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Food Safety Implications of Online Recipes for Preparing Soaked Nuts and Nut-Based Dairy Analogs

ABSTRACT

Foodborne outbreaks have been associated with tree nuts and nut-related products that include a soaking step. A content analysis of consumer-shared recipes for soaking tree nuts and subsequently preparing nut-based dairy analogs was conducted to explore consumer handling practices and evaluate available food safety information. A keyword search was performed on YouTube and Google for videos and blogs, respectively. Recipes (n = 505) were coded for general characteristics, handling practices, and food safety messages. Of the 465 recipes that included a soaking step, 76% (353) included soaking for >8 h or overnight, and 17% (79) soaked at room temperature or warmer. Among the 66 recipes that included dried soaked nuts, 22 (33%) specified drying below 65°C (150°F).

In recipes that included a fermentation step (212), commercial probiotics (63%; 133) were the most common starter culture, and the most frequently cited (14%; 30) temperature and time combination was 20 to 35°C (68 to 95°F) for 24 to 48 h. Of all the analyzed recipes, 49% (99) of videos and 30% (84) of blogs lacked food safety messages. These findings will aid development of science-based validation studies and educational materials for consumers and content creators for safe preparation of homemade soaked tree nut products.

INTRODUCTION

The increasing interest in plant-based foods has resulted in a wide range of plant-based dairy food analogs available in retail markets (e.g., nondairy cheeses, milks, and yogurt-style products). A corresponding interest has emerged in preparing similar products, especially those from tree nuts, in the home *(5, 32, 33)*. In a survey, of the tree nut consumers who reported soaking nuts, 67% soaked nuts for out-of-hand consumption and 80% soaked the nuts when preparing nut-based dairy alternatives (NBDA) at home *(37)*.

Soaking softens the nut kernel and may assist in removal of the kernel pellicle (skin). Both results may be desirable when directly consuming the soaked nut or when blending nuts to make other products (soaked nuts result in a smoother texture). Nuts are usually soaked in water and then held at refrigeration to ambient temperatures for a few hours to a

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day or more. In some cases, for out-of-hand consumption, the soaked nuts are dried at low temperatures to reduce the moisture content and allow for longer storage. The soaked nuts can be blended with water (sometimes followed by straining to remove solids) to prepare a milk-like liquid. Microorganisms (starter culture) or other ingredients can be added to the blended nuts, and the mixture can be held for various periods of time to allow fermentation and the development of cheese- or yogurt-type products. These NBDA are intended to mimic their dairy counterparts in taste, texture, and appearance.

Foodborne pathogens can multiply when tree nuts, seeds, and other low-moisture foods are soaked at ambient temperatures *(13, 16, 20, 23)*. However, very little is known about the food safety implications of preparing NBDA in the home, possible because of the lack of data on consumer handling of these products in home kitchens.

Consumers commonly refer to videos and online blogs for instructions or recipes for preparing soaked nuts and NBDA *(36)*. YouTube, a popular online video-sharing platform, has an estimated >30 billion daily views and 51 million channels *(34)*. YouTube allows consumers to view instead of using a written recipe or as a complement to such recipes. The most popular website in the world is Google, an online search engine with an estimated 3.5 billion searches per day, where consumers can find written content, including blogs with recipes *(18)*. Several research groups have evaluated the food safety implications of consumer food handling via content analysis of YouTube videos, online blogs, cookbooks, and consumer forums *(7, 22, 26)*. Although recipes can be used as a mechanism for food safety communication, they often are not. Analyses of consumer handling practices for low-moisture foods have revealed that essential food safety practices, such as hand washing and cleaning kitchen utensils, were generally lacking *(2, 3, 25)*. However, little has been reported on the specific handling practices and food safety messages in recipes highlighting the preparation of soaked nuts and NBDA.

Information gathered from YouTube videos and online blogs can be used to identify consumer handling practices. The present study focused on four types of tree nuts—almonds, cashews, pistachios, and walnuts—used to prepare soaked nuts and NBDA (e.g., milk, cheese, and yogurt analogs) at home. The aim of this study was to analyze the handling practices and food safety messages in popular recipes for soaked nuts and NBDA to identify the food safety implications and communication gaps.

MATERIALS AND METHODS

Video recipe selection

A search of YouTube videos on preparing soaked nuts or NBDA was conducted in August and September 2021. To be considered for the data analysis, the videos were screened based on the following criteria: (i) contained recipes for soaking nuts or nut-based milk, cheese, or yogurt analogs; (ii) recipes used almonds, cashews, pistachios, and/or walnuts; (iii) were in English; (iv) no more than 20 min long; and (v) had ≥500 views *(Fig. 1)*. To ensure that each video was analyzed only once, two researchers independently reviewed the videos to exclude any that used a recipe obtained from another source, used a commercial nut-based product (i.e., commercial almond milk to make almond yogurt) rather than tree nuts to make NBDA, did not include a fermentation step for cheese and yogurt analog recipes, or were duplicate recipes (appeared under a previous keyword search and already selected for analysis). A third researcher reviewed the two researchers' sets of excluded videos to resolve any discrepancies. For each video selected, the number of subscribers, views, likes, and dislikes were recorded. For each product (soaked nut, milk, cheese, or yogurt for each of the four nut types: almonds, cashews, pistachios, or walnuts), a maximum of 25 videos with the greatest viewership were selected for data analysis. The 204 videos that met the inclusion criteria were downloaded to preserve the data for consistent analysis. Supplemental Table S1 lists the keywords used in the search and the number of videos that resulted from each keyword search that met the inclusion criteria.

Blog recipe selection

A blog recipe is commonly referred to as a website post on "how to handle or prepare food," as adapted from previous studies *(3, 16, 28)*. A search for blogs on soaked nuts or NBDA was conducted in October 2021 using the search engine Google; for consistency, the same keywords were used as used for the video search. The Google search was depersonalized by using the Incognito mode in the Web browser and turning off "signed-out search activity" on Google's setting page. To be considered for the data analysis, the blog had to meet the following criteria: (i) contained recipes for soaked nuts or nut-based milk, cheese, or yogurt analogs; (ii) recipes used almonds, cashews, pistachios, or walnuts; and (iii) were in English *(Fig. 1)*. The same exclusion protocol used for the video selection was applied to the blogs. For each blog selected, Ahref's Rank Tracker Tool (https://ahrefs.com/rank-tracker) was used to judge the quality of the website's profile in terms of the all-time organic traffic per month in all countries and the all-time organic traffic per month in the United States. For each product, a maximum of 25 blogs with the most consumer interactions were selected for analysis. The consumer interaction was determined by the number of comments, shares, and monthly visits. A total of 301 blog recipes that met the inclusion criteria were downloaded as PDF files to preserve the data for consistent analysis. *Table S1* lists the keywords used and the number of blogs that were collected from each keyword search that met the criteria.

