States: 2013. American Community Survey Reports, ACS-28, U.S. Census Bureau, Washington, D.C.
21. Francis, S. L. 2014. Hybrid food preservation program improves food preservation and food safety knowledge. *J. Extension* 52: 4TOT8. Available at: https://www.joe.org/joe/2014august/tt8.php. Accessed 28 April 2018.
22. Gagne, M.-J., J. Barrette, T. Savard, and J. Brassard. 2015. Evaluation of survival of murine norovirus-1 during sauerkraut fermentation and storage under standard and low-sodium conditions. *Food Microbiol.* 52:119–123.
23. Gardini, F., Y. Özogul, G. Suzzi, G. Tabanelli, and F. Özogul. 2016. Technological factors affecting biogenic amine content in foods: a review. *Front. Microbiol.* 7:1218. Available at: https://www.frontiersin.org/articles/10.3389/fmicb.2016.01218 Accessed 4 October 2018.
24. Getz L. 2012. Fermented foods — are they the next big nutrition trend? *Today's Dietitian* 14:32. Available at: http://www.todaysdietitian.com/newarchives/070112p32.shtml. Accessed 23 August 2018.
25. Holvoet, K., I. Sampers, M. Seynnaeve, L. Jacxsens, and M. Uyttendaele. 2015. Agricultural and management practices and bacterial contamination in greenhouse versus open field lettuce production. *Intl. J. Environ. Res. Publ. Hlth.* 12:32–63.
26. Howlett, E., S. Burton, A. H. Tangari, and M. Bui. 2012. Hold the salt! Effects of sodium information provision, sodium content, and hypertension on perceived cardiovascular disease risk and purchase intentions. *J. Pub. Policy Marketing* 31:4–18.
27. Hutkins, R. W. 2006. Microbiology and technology of fermented foods. Blackwell Publ., Ames, IA.
28. Inatsu, Y., M. L. Bari, S. Kawasaki, and K. Isshiki. 2004. Survival of *Escherichia coli* O157:H7, *Salmonella* Enteritidis, *Staphylococcus aureus* and *Listeria monocytogenes* in kimchi. *J. Food Prot.* 67:1497–1500.
29. Jiao, Z., Y. Dong, and Q. Chen. 2014. Ethyl carbamate in fermented beverages: presence, analytical chemistry, formation mechanism, and mitigation proposals. *Compr. Rev. Food Sci. Food Saf.* 13:611–626.
30. Khanna, S. 2018. Effects of salt concentration on the physicochemical properties and microbial safety of spontaneously fermented cabbage. M.S. Thesis, University of Maine, Orono, ME.
31. Kim, J. K., E. M. D'Sa, M. A. Harrison, J. A. Harrison, and E. L. Andress. 2005. *Listeria monocytogenes* survival in refrigerator dill pickles. *J. Food Prot.* 68:2356–2361.
32. Kusumaningrum, H.D., E. D. van Asselt, R. R. Beumer, and M. H. Zwietering. 2004. A quantitative analysis of cross-contamination of *Salmonella* and *Campylobacter* spp. via domestic kitchen surfaces. *J. Food Prot.* 67:1892–1903.
33. Lee, S. C., R. B. Billmyre, A. Li, S. Carson, S. M. Sykes, E.Y. Huh, P. Mieczkowski, D. C. Ko, C. A. Cuomo, and J. Heitman. 2014. Analysis of a food-borne fungal pathogen outbreak: virulence and genome of a *Mucor circinelloides* isolate from yogurt. *mBio,* 5:e01390–14.
34. Li, H., H. Wang, J.-Y. D'Aoust, and J. Maurer. 2013. *Salmonella* species, p. 225–262. *In* M. P. Doyle and R. L. Buchanan (eds.), Food microbiology: fundamentals and frontiers, 4th ed. ASM Press, Washington, D.C.
35. Lin, Q.-B., Y. Chen, H. Song, H.-J. Wu, and X.-Y. Wang. 2014. Kinetic migration of chemical elements from ceramic packaging into simulated foods and mature vinegar. *Packag. Technol. Sci.* 27:59–67.
36. Ma, J., B. Almanza, R. Ghiselli, M. Vorvoreanu, and S. Sydnor. 2017. Food safety information on the Internet: Consumer media preferences. *Food Prot. Trends* 37:247–255.
37. Malsheimer, R. W., and R. H. Germain. 2002. Needs assessment surveys: do they predict attendance at continuing education workshops? *J. Ext.* 40: Article 4FEA4.
38. Marco, M. L., D. Heeney, S. Binda, C. J. Cifelli, P.D. Cotter, B. Foligné, M. Gänzle, R. Kort, G. Pasin, A. Pihlanto, E. J. Smid, and R. Hutkins. 2017. Health benefits of fermented foods: microbiota and beyond. *Curr. Opin. Biotechnol.* 44:94–102.
39. Markowiak, P., and K. Śliżewska. 2017. Effects of probiotics, prebiotics, and synbiotics on human health. *Nutrients* 9:1021. Available at: https://doi.org/10.3390/nu9091021https:// www.ncbi.nlm.nih.gov/pmc/articles/PMC5622781/. Accessed 14 August 2018.

