BC Centre for Disease Control
An agency of the Provincial Health Services Authority

Environmental Health Services

Food Issue

Notes from the Field

Fermented nut cheese

Request received from:	Island Health Authority
Date of request:	16 August 2017
Issue *(brief description)*:	Review food safety process and guidance for manufacture of fermented cashew nut cheese. Operators making these products are being evaluated following *Salmonella* illnesses at a restaurant associated with similar product.

Disclaimer: The information provided in this document is based on the judgement of BCCDC's Environmental Health Services Food Safety Specialists and represents our knowledge at the time of the request.
It has not been peer-reviewed and is not comprehensive.

Summary of search information:

1. Internet sources: review on-line information about nut cheese processing; site of interest[1], [a] and [a], Google scholar search, 1 site of interest [b]
2. PubMed: ["tree nut salmonella", n=15, 10 citations of interest; "tree nut e.coli", n=19, 2 citations of interest.
3. OVID: ["nut cheese", 0 returns; "nut butter", n=11, 0 citations of interest; "ferment*+food or food contamination, n=>200k, combined with "food safety" + "cashew or Anacardium", n=3, 1 citation of interest[c]; reviewed "cashew, n=657, 6 citations of interest: 3 bacteriological surveys, 2 mycotoxin surveys, 1 on nut butter. Of note: none on nut butter fermentations].
4. Expert correspondence: Dr. Randy Worobo (Cornell Univ., US) and Dr. Fausto Gardini (Bologna Univ., Italy)

Background information:

Comprehensive information about nuts and nut pastes may be found on a UC Davis site. [1] Nut cheeses recipes can be prepared fresh or fermented. Fresh style nut cheese involves blending of nuts that have been soaked in water and addition of spices and other items as desired, such as nutritional yeast to provide cheese flavour. Fresh nut cheese prepared in this way looks more like a dip, and may be served this way in a bowl. Alternatively, moisture may be removed by wrapping and squeezing liquid out using cheese cloth, then forming into a round, or through the use of a dehydrator.[2] Once the fresh cheese is made if is refrigerated. In this process, there are two process steps that can increase the risk in the product: the soaking step, which will be covered in a fermented nut cheese process, and dehydration. Dehydration of raw diet foods, and associated risks have been reviewed in a previous food issue note and will not be covered here.[3]

[a] Nut and nut pastes. http://ucfoodsafety.ucdavis.edu/Nuts_and_Nut_Pastes/ (reference #1)
[b] Tabanelli et al. 2013 (reference #31).
[c] Mohanty et al. 2006 (reference #13)

Fermented nut cheeses involve a lactic acid bacteria (LAB) fermentation process, and will form the basis of this food issue review. Figure 1 shows a basic food flow process for a fresh nut cheese and a fermented nut cheese.