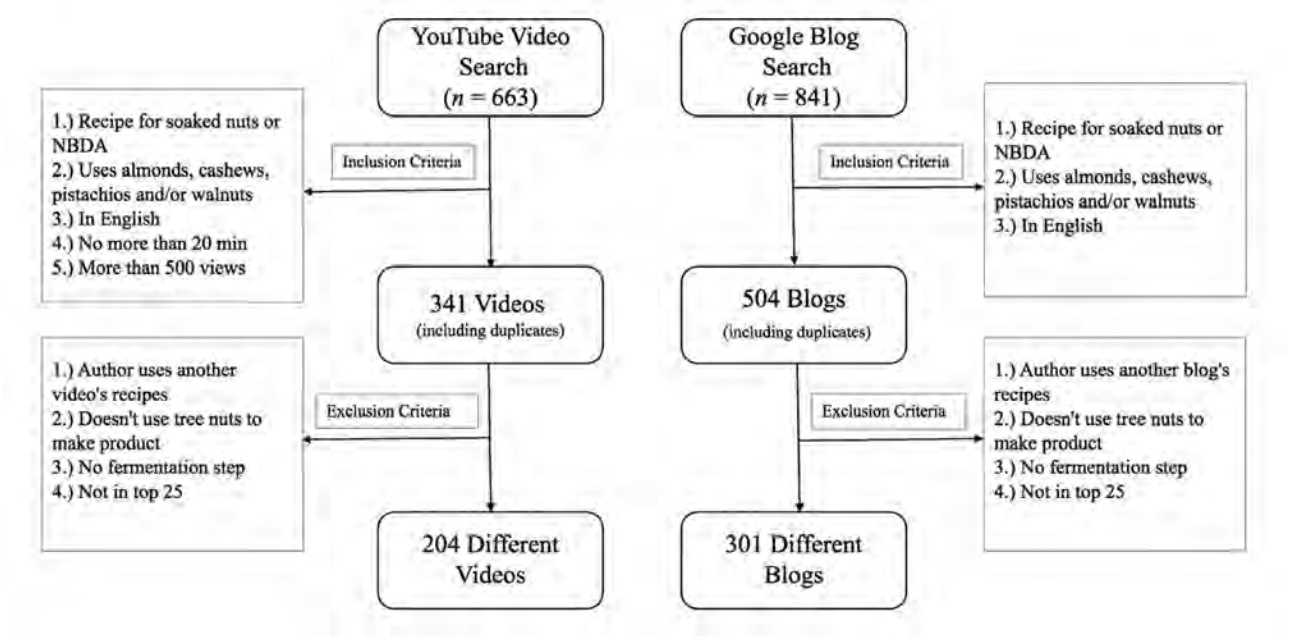

FIGURE 1. YouTube video and online blog selection process.

Coding system

A coding system was developed to evaluate how tree nuts were handled in videos and blogs and what food safety messages were mentioned for preparing soaked nuts and NBDA. The coding system was modified from previous content analyses of food safety information in recipes on YouTube videos and online blogs *(3, 16, 24, 28, 40)*. The coding system consisted of a series of questions developed by the researchers to determine source classification, user interactions, and tree nut handling practices and rationale for those practices. The tree nut handling practices were categorized into the following: (i) source of tree nuts, (ii) washing hands, kitchen tools, surfaces, and tree nuts, (iii) soaking tree nuts, (iv) removing almond skins, (v) blending and straining, (vi) fermentation for cheese and yogurt, (vii) storage, and (viii) use of soaked nuts and/or NBDA. For each question, a code represented a different practice and was used to quantify the frequency of that practice mentioned in all the recipes. For the coding questions with a large range of answers, such as the rationale of a practice, qualitative answers were recorded and grouped into broad codes to determine how many recipes provided similar information. After the initial coding and analysis, researchers reevaluated the videos and blogs to code for additional information on the fermentation ingredients and final pH. Three trained researchers independently viewed and coded the videos and blogs to limit errors or misinformation. A fourth researcher checked and resolved any discrepancies among the coding results of the three researchers to produce the final coding results. All coding data were recorded on Excel (Microsoft, Redmond, WA) spreadsheets.

Data analysis

Descriptive data analysis of the video and blog recipes was conducted in Excel to quantify the frequency of practices and messages in recipes.

RESULTS

Characteristics of recipes

Following the initial searches using all keywords, 663 videos and 841 blogs were reviewed. After selecting videos and blogs based on the inclusion and exclusion criteria, a total of 505 recipes (204 videos and 301 blogs) for soaked nuts and NBDA were analyzed *(Tables 1 and S1)*. The largest number of recipes analyzed were for nut-based milk (37%), cheese (21%), yogurt (21%), and soaked nuts (21%) *(Table 1)*. Most of the NBDA recipes used soaked nuts (89, 93, and 89% for milk, cheese, and yogurt analogs, respectively). Videos and blogs were found under all keywords; however, no videos were analyzed under the keywords "soaked pistachios" or "pistachio cheese" because these videos were either duplicates or did not meet the inclusion criteria.

The video and blogs creators often described the recipes as providing "health benefits" (50%) or as being "tasty" (37%), "easy to make" (25%), or an alternative to dairy products (21%) *(Table S2)*. The creators most often described themselves as a blogger (11%), cookbook author (8%), or recipe developer (6%) *(Table S2)*.

Cashews (50%) and almonds (47%) were the most popular tree nuts used in recipes followed by walnuts (20%) and pistachios (13%) *(Table 1)*. Most recipes did not specify the source of the tree nuts used in the recipe development; 4% mentioned obtaining the tree nuts from

TABLE 1. Tree nut information provided in video and blog recipes

Topic and information	No. (%) of recipes		
	Videos (*n* = 204)	Blogs (*n* = 301)	Total (*n* = 505)
Recipe			
Soaked nuts	32 (15.7)	76 (25.2)	108 (21.4)
Milk	85 (41.1)	100 (33.2)	185 (36.6)
Cheese	39 (19.1)	69 (22.9)	108 (21.4)
Yogurt	48 (23.5)	56 (18.6)	104 (20.6)
Variety of tree nut[a]			
Almond	100 (49.0)	139 (46.2)	239 (47.3)
Cashew	93 (45.6)	157 (52.2)	250 (49.5)
Walnut	32 (15.7)	71 (23.6)	103 (20.4)
Pistachio	16 (7.8)	48 (15.9)	64 (12.7)
Source of tree nut[a]			
Not mentioned	188 (92.6)	285 (94.7)	473 (93.7)
Local store[b]	8 (3.9)	10 (3.3)	18 (3.6)
Online websites[c]	3 (1.5)	5 (1.7)	8 (1.6)
Friends or family	2 (1.0)	1 (0.3)	3 (0.6)
Other[d]	4 (2.)	2 (0.7)	6 (1.2)
State of tree nut			
Raw or organic[e]	90 (44.1)	208 (69.1)	298 (59.0)
Roasted, treated, or pasteurized	114 (55.9)	93 (30.9)	207 (41.0)
Rationale for raw or organic tree nuts[a]			
Not mentioned	198 (97.1)	263 (87.4)	461 (91.3)
For better taste or flavor	2 (2.2)	11 (3.7)	13 (2.6)
For better or smoother final product	NA[f]	9 (3.0	9 (1.8)
To preserve enzymes and nutrients	3 (3.3)	5 (1.7)	8 (1.6)
No salt residue	NA	5 (1.7)	5 (1.0)
No chemicals	NA	5 (1.7)	5 (1.0)
To avoid oils (rancidity)	NA	5 (1.7)	5 (1.0)
For longer shelf life	1 (1.1)	1 (0.3)	2 (0.4)
For sprouting effect	NA	1 (0.3)	1 (0.2)
Sustainable	NA	1 (0.3)	1 (0.2)
Other[g]	NA	4 (1.3)	4 (0.8)

[a]Because multiple answers were provided, calculated numbers and proportions exceed the actual number of videos and blogs analyzed.
[b]Local store specified included Costco and Trader Joe's.
[c]Online websites mentioned were Amazon, Thrive Market, Raw Food World, and Nuts.com.
[d]Other sources mentioned were Spain, Italy, and California.
[e]Raw is defined as not roasted, treated, or pasteurized.
[f]NA, not applicable.
[g]Other rationales for using raw or organic nuts were "raw nuts are paramount," "organic is best," "highest quality," and "best way to eat them."

local supermarkets, and 2% obtained the nuts from online websites. More than half of recipes (59%) specified raw (not roasted, treated, or pasteurized) or organic tree nuts. Few recipes (9%) provided a rationale for using raw or organic tree nuts, but the most common rationales were "for flavor" (3%), "for a better final product" (2%), and "to retain beneficial enzymes and nutrients" (2%).