40. Meranger, J. C. 1973. Lead in ceramic glazes. *Can. J. Publ. Hlth.* 64:472–476.

41. Naila, A., S. Flint, G. Fletcher, P. Bremer, and G. Meerdink. 2010. Control of biogenic amines in food- existing and emerging approaches. *J. Food Sci.* 75:R139–R150.

42. National Center for Home Food Preservation. 2018. Preparing and canning fermented and pickled foods. General information. Available at: https://nchfp.uga.edu/how/can_06/prep_foods.html. Accessed 9 August 2018.

43. Painter, J. A., R. M. Hoekstra, T. Ayers, R. V. Tauxe, C. R. Braden, F. J. Angulo, and P. M. Griffin. 2013. Attribution of foodborne illnesses, hospitalizations, and deaths to food commodities by using outbreak data, United States, 1998-2008. *Emerg. Infect. Dis.* 19:407–415.

44. Paramithiotis, S., A. I. Doulgeraki, I. Tsilikidis, G.-J. E. Nychas, and E. H. Drosinos. 2012. Fate of *Listeria monocytogenes* and *Salmonella* Typhimurium during spontaneous cauliflower fermentation. *Food Control* 27:178–183.

45. Paramithiotis, S., K. Kouretas, and E. Drosinos. 2014. Effect of ripening stage on the development of the microbial community during spontaneous fermentation of green tomatoes. *J. Sci. Food Agric.* 94:1600–1606.

46. Patil, S. R., S. Cates, and R. Morales. 2005. Consumer food safety knowledge, practices, and demographic differences: findings from a meta-analysis. *J. Food Prot.* 68:1884–1894.

47. Patil, S. R., R. Morales, S. Cates, D. Anderson, and D. Kendall. 2004. An application of meta-analysis in food safety consumer research to evaluate consumer behaviors and practices. *J. Food Prot.* 67:2587–2595.

48. Penas, E., J. Frias, B. Sidro, C. Vidal-Valverde. 2010. Impact of fermentation conditions and refrigerated storage on microbial quality and biogenic amine content of sauerkraut. *Food Chem.* 123:143–150.

49. Pereira, V., C. Lopes, A. Castro, J. Silva, P. Gibbs, and P. Texeira. 2009. Characterization for enterotoxin production, virulence factors, and antibiotic susceptibility of *Staphylococcus aureus* isolates from various foods in Portugal. *Food Microbiol.* 26:278–282.

50. Phan, T. G., J. Estell, G. Duggin, I. Beer, D. Smith, and M. J. Ferson. 1998. Lead poisoning from drinking kombucha tea brewed in a ceramic pot. *Med. J. Aust.* 169:644–646.

51. Redmond, E. C., and C. J. Griffith. 2003. Consumer food handling in the home: a review of food safety studies. *J. Food Prot.* 66:130–161.