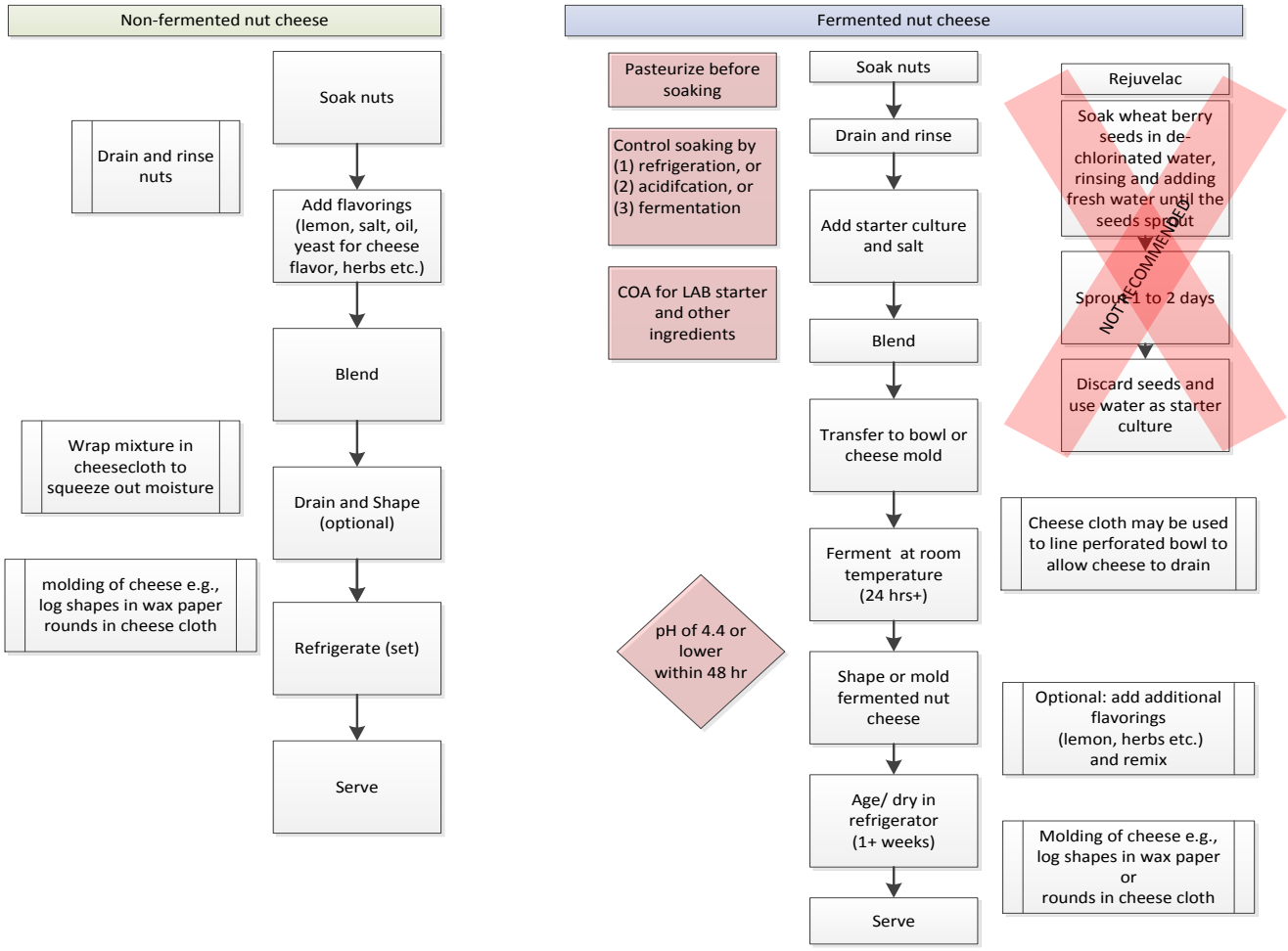

Figure 1. Examples of a non-fermented and fermented nut cheese – control steps to improve safety of fermented nut cheese are shown in red

While there are many variations in the actual production of fermented nut cheeses, the overall process involves:

1. Soaking of nuts to soften
2. Mechanical grinding / blending of nuts (before or after fermentation step)
3. Addition of LAB culture* and other ingredients for flavour
4. Fermentation
5. Drying and molding (shaping) of cheese
6. Packaging and storage

* One example of fermented cashew nut cheese uses *Lactobacillus acidophuilus*, which is listed as an ingredient in all of the fermented nut cheeses from one company.[4] A number of sites suggest using *Rejuvelac (*also spelled as *Rejuvulac)* liquid which is made by soaking a wheat berry based grain, such as quinoa, for several days until sprouting. The liquid following sprouting can be used as a wild fermentation starter.[5-7]

From a food safety perspective, all of the steps listed above have inherent risk, either from the source ingredient or process method. Fermented nut cheese is a novel food application; it is not a traditional ethnic food. While soybeans have been fermented by many cultures (Indonesia and tempe; Japan and koji; China and fermented black soybean or Douchi)[8-10] there is no traditional record for fermentation of tree nuts, such as cashews, to produce a cheese. Tree nut sap and juice is fermented in some countries to produce an alcoholic beverage, such as coconut palm wine, but no record of the use of the cashew nut for this purpose was found in the literature.[11] Of note, 'cashew apple juice' refers to the outer portion of a cashew nut that is usually discarded at harvest. This product is being commercially developed and fermented to produce value-added products in biotechnological manufacturing as well as wines and vinegars.[12,13]