Preparing soaked nuts

A total of 465 recipes (92%) called for soaking tree nuts in water for a variety of reasons. About half of the recipes (51%) claimed that soaking tree nuts provides additional benefits, including "aids in digestion and absorption of nutrients" (25%), "neutralizes the toxins in the skin" (22%), and "increases the health benefits of the nut" (5%) *(Table S4)*. In 108 (23%) of the 465 recipes, the soaked nuts were used only for direct consumption; in the remaining 357 recipes (77%), the soaked tree nuts were further processed into NBDA. Of the 465 recipes that specified the use of soaked nuts, half (ca. 50%) mentioned almonds and/or cashews, and fewer specified walnuts (21%) or pistachios (10%) *(Table S3)*. Parameters that can potentially affect pathogen growth during soaking of tree nuts—source of nut, temperature control, time restrictions, and the addition of salt or an acid—were explored in more depth.

Of the 465 recipes that called for soaking, 9% (42 recipes) suggested using hot or previously boiled water, and 4.5% (21 recipes) specified boiling water *(Table 2)*. The soaking temperature was not specified in 75% of the recipes (348 recipes). Of those that included a temperature, 15% (68 recipes) mentioned soaking on a countertop at room temperature (18 to 24°C [65 to 75°F]) or warmer, and 9% (44 recipes) advised soaking in the refrigerator. Many recipes (44%, 206 recipes) that provided a soaking method recommended soaking "overnight" (generally defined as about 8 to 12 h), and nearly a third (30%) mentioned either a soaking time of <8 h or ≥8 h *(Table 2)*. Of the recipes that included soaking, approximately one-third (144 of 465, 31%) included both temperature and time parameters *(Fig. 2)*. Nine percent of recipes *(44)* that included soaking recommended refrigeration for ≥8 h or overnight, and 13% (60 recipes) recommended holding at room temperature for ≥8 h or overnight.

Some of the 465 recipes called for adding salt (15%, 71 recipes), lemon juice (2%, 7 recipes), or vinegar (1%, 3 recipes) in addition to the water used for soaking *(Table 2)*. Of the recipes that added salt or acid (81), 16% (13) used vague descriptive terms such as "pinch," "dash," "tiny bit," "little," or "splash," and 11 recipes (14%) did not specify a measurement *(Table S5)*. Fourteen recipes (17%) provided both salt and water measurements that allowed for the salt-to-water concentration to be calculated, which was 0.4 to 2.1%. None of the recipes that called for adding lemon juice or vinegar provided a concentration of acid or the pH of the mixture.

Some recipes included additional postsoaking steps, such as draining the soaking water and/or removing the skin from almonds. Most recipes (73%, 341) called for discarding the soaking water into a sink using a strainer, 2% recommended using the soaking water to help when blending the soaked nuts, and two videos (<1%) suggested drinking the soaking water *(Table 2)*. Nearly a third of the recipes that specified the use of almonds (72 of 240, 30%) recommended removing the skins, and most of these recipes (32 of 240, 44%) suggested using hands to pop the skins off *(Table S6)*. Recipes mentioned that removal of almond skins provides a "creamier and smoother consistency" (17%, 12 recipes), "whiter appearance" (11%, 8 recipes), and "easier food to digest" (8%, 6 recipes).

Postsoaking practices

A total of 66 (61%) of the 108 recipes that specified using soaked nuts for direct consumption (not for further processing into NBDA) recommended drying after soaking *(Table 3)*. Some recipes *(10)* provided more than one drying method. A third of recipes (33%, 22 recipes) specified using temperatures <65°C (150°F), whereas 71% (47 recipes) recommended drying at ≥65°C (150°F). The drying time differed by drying method, ranging from 40 min to 48 h, but most recipes (44%) recommended drying for 13 to 24 h. Some recipes (17%) did not provide an exact time but provided textural cues such as "until completely dry" or "until crisp." A total of 35 recipes (53%) provided both time and temperature recommendations. The most common drying temperature and time combination was <65°C for ≤12 h, mentioned in 15 (23%) of the 66 recipes that included a drying step *(Fig. 3)*.

Of the 465 recipes for soaking nuts, a total of 357 (77%) specified using the soaked nuts to make NBDA. Of those recipes that used soaked nuts, most were providing instructions for making milk (46%, 164 recipes), cheese (28%, 100 recipes), and yogurt analogs (26%, 93 recipes). After soaking, tree nuts can be blended with water and strained to separate the liquid from the solids (pulp) to make a milk analog. All recipes for NBDA called for blending the soaked nuts, and 225 (57%) of the recipes specified straining the blended mixture *(Table S7)*. The most common straining tools mentioned were nut milk bag (61%), cloth (61%), and strainer (50%). Some recipes (144) suggested more than one type of straining tool. Although 27% of recipes mentioned discarding the pulp, 35% recommended saving the pulp to use in other recipes (e.g., energy bars, oatmeal, bread, or cookies), and 11% suggested drying the pulp to make nut flour *(Table S7)*.

A total of 212 recipes included fermentation instructions for making nut-based cheese or yogurt analogs. Of these 212 recipes, 42% recommended adding a starter culture to the blended soaked nut mixture *(Table 4)*, and various starter cultures were proposed. The most popular starter culture was

TABLE 2. Recipe-specified soaking practices during preparation of soaked nuts and NBDA

Topic and information	No. (%) of recipes		
	Videos (*n* = 182)	Blogs (*n* = 283)	Total (*n* = 465)
Nut-to-water ratio (v/v)[a]			
Not mentioned	118 (64.8)	138 (48.8)	256 (55.1)
<1:1	1 (0.5)	6 (2.1)	7 (1.5)
1:1	3 (1.6)	5 (1.8)	9 (1.9)
1:2	5 (2.7)	17 (6.0)	22 (4.7)
1:3	4 (2.2)	3 (1.1)	7 (1.5)
1:4	5 (2.7)	5 (1.8)	9 (1.9)
≥1:5	1 (0.5)	2 (0.7)	3 (0.6)
Enough water to cover nuts	28 (15.4)	107 (37.8)	135 (29.0)
Fill container with water	6 (3.3)	3 (1.1)	9 (1.9)
Other[b]	11 (6.0)	4 (1.4)	15 (3.2)
Soaking water temp (initial)[a]			
Not mentioned	141 (77.5)	188 (66.4)	329 (70.8)
Cold or refrigerated	16 (8.8)	32 (11.3)	48 (10.3)
Room temp or warm	10 (5.5)	44 (15.2)	54 (11.6)
Hot or boiled	12 (6.6)	30 (10.6)	42 (9.0)
Boiling	6 (3.3)	15 (5.3)	21 (4.5)
Other[c]	1 (0.5)	NA[d]	1 (0.2)
Soaking environment temperature[a]			
Not mentioned	143 (78.5)	205 (72.4)	348 (74.8)
Refrigerator (<7°C [45°F])	8 (4.4)	36 (12.7)	44 (9.4)
Dark and cool place (7–18°C [45–65°F])	3 (1.6)	NA	3 (0.6)
On countertop (18–24°C [65–75°F])	25 (13.7)	40 (14.1)	68 (14.6)
Other[e]	3 (1.6)	6 (2.1)	9 (1.9)
Additions to soaking water[a]			
None	163 (89.6)	221 (78.1)	384 (82.6)
Salt	16 (8.8)	55 (19.4)	71 (15.3)
Lemon juice	1 (0.5)	6 (2.1)	7 (1.5)
Vinegar	NA	3 (1.1)	3 (0.6)
Other[f]	2 (1.1)	3 (1.1)	5 (1.1)
Soaking time[a]			
Not mentioned	35 (19.2)	9 (3.2)	44 (9.5)
<8 h	40 (22.0)	115 (40.6)	151 (32.5)
≥8 h	56 (30.7)	85 (30.0)	141 (30.3)
Overnight	76 (41.7)	130 (45.9)	206 (44.3)
Other[g]	3 (1.6)	2 (0.7)	5 (1.1)

Continued on the next page.