52. Rosengren, A., A. Fabricius, B. Guss, S. Sylvén, and R. Lindqvist. Occurrence of foodborne pathogens and characterization of *Staphylococcus aureus* in cheese produced on farm-dairies. *Intl. J. Food Microbiol.* 144:263–269.

53. Ryser, E. T., and R. L. Buchanan. 2013. *Listeria monocytogenes*, p. 503–545. *In* Doyle, M. P., and R. Buchanan (ed.), Food microbiology: fundamentals and frontiers. Fourth Edition. ASM Press, Washington, D.C.

54. Seo, K. S., and G. A. Bohach. 2013.*Staphylococcus aureus* p. 547-573. *In* Doyle, M. P., and R. Buchanan (ed.), Food microbiology: fundamentals and frontiers. Fourth Edition. ASM Press, Washington, D.C.

55. Septembre-Malaterre, A., F. Remize, and P. Poucheret. 2018. Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. *Food Res. Intl.* 104:86–99.

56. Snyder, A. B., and R. W. Worobo. 2018. Risk mitigation for immunocompromised consumers of *Mucormycete* spoiled and fermented foods: germane guidance and remaining needs. *Microorganisms* 6:45. https://www.mdpi.com/2076-2607/6/2/45. Accessed 4 October 2018.

57. Spyropulou, K. E., N. G. Chorianopoulos, P. N. Skandamis, and G. - J. E. Nychas. 2001. Survival of *Escherichia coli* O157:H7 during the fermentation of Spanish-style green table olives (conservolea variety) supplemented with different carbon sources. *Intl. J. Food Microbiol.* 66:3–11.

58. Steinkraus, K. H. 1997. Classification of fermented foods: worldwide review of household fermentation techniques. *Food Control* 8:311–317.

59. Stratton, J. E., R. W. Hutkins, and S. L. Taylor. 1991. Biogenic amines in cheese and other fermented foods: A review. *J. Food Prot.* 54:460–470.

60. SunHee Kole, A., H. D. Jones, R. Christensen, and J. Gladstein. 2009. A case of kombucha tea toxicity. *J. Intens. Care Med.* 24:205–207.

61. Tamang, J. P., D.-H. Shin, S.-J. Jung, and S.-W. Chae. 2016. Functional properties of microorganisms in fermented foods. *Front. Microbiol.* 7:158. Available at: https://doi.org/10.3389/ fmicb.2016.00578. Accessed 22 August, 2018.

62. Thayer, D. W., W. S. Muller, R. L. Buchanan, and J. G. Phillips. 1987. Effect of NaCl, pH, temperature, and atmosphere on growth of *Salmonella* Typhimurium in glucose-mineral salts medium. *Appl. Environ. Micro.* 53:1311–1315.

63. Todd, E., R. Szabo, H. Robern, T. Gleeson, C. Park, and D. S. Clark. 1981. Variation in counts, enterotoxin levels and TNase in Swiss-type cheese contaminated with *Staphylococcus aureus. J. Food Prot.* 44:839–848.

64. Underthun, K., and D. Dekevich. 2018. Kombucha. Available at: http://fsi.colostate.edu/ kombucha/#food-safety. Accessed 22 August 2018.

65. U.S. Census Bureau. 2016. Quick facts: Maine. Available at: https://www.census.gov/quickfacts/ME. Accessed 12 October 2017.

66. Vepštaitė-Monstavičė, I., J. Lukša, R.Stanevičienė, Ž. Strazdaitė-Žielienė, V. Yurchenko, S. Serva, and E. Servienė. 2018. Distribution of apple and blackcurrant microbiota in Lithuania and the Czech Republic. *Microbiol. Res.* 206:1–8.

67. Wolkers-Rooijackers, J. C. M., S. M. Thomas, and M. J. R. Nout. 2013. Effects of sodium reduction scenarios on fermentation and quality of sauerkraut. *LWT – Food Sci. Technol.* 54:383–388.