Fermented nut cheese has emerged as part of a growing vegan plant-based diet.[14] Nut consumption in general appears to be protective for coronary heart disease, and foods such as roasted nut butters contain protective phytochemicals.[15] A recent recipe book published by K. McAthy (2017) describes several recipes for fermented and non-fermented nut-based cheeses, including those made from coconut milk.[14] Good information about the importance of cleaning and sanitation during home-cheese making is stressed, however, methods to control bacterial risks are not described for some process steps, for e.g., soaking nuts in refrigerated or acidic conditions in this book.

Firm nut-cheeses made from cashew on left, and coconut milk on right (K. McAthy, 2017)[14]

What are the risks associated with fermented nut cheese

A. Contaminated nuts

Risks associated with tree nuts and ground nuts (peanuts) are well established. Many countries harvest nuts by hand, drying occurs outside in the sun, and nuts may become contaminated via exposure to animals, soils and dusts.[16] Wet, humid conditions create a significant hazard for aflatoxin in tree nuts and peanuts.[16] Nuts and seeds are both known sources for *Salmonella,* the bacterial hazard of primary

concern in this product, although *E. coli* O157 is also of significance. These pathogens are found on tree nuts and seeds because environmental contamination of the trees and ground occur from insect, bird, rodent and mammal (incl. human) fecal contamination. A recent review found 36 outbreaks associated with a variety of nuts: almonds (n=6), cashews, coconuts and hazelnuts (n=3 each), walnuts and pinenuts (n= 1 each), peanuts (n=11) and sesame seeds (n=8).[17] *Salmonella* and *E. coli* bacteria are tolerant of low moisture, surviving well on dried raw nuts and seeds.[18]

Contamination rates in nuts, including organic nuts are comparable and very low – for e.g., 0.55% of cashews sampled in one study were positive for *Salmonella*, overall amounts found on nuts were also low, with counts of 0.003 MPN/g (MPN=most probably number).[19]

B. Rejuvelac (sprouted seed water)

Rejuvelac is a health food term applied to the water used to sprout various seeds, traditionally from wheat berry seeds for e.g., wheat, rye, quinoa and others. It is a popular health food with vegans, wheat berries are placed in water for 24 to 48 hours, the seeds sprout, and the water begins fermenting, with lactic acid bacteria and other wild fermenters.[20] Many vegan nut cheese recipes call for Rejuvelac as the culture starter.[5-7] While this might be an appropriate choice for a home cook, it is not a recommended practice for commercial applications, unless there are strict controls in place. Sprouted seed outbreaks have been common worldwide for decades, including BC and Canada.[21-23] A scientific risk assessment stated there is no guarantee that bacteriocidal treatments for seeds will control contamination because the humidity, temperature and growing conditions can amplify even small amounts of bacteria present on seeds: it is estimated that counts as low as 4 *Salmonella* per kg of seed can amplify to high enough numbers to cause illness.[23] In one experts' opinion, the method to produce and employ Rejuvelac *'resembles more a bacterial bomb than a starter culture'*.[24]

C. Fermented nut butter cheeses

While lactic acid bacterial (LAB) fermentations are generally regarded as safe, unsanitary conditions and poor hygiene can amplify existing risks.[25] It is crucial that processes do not amplify existing hazards into levels capable of causing illness. Specific guidance is given in industry guidelines for heat-treating tree nuts to minimize these hazards before foods are considered ready-to-eat.[26]

There have been outbreaks associated with both nut butters and raw cashew cheese products in the United States in the last five years.[27-29] Although the exact process for the manufacture of the raw cashew nut cheese is not described in the CDC posting, the web-site for Cultured Kitchen raw cashew cheese states products marketed currently are fermented. https://www.cashewreserve.com/