TABLE 2. Recipe-specified soaking practices during preparation of soaked nuts and NBDA (cont.)

Topic and information	No. (%) of recipes		
	Videos (n = 182)	Blogs (n = 283)	Total (n = 465)
Use of soaking water[a]			
Not mentioned	90 (49.5)	65 (22.9)	155 (33.3)
Discard	109 (59.9)	232 (82.0)	341 (73.3)
Add to blender	5 (2.7)	6 (2.1)	11 (2.4)
Drink	2 (1.1)	NA	2 (0.4)

[a]Because multiple recommendations were mentioned, calculated numbers and proportions exceed the actual numbers of videos and blogs analyzed.

[b]Other nut-to-water ratios provided were "1 cup of walnuts to 32 oz of water," "½ cup of nuts and a little bit of water," "15 almonds to 1 cup of water," "2 cups of almonds with generous amount of water," "100 g of cashews to plenty of water," "2 cups of almonds with water filled as necessary," "500 g of cashews to 1 can of coconut water," "8 to 10 almonds to ¼ cup of water," "handful of almonds to 1 cup of water," "handful of almonds to ½ cup of water," "150 g of cashews and some water," "handful of almonds and ½ cup of water," "handful of almonds and 1 cup of water," and "2 to 4 walnut pieces in 1 cup of water."

[c]One other soaking water temperature (initial) provided was "manual on instant pot."

[d]NA, not applicable.

[e]Other soaking environment temperatures were "in instant pot," "boiled on the stove," "microwave," "on top of fridge," and "stovetop."

[f]Other additions to the soaking water were jalapenos, probiotics, and kefir grains.

[g]Other soaking times provided were "several hours," "couple of hours," "time required," and "until water is steaming hot but well below a simmer or even at simmer."

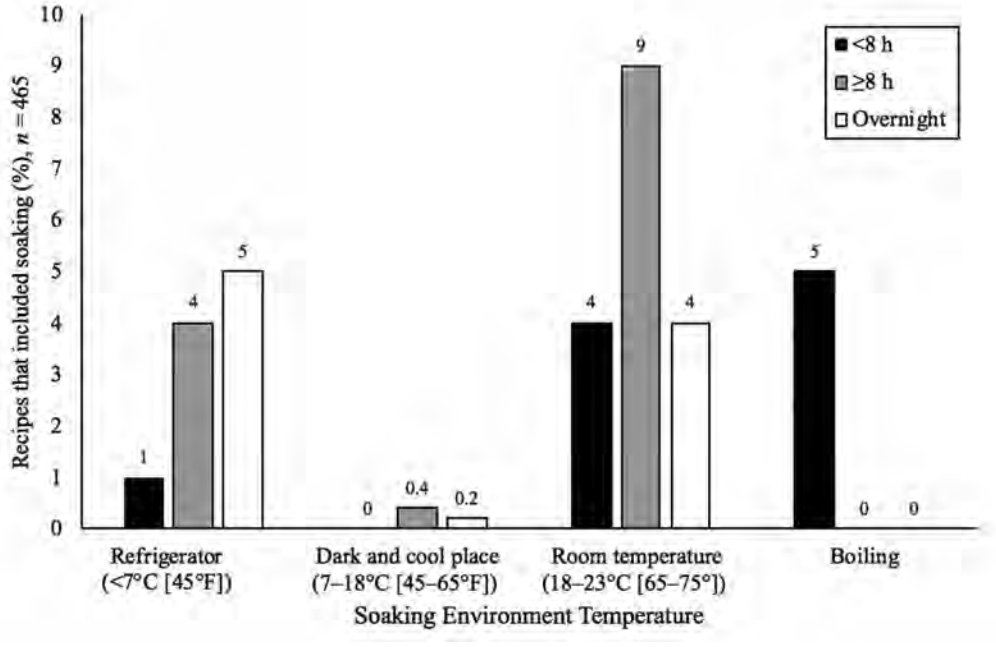

FIGURE 2. Video and blog recipes that specified soaking tree nuts (465 recipes, 31%) at different temperatures for <8 h (solid bars), ≥8 h (shaded bars), or overnight (open bars). The remaining 69% of recipes that included a soaking step did not indicate a temperature and/or time.

TABLE 3. Recipe-specified drying practices after soaking tree nuts for direct consumption

Topic and information	No. (%) of recipes		
	Videos (n = 9)	Blogs (n = 57)	Total (n = 66)
Drying method[a]			
Not mentioned	NA[b]	3 (5.3)	3 (4.5)
Dehydrator	5 (55.6)	41 (71.9)	46 (69.7)
Oven	6 (66.7)	40 (70.2)	46 (69.7)
Air dry	1 (11.1)	2 (3.5)	3 (4.5)
Drying time[a]			
Not mentioned	1 (11.1)	8 (14.0)	9 (13.6)
<1 h	NA	6 (10.5)	6 (9.0)
1–4 h	1 (11.1)	3 (5.3)	4 (6.1)
5–8 h	NA	1 (1.8)	1 (1.5)
9–12 h	1 (11.1)	10 (17.5)	11 (16.7)
13–24 h	4 (44.4)	25 (43.9)	29 (44.0)
>24 h	NA	2 (3.5)	2 (3.0)
Until dry or crisp	2 (22.2)	9 (15.8)	11 (16.7)
Drying temperature[a]			
Not mentioned	1 (11.1)	3 (5.3)	4 (6.1)
<65°C (150°F)	6 (66.7)	16 (28.1)	22 (33.3)
≥65°C (150°F)	1 (11.1)	46 (80.7)	47 (71.2)
Other[c]	2 (22.2)	1 (1.8)	3 (4.5)

[a]Because of multiple recommendations mentioned, calculated numbers and proportions exceed the actual numbers of videos and blogs analyzed.

[b]NA, not applicable.

[c]Other drying temperatures provided were "low heat," "lowest temperature of oven," "on lowest setting," and "turn on oven light and set on lowest rack."

undefined probiotics (63%) in either capsule or powdered form. Many other recipes recommended adding a previously fermented product as a starter culture, a technique known as backslopping. The fermented product starter cultures mentioned in these recipes included cultured yogurt (14%), fermented vegetables or fruits (e.g., sauerkraut, pickle brine, green chilies, jalapenos, kimchi, or chutney) (11%), rejuvelac (a fermented beverage typically made by soaking wheat berries or other grains) (9%), miso paste (7%), kefir (7%), and kombucha (3%).

Of the 212 recipes that included a fermentation step, 25% did not specify any temperature or time parameters for the fermentation *(Fig. 4)*. Varius fermentation temperatures were recommended: >35°C (95°F) (16%), 20 to 35°C (68 to 95°F) (7%), and <20°C (2%); nearly half of the recipes used vague descriptive terms such as "room temperature" (25%) or "warm" (24%). When specified, fermentation times ranged from 1 h to 5 weeks; the most common times were 7 to 12 h (26%, 58 recipes) and 19 to 24 h (25%, 46 recipes). The most popular fermentation temperature and time combinations mentioned in recipes were 20 to 35°C for 24 to 48 h (14%) and >35°C for <24 h (14%) *(Fig. 4)*.

Of the recipes that included a fermentation step, 67% recommended using a covered container, bowl, or jar during fermentation, and 6% showed or specified using an uncovered container *(Table S8)*. Of recipes that included instructions for covering the fermentation vessel, most mentioned using a lid (46%), but four videos and 10 blogs included the direction to "loosely screw on the lid" or use a sprouting lid to allow gases to pass through. Other coverings included a cloth or nut milk bag (10%), kitchen towel (8%), or plastic wrap (7%).

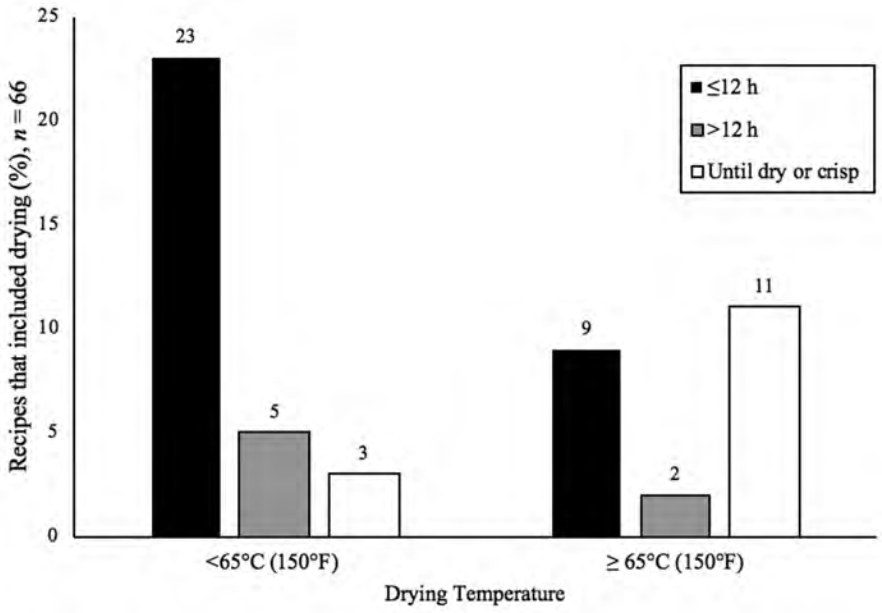

FIGURE 3. Video and blog recipes that specified using soaked tree nuts for direct consumption (108 recipes) and also recommended drying after soaking (66 recipes). Of the recipes that included a drying step, 35 (53%) provided a specific temperature and time. These recipes recommended drying at specific temperatures for ≤12 h (solid bars), >12 h (shaded bars), or until the tree nuts were completely dry or crisp (open bars). The remaining 31 recipes (47%) did not provide a specific drying temperature or time.

Of recipes that included a fermentation step *(Table 4)*, many mentioned the addition of other ingredients or flavorings to the mixture before fermentation, such as salt (36%), sugars (granulated sugar, syrup, honey, coconut water or meat, or dates) (41%), lemon juice (18%), and apple cider vinegar (5%), and the recommended amounts ranged from 1 ml (¼ teaspoon) to 15 ml (1 tablespoon). Other ingredients added before fermentation included thickeners (e.g., gelatin, gums, or agar agar powder), herbs, spices, nutritional yeast, and oil.

To indicate completion of the fermentation process, 26% of recipes suggested tasting for tanginess or agreeable flavor, 11% suggested looking for the formation of bubbles or air pockets, and 8% suggested using smell. No recipes mentioned monitoring the pH as an indicator of completion of fermentation.

Food safety messages

Nearly half of the videos (49%, 99) and a third of blogs (28%, 84) lacked specific food safety messages *(Table 5)*. For messages on washing practices, over half (56%, 282) of the recipes mentioned rinsing the tree nuts with running water after soaking, and 23% *(114)* recommended cleaning or sterilizing kitchen tools *(Table 5)*. However, the recipes that recommended cleaning or sterilizing either did not explain how, only stating to "use clean hands and utensils," or suggested methods that may be ineffective for eliminating pathogens, such as "sterilize by pouring boiling water over." Of the recipes that strained the blended product (44%, 225 recipes), few (9%) specified use of a clean or sterilized straining tool, and 59% suggested using hands to help "squeeze out the liquids" *(Table S7)*. Of the 212 recipes that included a fermentation step, one video and two blog recipes mentioned the use of clean utensils for tasting, and four recipes warned against double dipping. Five videos and two blogs included instructions to wash hands before squeezing, and one video showed the use of gloves during this process. Seven videos and seven blogs, making up 3% of the 505 analyzed recipes, mentioned washing hands before and/or during the nut preparation process, with one video specifying "wash hands with vinegar to disinfect." One blog mentioned using gloves or plastic film when touching the prepared cheese analog.

Of the 397 recipes for processing the tree nuts to make NBDA, 38 (10%) provided safety-enhancing steps, including milk pasteurization by heating or bringing it to boil (100°C) "to sterilize the milk" and "prevent bad bacteria from cultivating" *(Table 5)*. However, only three recipes provided specific temperatures and times for this heating process, from 49 to 87°C and for 15 s to 10 min, whereas some recipes indicated until a "thick consistency," "boil," or "bubbling" is reached.

Of the 212 recipes using fermentation to make nut-based cheese and yogurt analogs, 18 (8%) recommended avoiding

TABLE 4. Recipe-specified fermentation methods to prepare nut-based cheese and yogurt analogs

Topic and information	No. (%) of recipes		
	Videos (*n* = 87)	Blogs (*n* = 125)	Total (*n* = 212)
Starter culture[a]			
Not mentioned	1 (1.1)	2 (1.6)	3 (1.4)
Probiotics	54 (63.2)	79 (63.0)	133 (62.7)
Yogurt starter	9 (10.3)	27)21.6)	36 (17.0)
Cultured yogurt	14 (16.1)	16 (12.8)	30 (14.2)
Fermented produce	4 (4.6)	19 (14.4)	23 (10.8)
Sauerkraut	NA[b]	9 (7.2)	9 (4.2)
Chilies	4 (4.6)	1 (0.8)	5 (2.3)
Kimchi	NA	4 (3.2)	4 (1.9)
Pickles and/or pickle brine	NA	3 (2.4)	3 (1.4)
Jalapeños	1 (1.1)	1 (0.8)	2 (1.0)
Chutney	NA	1 (0.8)	1 (0.5)
Rejuvelac	4 (4.6)	15 (12.0)	19 (9.0)
Miso paste	5 (5.7)	9 (7.2)	14 (6.6)
Kefir	5 (5.7)	8 (6.4)	14 (6.6)
Kombucha	NA	6 (4.8)	6 (2.8)
Vinegar	1 (1.1)	5 (4.0)	6 (2.8)
Cultured cheese	3 (3.4)	2 (1.6)	5 (2.3)
Whey	1 (1.1)	2 (1.6)	3 (1.4)
Bacteria culture	2 (2.3)	NA	2 (0.9)
Other[c]	2 (2.3)	4 (3.2)	6 (2.8)
Fermentation time			
Not mentioned	NA	4 (3.2)	4 (1.9)
≤6 h	9 (10.3)	7 (5.6)	16 (6.6)
7–12 h	26 (29.9)	32 (25.6)	58 (25.5)
13–18 h	6 (6.9)	8 (8.8)	14 (7.5)
19–24 h	17 (19.5)	29 (23.2)	46 (25.0)
25–48 h	15 (17.2)	27 (21.6)	42 (21.7)
≥48 h	9 (10.3)	15 (12.0)	24 (10.0)
Overnight	4 (4.6)	3 (2.4)	7 (3.3)
Other	1 (1.1)	NA	1 (0.5)
Fermentation temperature			
Not mentioned	19 (21.8)	30 (24.0)	49 (23.1)
<20°C (68°F)	2 (2.3)	2 (1.6)	4 (1.9)
20–35°C (68–95°F)	8 (9.2)	7 (5.6)	15 (7.1)
>35°C (95°F)	14 (16.1)	19 (15.2)	33 (15.6)
Room temperature	25 (28.7)	28 (22.4)	53 (25.0)
Warm	18 (20.7)	33 (26.4)	51 (24.1)
Other[d]	1 (1.1)	6 (4.8)	7 (3.3)

Continued on the next page.