Other hazards of concern in fermented vegetables include *C. botulinum* and *L. monocytogenes.*[30] Foods with higher pH, that are unrefrigerated and sealed in anaerobic containers pose a risk for formation of botulinum toxin.[30] As these nut-cheese fermented products likely have a high water activity (higher than a water activity, a_w of 0.94, similar to soft dairy cheeses) they are considered a potentially

hazardous food, requiring refrigeration. Unless a final pH of 4.4 or lower during the shelf-life of the cheese is maintained, the risk of *Listeria monocytogenes* must also be considered in fermented vegetable products, including nut cheeses, even when the nut cheese is placed under refrigeration.[30] Although refrigerated conditions lower the risk of bacterial growth, *Listeria* are able to grow at refrigerated temperatures down to -1°C (30°F). Sanitation and sanitary food handling procedures are important to not allow for any post-processing contamination in these types of products. In general, while most fermentations do not allow pathogens to grow, several studies of fermented vegetable products have shown pathogens present can survive, including *S. aureus, Y. enterolitica, E.coli* and *Salmonella,* likely because these bacteria develop resistance under stress.[30]

Previous guidance on fermented nut cheese from British Columbia

A food issue note on raw diet foods that included general advice on fermented foods was done in March 2016, however, it did not review specific guidance for manufacture of raw nut cheese.[3] This review included Canadian recalls of concern with raw nut spreads (almond, cashew and hazelnut) and assorted spices.[3] The guidance listed several options for reducing existing risks for raw foods, many of which are applicable to this process.

Previous guidance on fermented nut cheese from elsewhere

Although a directed literature search on this topic was conducted, we did not find OVID nor PubMed related articles on nut-cheese fermentation. Through a google scholar search we found one abstract describing a cashew nut cheese fermentation. This paper characterizes the microbial community during the fermentation process, and recommends prevention of microbial hazards using acidification (although the process steps requiring acidification were not described in the abstract), and avoiding the possible growth of *Listeria monocytogenes*.[31] The LAB detected during this natural fermentation process included *Leuconostoc mesenteroides* and *Weisella* spp. 24 hours, followed by *Pediococcus pentosaceus* after 24 to 48 hours: indicating hetero and homo-fermentative LAB typically seen in vegetables and fruit wild fermentations. We could find no other reputable sources in the literature describing food safety required for manufacture of fermented nut cheeses. However, there is literature available on minimizing risks from tree nuts, sprouted seeds, and general approaches to safe lactic acid fermentations. The use of starter cultures over wild fermentations, for example, has improved the overall safety of traditionally prepared Greek fermented foods.[32] LAB vegetable fermentations are generally regarded as safe, due to low pH in the products, however heat treatments such as pasteurization are necessary to deactivate vegetative bacteria to improve safety in some types of foods, for e.g., olives.[30] Dr. Randy Worobo (Cornell University) advised acidification of water for sprouting nuts, and acidification of Rejuvelac water, with starter culture preferred to provide a more standardized fermentation.[33] Disinfecting seeds will not remove all LAB, but will reduce populations, thus starter culture for production of Rejuvelac is also recommended.[33]

Specific advice for fermentation of nut-based cheeses

Product sourcing

Ingredients should be sourced from suppliers that can provide a Certificate of Assurance (COA) that ingredients have been screened and tested free of hazards of concern, e.g. *Salmonella* and *E. coli.* The ingredients that require a COA include (1) nut supplier for cooked and raw nuts; (2) LAB culture; (3) flavour ingredients and spices, and (4) seed supplier if Rejuvelac is made. Cooked, rather than raw, nuts are recommended.

Soaking of nuts prior to fermentation

A COA does not completely eliminate the hazard of *Salmonella* or *E.coli* in nut products. It is recognized that testing does not detect all low or intermittent levels of bacteria of concern on nut products.[26] For this reason, it is recommended that nuts, both cooked and in particular raw nuts undergo a heat treatment sufficient to allow for reduction in *Salmonella* levels. The nut safety handbook prepared by the GMA nut safety task force recognizes a number of methods to reduce bacterial levels, including frying, wet and dry roasting and blanching.[26] It is recommended that a hot-water blanching step be used prior to soaking of cashews and other types of tree nuts.