TABLE 4. Recipe-specified fermentation methods to prepare nut-based cheese and yogurt analogs (cont.)

Topic and information	No. (%) of recipes		
	Videos (n = 87)	Blogs (n = 125)	Total (n = 212)
Flavors added before fermentation[a]			
None	35 (40.2)	43 (34.4)	78 (36.8)
Sugars			
Syrup	4 (4.6)	23 (18.4)	27 (12.7)
Honey	2 (2.3)	20 (16.0)	22 (10.4)
Coconut water or meat	11 (12.6)	5 (4.0)	16 (7.6)
Granulated sugar	2 (2.3)	12 (9.6)	14 (6.6)
Dates	3 (3.8)	4 (3.2)	7 (3.3)
Salt	21 (24.1)	55 (44.0)	76 (35.8)
Thickeners			
Agar agar powder	7 (8.0)	10 (8.0)	17 (8.0)
Arrowroot powder	2 (2.3)	10 (8.0)	12 (5.7)
Gelatin	NA	9 (7.2)	9 (4.2)
Starch	2 (2.3)	5 (4.0)	7 (3.3)
Gums (Xanthan, guar)	2 (2.3)	3 (2.4)	5 (2.4)
Acids			
Lemon juice	11 (12.6)	27 (21.6)	38 (17.9)
Apple cider vinegar	2 (2.3)	9 (7.2)	11 (5.2)
Herbs and spices	9 (10.3)	26 (20.8)	35 (16.5)
Nutritional yeast	7 (8.0)	24 (19.2)	31 (14.6)
Oil	3 (3.8)	13 (10.4)	16 (7.5)
Miso	4 (4.6)	8 (6.4)	12 (5.7)
Vanilla	2 (2.3)	10 (8.0)	12 (5.7)
Seeds and nuts	NA	5 (4.0)	5 (2.4)
Other[e]	9 (10.3)	2 (1.6)	11 (5.2)
Test for doneness[a]			
Not mentioned	59 (67.8)	72 (57.6)	131 (61.8)
Taste for preference or tanginess	11 (12.6)	33 (26.4)	44 (20.8)
Formation of bubbles or air pockets	6 (6.9)	14 (11.2)	20 (9.4)
Cheese- or yogurt-like smell	5 (5.7)	10 (8.0)	15 (7.1)
Thick and creamy texture	5 (5.7)	3 (2.4)	8 (3.8)
Firm shape	3 (3.8)	1 (0.8)	4 (1.9)
Layer covering cheese	NA	2 (1.6)	2 (0.9)
Other[f]	2 (2.3)	2 (1.6)	4 (1.9)

[a]Beause of multiple recommendations, calculated numbers and proportions exceed the actual numbers of videos and blogs analyzed.
[b]NA, not applicable.
[c]Other starter cultures mentioned were "water from soaked rice," "yeast and bacteria from the air," dehydrated koji, kvass, lemon juice, and alfalfa."
[d]Other fermentation temperatures were "cool," "bring to boil," "on low in dehydrator," and "residual low heat."
[e]Other flavors added before fermentation were dulse ("seaweed to feed the cultures minerals"), thickener, kefir, Irish moss, jalapeño, Life Essentials nutrition mix, chocolate, natural dietary fiber, and blackberries.
[f]Other methods to test for doneness were "will be runny and warm," "when it feels dry on the outside," "color change," and "liquid separated."

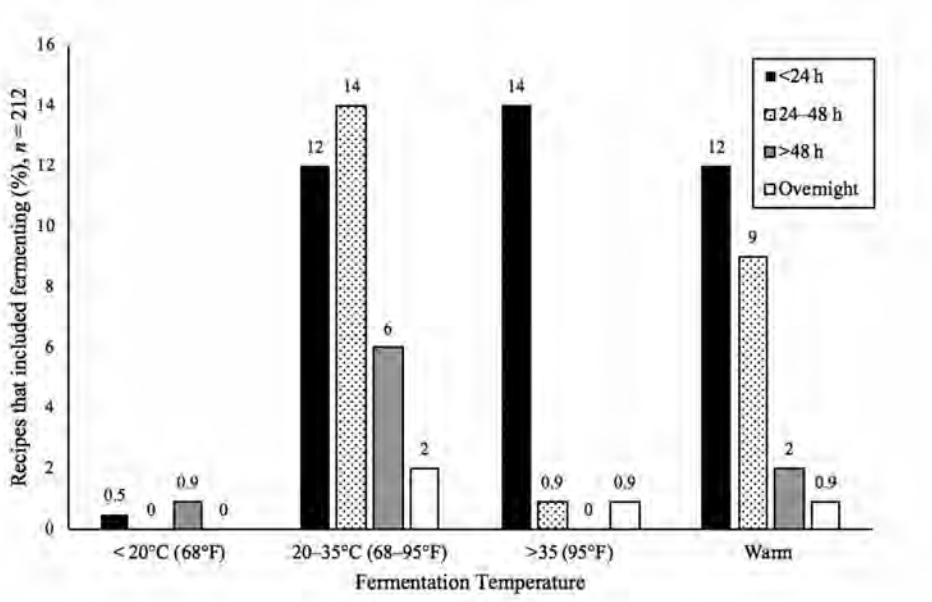

FIGURE 4. Video and blog recipes that specified fermenting (212 recipes) to make nut-based cheese and yogurt analogs after soaking. Of the recipes that included a fermentation step, 159 (75%) provided a specific temperature and time. These recipes recommending fermenting at specific temperatures for <24 h (solid bars), 24 to 28 h (stippled bars), >48 h (shaded bars), and overnight (open bars). The remaining 53 recipes (25%) did not provide a specific fermentation temperature or time.

metal and/or plastic utensils *(Table 5)* because "they will kill lactic acid bacteria" or "tamper with the effectiveness of the probiotics." Twelve (18%) of the 67 recipes that mentioned drying the tree nuts after soaking specified that the nuts should be completely dry to prevent mold growth during storage *(Table 5)*. Ten (2%) of all analyzed recipes suggested discarding nuts or products with unpleasant sensory characteristics (e.g., unpleasant smell or color change) *(Table 5)*. However, one blog mentioned that if mold develops on the cheese, "scrape those parts off and wrap in paper towel before placing back into container." In contrast, some noteworthy potential food safety suggestions included changing the soaking water, using fresh ingredients, avoiding touching, using single-use utensils, and sprinkling salt over the cheese during fermentation.

DISCUSSION

The preparation of soaked tree nuts for direct consumption and the further processing for NBDA provides opportunities for both pathogen introduction and proliferation. The present content analysis was conducted to highlight common handling practices and food safety messages mentioned in online recipes of soaked nuts and NBDA.