The following guidance applies specifically to almonds, but is useful guidance for other types of nuts to provide for a 5-log reduction of *Salmonella*:[26]

a. 82.2°C (180°F) water for a minimum of 3.09 minutes;
b. 85°C (185°F) water for a minimum of 2.49 minutes;
c. 87.8°C (190°F) water for a minimum of 2.0 minutes.

Note: guidance given above is taken from an example for nut processing industry. Nuts should be immersed in water at the temperature and time given and extra time allotted to ensure all nuts reach the appropriate temperature. An alternative simpler method would be to pour boiling water over the nuts and ensure the temperature stays above 90°C for at least two minutes. The first process step listed in one commercial production of fermented nut cheese is a 10 minutes soak of nuts in 90°C water.[24] This would provide adequate safety margins to achieve the minimum requirements listed above.

Following a treatment that will reduce *Salmonella*, the nuts and water mixture should be cooled from 60°C to 20°C within two hours (per normal guidelines), then soaked prior to the addition of a fermentation agent. Alternatively, the fermentation agent may be added directly to the soaking nuts. However, the soaking of nuts must occur under conditions that minimize and do not further amplify potential hazard. Soaking options:

1. Nuts are soaked between 20°C and 4°C for no longer than four hours before either the fermentation agent is added; or
2. Nuts are soaked for periods longer than four hours under refrigerated conditions of 4°C or less; or

3. Soaking water is pre-acidified with an acidifying agent (e.g., citric acid, or equivalent) to a pH of 4.6 or less; or
4. LAB culture is added at the beginning of the soaking step, soaking occurs at room temperature, and active fermentation is verified within 24 hrs to a pH of 4.7.[24] Instructions for verifying fermentation are detailed in the fermentation section on the following pages. Addition of 1% glucose will aid fermentation of soaking nuts.[24]

Potable water must be used during the soaking process.

Equipment design and sanitation

At this stage, the soaked nuts may be ground prior to fermentation or ground after the fermentation is completed. Either choice requires sanitary and hygienic conditions so that potential contaminants are not introduced into the nuts. Equipment used to grind the nuts must be able to be cleaned, and all parts in contact with food cleaned and sanitized after each use. A sanitation plan must be provided that will show steps on how to clean and sanitize the blending equipment used. Food grade cleaning and sanitizing agents, and additional instructions on how to disassemble rotor blades or other equipment used for this purpose may be necessary. All equipment, utensils and food contact surfaces need to be cleaned and sanitized before each use. If too much time has passed between use, re-sanitize immediately prior to use.

Addition of LAB culture

We recommend a LAB starter culture be used to ferment nut cheese. This will ensure the consistency in fermentation conditions with every batch. *Lactobacillus acidophilus* or other LAB culture suitable for this purpose and style of nut cheese may be purchased directly from reputable suppliers. The quantity of LAB culture required per quantity of nut should be established for the process. The culture should come with a certificate of assurance (COA) that the culture is free from *Salmonella, Listeria, E. coli* and other hazards. The COA may optionally also be declared as being produced from vegan sources. This would mean the starter culture was produced by growing on a vegan approved substrate.[24]

The use of Rejuvelac starter culture, kombucha culture, yogurt culture, or other pickling brines is not recommended. The use of culture from previous batches of nut-cheese (known as back-slopping), or from other sources such as kombucha, yogurt, probiotic capsules, miso or pickling brines must not be used to produce fermented nut-cheese products. While such methods are reported by home chefs, the re-use of other fermentation agents are not appropriate for manufacture of fermented product for home sales. Specifically, the use of previous batches of product is subject to batch to batch variability in the strength and microbial flora of the starter culture. Rejuvelac liquid is produced from a wild fermentation that occurs following the soaking of wheat berry or other seeds, and may amplify existing hazards present on the seeds.