Food safety implications of soaking tree nuts

Soaking tree nuts in water is purported to have many health benefits. Of the 505 recipes analyzed, 108 called for soaking nuts for direct consumption and 357 called for soaking nuts to make NBDA. Although foodborne pathogens do not grow on dry tree nuts because of their low water activity (typically <0.6), pathogens can survive for a prolonged time in low-moisture foods *(8, 11, 16, 31)*. The addition of water to tree nuts can substantially and quickly increase the water activity (>0.98), thus providing an environment for pathogen growth *(13, 16, 23)*. Pathogen populations significantly increased on almonds, cashews, and walnuts soaked at ambient temperatures for 24 h *(13, 16, 23)*, with significant increases of *Salmonella* after 12 h of soaking almonds *(16)*. Many recipes in the present study neglected to include a temperature parameter, advised soaking at ambient temperatures for long periods of time (≥8 h), or included vague instructions such as "overnight," which may be interpreted as roughly 8 to 12 h. This finding corroborates the results from other studies in which recipes commonly lacked temperature parameters or advised soaking tree nuts at "room temperature" for 4 to 24 h or "overnight" *(16, 37)*.

Although not motivated to improve food safety measures, some recipe creators included steps that might enhance food safety. Of the recipes analyzed, 13% recommended using hot or boiling water to shorten the soaking time. Under highly controlled (commercial) conditions, exposure to hot water (2 min at 88°C for almond kernels or 4.6 min at 90°C for inshell pecans) can effectively reduce pathogen levels in some tree nuts *(17, 21)*. No data have been published on microbial reductions (if any) that would be achieved by adding hot or boiling water to tree nuts in a home setting. A small number of recipes (44, 9%) advised soaking nuts at low temperatures,

TABLE 5. Food safety messages mentioned in recipes for soaked nuts and NBDA

Topic and information	No. (%) of recipes		
	Videos (*n* = 204)	Blogs (*n* = 301)	Total (*n* = 505)
Food safety message[a]			
Not mentioned	99 (48.5)	84 (27.9)	183 (36.2)
Rinse tree nuts	84 (41.2)	198 (65.8)	282 (55.8)
Use clean, sterile, or sanitized tools[b]	35 (17.2)	79 (26.2)	114 (22.6)
Pasteurize or sterilize milk	14 (6.9)	27 (9.0)	41 (8.1)
Avoid metal or plastic	4 (2.0)	14 (4.7)	18 (3.6)
Wash hands	7 (3.4)	7 (2.3)	14 (2.8)
Make sure nuts are completely dry	2 (1.0)	10 (3.3)	12 (2.4)
Change soaking water	6 (3.0)	4 (1.3)	10 (2.0)
Discard "funky" products	2 (1.0)	8 (2.7)	10 (2.0)
Use fresh ingredients	3 (1.5)	6 (2.0)	9 (1.8)
Sprinkle salt over cheese	NA[c]	6 (2.0)	6 (1.2)
Avoid touching with hands	1 (0.5)	4 (1.3)	5 (1.0)
Do not oversoak	1 (0.5)	4 (1.3)	5 (1.0)
Do not double dip	1 (0.5)	3 (1.0)	4 (0.8)
Cover the product	1 (0.5)	2 (0.7)	3 (0.6)
Do not mix types of nuts	NA	2 (0.7)	2 (0.4)
Discard floating nuts	NA	2 (0.7)	2 (0.4)
Do not leave soaked nuts out	1 (0.5)	NA	1 (0.2)
Do not wear jewelry	1 (0.5)	NA	1 (0.2)
Use gloves	NA	1 (0.3)	1 (0.2)
Rationale for food safety message(s)			
To prevent bacterial contamination	6 (3.0)	23 (7.6)	29 (5.7)
To prevent mold growth	NA	16 (5.3)	16 (3.2)
To remove enzyme inhibitors	7 (3.4)	5 (1.7)	12 (2.4)
To clean nuts	7 (3.4)	2 (0.7)	9 (1.8)
To prevent spoilage	3 (1.5)	5 (1.7)	8 (1.6)
For effective fermentation	2 (1.0)	5 (1.7)	7 (1.4)
To remove salt	NA	6 (2.0)	6 (1.2)
To extend shelf life	NA	5 (1.7)	5 (1.0)
To prevent rancidity	1 (0.5)	3 (1.0)	4 (0.8)
For better end result	1 (0.5)	3 (1.0)	4 (0.8)
To prevent dust or bugs getting in	1 (0.5)	NA	1 (0.2)
To easily remove the skin	NA	1 (0.3)	1 (0.2)
Other[d]	NA	3 (1.0)	3 (0.6)

[a]Because multiple food safety messages were mentioned, calculated numbers and proportions exceed the actual number of videos and blogs analyzed.
[b]Of the 505 analyzed recipes, 4.9% specified that all tools should be clean, sterilized, or sanitized, whereas 17.7% specified only that certain tools should be clean (i.e., straining tools, fermentation jars, and utensils).
[c]NA, not applicable.
[d]Other rationales for food safety messages mentioned were "I rinse [the nuts] with cold water so they are firm and easy to handle," "because they have been sitting in a warehouse after traveling from other countries," and "freeze to hold shape better."

such as refrigeration. Soaking tree nuts at lower temperatures (<15°C) prevents pathogen growth within a 24-h soaking period *(13, 16, 23)*.

Although 18% of the recipes called for adding salt or acid to the soaking water, the reason often given was for "taste" or "to inhibit enzyme inhibitors" rather than as a food safety precaution. Nonetheless, results of previous studies have indicated that high concentrations of salt (≥10%) or low pH (<4.6) can prevent pathogen growth during soaking *(13)*. However, the recipes that mentioned adding salt or acid lacked measurement information or the concentrations used were much lower than levels that are likely to impact microbial growth.

Food safety implications of postsoaking practices

After soaking tree nuts, consumers may choose to dry nuts to store for later consumption. Of all the recipes analyzed, a drying step was included in 66 of 108 recipes that specified using soaked nuts for direct consumption. Some recipes indicated use of low heat (≤46°C) for drying because the content creators believed that "high temperatures will destroy the enzymes." In previous studies, drying of almonds (66°C [151°F] for 14 h) and walnuts (64°C [147°F] for 12 h) resulted in little to no decrease in *Salmonella* populations; higher temperatures may be needed to attain meaningful pathogen reduction *(16, 23)*. High temperatures may be necessary to achieve adequate pathogen reduction in low-moisture foods because of the increase in heat resistance as water activity decreases *(38)*. Further studies are needed to determine drying temperatures and times that could effectively reduce pathogens while retaining product quality in a home setting.

Many recipes included instructions for making fermented nut-based cheese or yogurt analogs. Probiotics were the most popular starter culture for nut-based cheese and yogurt analogs. This finding aligns with results of a consumer survey in which probiotics were reported as widely used as starter cultures in the home *(37)*. Nearly half of the recipes that used probiotics suggested a probiotic brand or recommended that the probiotic contain lactic acid bacteria (LAB) strains. In some cases, specific strains were mentioned (e.g., *Lactobacillus acidophilus, Lactobacillus bulgaricus,* or *Streptococcus thermophilus*). Although commercial probiotic products often contain one or more strains of LAB, not all probiotics do. For example, one recipe specifically recommended using a probiotic with the strain *Bifidobacterium lactis*, which is not considered an LAB. LAB metabolize lactose to produce lactic acid, lowering the pH and contributing to the characteristic flavor of fermented dairy products *(10)*. However, dairy fermentation methods are not necessarily transferable to NBDA because of the differences in composition, including carbohydrate content. Most tree nuts do not contain lactose but contain mixtures of fructose, glucose, sucrose, and maltose, depending on the tree nut *(19)*. Heterofermentative strains of LAB, such as *Leuconostoc* spp. and *Leuconostoc lactis* subsp. *lactis*, may be more effective for metabolizing the sugars within tree nuts *(4)*. A higher initial concentration of heterofermentative LAB strain *Leuconostoc mesenteroides* in a starter culture for fermented cashew cheese achieved a pH of <4.4 within 48 h *(39)*. However, heterofermentative strains produce gas by-products that may alter the flavor profile and leave undesirable gas bubbles *(29, 39)*. Further studies are needed to determine the most appropriate starter culture composition for a range of nut-based fermented products.

In the present study, some recipes used previously fermented products, such as kombucha, rejuvelac, and kefir as the starter culture for making NBDA. These starter cultures can lead to less predictable outcomes, because the levels and variability of the LAB in the source material will differ *(6)*. Kombucha and miso paste are the result of complex fermentations and involve non-LAB microorganisms that may be inadequate for producing NBDA *(12)*. Some recipes recommended using homemade rejuvelac as the starter culture. Rejuvelac is made by soaking wheat berries for 24 to 48 h at ambient temperatures *(6, 27)*. As with nuts and seeds, *Salmonella* populations can significantly increase in soaked grains after 24 h of soaking at ambient temperatures *(13, 20)*, which introduces another potential point of contamination.

The temperature and time to complete the fermentation may differ based on the starter culture used, the nut type, and the presence of other ingredients. Most recipes included instructions for fermenting at 20 to 35°C or "warm" temperatures for 13 to 48 h. In contrast, a recent survey reported that consumers most commonly fermented NBDA at cool ambient temperatures for ≤12 h *(37)*. The disparity in times between the survey and online recipes may be due to misreporting of consumer behavior. The optimal temperature range to favor LAB growth is ambient or greater (20 to 35°C) *(1)*.

The time for successful fermentation depends on the initial levels of starter culture, the temperature, and the availability of fermentable sugars. For most NBDA, no standards exist for the fermentation end point, largely because of a lack of data to support such standards. The British Columbia Centre for Disease Control *(6)* published comprehensive guidance for producing commercial fermented nut cheeses that includes ingredient sourcing, potential pathogen reduction treatments for the nuts, sanitation measures, temperature controls for soaking, and use of a commercial starter culture. The guidance suggests that a pH of ≤4.4 (as measured with a pH meter) should be reached within 24 h but not later than 48 h. Further research on the behavior of foodborne pathogens during fermentation of nuts to produce NBDA would help to strengthen such recommendations. However, these recommendations provide a framework for the development of consumer-based guidance for production of NBDA.

Some ingredients added to the product before fermentation may hinder pathogen growth, drive fermentation, or

help achieve a low pH. For example, nearly half of the recipes called for adding salt to the product before fermentation for improving sensory properties. The addition of salt can influence microbial growth and thus drive fermentation *(13, 35)*. However, the salt concentrations likely added to NBDA, especially yogurt analogs, are not likely to lower the water activity to levels that would influence the fermentation or prevent the growth of pathogens. Thus, adding salt may not be a practical food safety measure for nut-based yogurt and cheese fermentation. The addition of acidic ingredients (23% of recipes included this as a fermentation step) should lower the initial pH and may impact the competition between LAB and other bacteria. The addition of sugars also may drive the fermentation by providing an additional energy source for the starter cultures to metabolize and produce acid. In recipes evaluated in the present study, acids were included to enhance flavor rather than for food safety.

Food safety communication gaps

Online recipes can be a platform to provide food safety messages. In a previous study, consumers modeled the behaviors of television celebrity chefs, whether safe or not *(41)*. Food safety messages embedded into recipes can increase safe consumer food handling *(26)*. However, the present content analysis revealed three main gaps in food safety communication.

One food safety communication gap was the lack of safe food handling practices; many content creators excluded specific hand washing and cleaning steps. Content creators may assume that common knowledge will ensure that consumers will use those practices when preparing food. Yet, in one study only ca. 37% of food handlers knew the importance of washing hands for 20 s *(30)*. In another content analysis of recipes containing wheat flour, cross-contamination from handling practices occurred in one quarter of the recipes *(3)*. In the present study, one recipe recommended using vinegar for hand washing. Although vinegar has antimicrobial properties, it is not a disinfectant and is unlikely to be an appropriate substitute for hand washing with soap and water *(42)*. During the straining step, many recipes called for reusable tools and bare hands and did not stipulate that tools and hands should be cleaned before use, which presents a potential point for cross-contamination. The absence or misinformation regarding hand washing and cleaning increases the risk of cross-contamination. The lack of instructions for washing hands and kitchen tools is consistent with other content analysis studies, in which hand washing instructions were completely missing from all video and blog recipes on wheat flour and apple drying *(3, 24)*.

A second food safety communication gap identified in online recipes was the limited descriptions of processes and parameters. Many recipes used vague instructions such as "overnight," "room temperature," and "warm." Interpretation of these imprecise terms can differ among consumers and may result in unsafe food handling due to misunderstanding of the terms. To test for doneness during drying and fermentation, many recipes used sensory cues, such as "until dry or crisp," "formation of air pockets," or "smells like cheese," which are subjective. Sensory cues also were used to test the doneness in recipes for dried apples and eggs *(22, 24)*. Only a few recipes recommended pasteurization of the nut-based milk analogs or specifically sourcing pasteurized nuts.

Many online recipes also lacked consistent or science-based explanations of their food safety messages. Some recipes warned against oversoaking because "it will cause rancidity of the oils" leading to "bitter, slimy, and flavorless [nuts]." These statements may be true but fail to emphasize the potential microbial food safety risk of oversoaking. Other recipes encouraged oversoaking to improve the quality because the "longer you soak, the creamier the milk." The contradicting messages among recipes may confuse consumers about best practices and what messages to trust. Some recipes mentioned refrigeration only after soaking for an extended time (e.g., "if left up to 2 days") but neglected to explain why, which leaves the consumer unmotivated to move the soaking nuts into the refrigerator. A survey on flour found that consumers believed that food safety messages that included the explanation and benefits of a practice were more effective *(14)*. Other study results suggest that messages with explanations can lead to safer food handling practices *(9, 15)*.

Limitations

Although this study was carefully designed, it had some limitations. For example, the popularity of online recipes can be evaluated in many ways. In the present study, popularity was determined by the view count for videos and monthly visits of the website for blogs. However, Ahref's Rank Tracker Tool used to collect monthly visits estimates the numbers. Thus, the blogs and videos analyzed may not represent the most popular recipes for soaking nuts and making NBDA. Only videos and blogs that appeared under the keyword search were evaluated. Because of the personalization tools utilized by search engines, individual consumer search results can differ from those in our study. YouTube search results may differ among users, depending on the interactions of the account *(43)*, and the videos collected may not appear to all YouTube users.

CONCLUSION

The analysis of YouTube videos and online blogs revealed that recipes for soaked nuts and NBDA contain a wide range of handling practices that may impact food safety. For example, many recipes included instructions for soaking nuts for >8 h at ambient temperatures and drying soaked nuts at low temperatures and failed to provide time, temperature, or pH parameters for fermentation. Overall, recipes lacked food safety messages pertaining to hand washing and tool cleaning

or provided vague instructions. The findings convey the need for studies to investigate the parameters that influence survival or growth of pathogens during the preparation of soaked nuts and NBDA. Data are especially lacking with respect to the behavior of foodborne pathogens during fermentation of soaked nuts. Future validation studies and educational materials for consumers and content creators are needed to provide science-based food safety handling practices for preparing microbiologically safe soaked nuts and NBDA at home and to eliminate communication gaps.

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SUPPLEMENTAL MATERIAL

Supplemental material associated with this article can be found online at: [URL to be completed by the publisher].

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