Fermentation

Other ingredients may be added to the mixture at this stage (prior to fermentation), or depending on the process, mixed in after the fermentation process. As long as ingredients do not add new hazards, or interfere with the active LAB, flavorings such as spices, salt, nutritional yeast or other ingredients may be added prior to fermentation. Addition of salt is recommended to promote LAB fermentation (1% or higher).[24]

Following addition of suitable LAB starter culture the nuts are fermented at room temperature in containers that are covered but not sealed. As the fermentation is active, there should be allowance for 'breathable' conditions for gas formation. The fermentation mix may be held in food-grade containers, wrapped in a food-grade material, for e.g. cheese-cloth and stored in a mold, or in a food-grade fabric material. During the fermentation process, similar to a dairy cheese process, the nut mixture will separate out into a liquid and solid mass, the solid mass becomes the cheese. Recipes suggest fermentation at room temperature for up to two days, depending on acidity and flavour profiles. From a food safety perspective, an active fermentation should be demonstrated within 24 hours, and no later than 48 hours. The nut cheese mixture will begin to separate (liquid and solid phase, akin to curds and whey in cheese) and a pH drop should be measureable with the first 24 hours. Within 48 hours, the pH must be at 4.4 or lower, or the batch has failed. To establish pH measurements, we recommend using a pH meter, or pH paper capable of measuring to within ±0.3 pH units. Active LAB culture is necessary to outcompete undesirable micro-organisms. Operators should be able to demonstrate pH drop in the process during verification of the recipe.

Drying, molding, packaging and storage

After a maximum of two days of room temperature fermentation, the cheese product should be refrigerated for further aging. The process may involve squeezing the excess liquid from the cheese through cheese cloth if it has not developed in a mold. The cheese should be wrapped and refrigerated in a sealed container. Storage in the refrigerator will promote hardening and drying. Recipes report leaving fermented nut-cheese for several days and up to one week. The final pH of the fermented nut-butter cheese should be assessed to determine shelf-life and storage conditions under reduced oxygen packaging (ROP) conditions. Cheeses with acidity greater than a pH of 4.4 or water activity, a_w of greater than 0.94 should be held refrigerated to control for the risk of *Listeria monocytogenes*.

Recommendations from BCCDC:

Fermented plant-based nut cheeses are a high risk potentially hazardous food. This is evident from previous illness outbreaks associated with these products, and because many fermented nut-cheeses will require refrigeration (i.e. are PHF) before consumption.

1. Ingredients **must** be sourced from suppliers that can verify products are testing free of *Salmonella, Listeria, E. coli* and other hazards (a COA should come with the ingredient);
2. Sanitary facilities and handling are required for manufacture of this product. If the cashews or other nuts are mechanically chopped / blended there must be a sanitation plan in place to limit contamination from this processing and handling step;
3. Rejuvulac water is not recommended for the manufacture of nut cheeses. Biological hazards (e.g., *Salmonella*) are difficult to control in sprouted seeds and significant risk of illness exists associated with sprouted seeds, wild fermentation cultures that are created through soaking of wheat berries or other seeds to create Rejuvulac;
4. Back-slopping (using a previous culture), use of kombucha, yogurt, miso paste, probiotic pills, or pickling brine as a starter culture is not recommended;
5. Nuts should be heat pasteurized (pasteurized is preferable over raw) prior to the soaking / fermentation step;
6. After heat pasteurizing, nuts should be cooled from 60°C to 20°C in two hours, and further cooled from 20°C to 4°C in four hours (per normal guidance);
7. Nuts soaked in water **must** have an additional control step to minimize growth of *Salmonella* by either (1) refrigeration, or if soaking nuts at room temperature (2) acidification of the water to below 4.6, or (3) addition of LAB starter culture with fermentation verification at 24 hr;
8. Fermentation verification: pH tests of the initial cashew ferment (0 hrs), and ferment process (at 24 and 48 hrs) must be provided, and sufficient to show an active fermentation with 2 days is established with pH dropping to below 4.4 by end of 2nd day. Use of pH meter is recommended.
9. Packaging should comply with ROP products according to the pH and a_w of the final product.

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