



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

Environmental Health Services

Food Issue

Notes from the Field

Raw food handling to limit existing hazards

Request received from:	Fraser Health Authority
Date of request:	December 7, 2015
Issue (brief description):	Raw food enthusiasts dehydrate foods within the danger zone ($\leq 60^{\circ}\text{C}$). A recent presentation at BCCDC recommended all dehydrations begin for 1 hr at 63°C to limit pathogen growth. Does this mean we can no longer approve dehydration recipes for raw foods?

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Summary of search information

1. Internet sources: review of CFIA recall database; Combase modelling
2. Pubmed: "raw food diet" 18 hits: 5 of interest; Web of Science: "raw food diet" AND "safety", 73 hits: 3 of interest.

Background information

The raw food diet is implicit in the name, proponents consume unprocessed foods in their natural form. Raw food diets can be described as uncooked vegetarian (vegan) diets, or "living food" diets.¹ These diets usually include germinated seeds, sprouts, cereals, vegetables, fruits, berries and nuts. Preparation of raw diet foods is often minimal, involving dehydrating foods at low heat, producing non-baked good mixes, such as granola, cultured and fermented foods, or blended fruit and vegetable smoothies.

Lack of heat is important to raw food diet proponents, as it is their belief that heating foods denatures natural enzymes and vitamins present, sustaining the "life force" and "energy" in the foods.^{1,2} In one survey of raw foods diet, participants declared maximum temperatures for cooking foods to be in the range of 108 to 120°F, equivalent to 42 to 49°C.²

Vegetarian based diets are growing in popularity, approximately 4% of Canadians were vegetarian in 2003 and 8% are estimated to be vegetarian based on a recent poll conducted in 2015.^{3,4} Evidence suggests benefits of raw food diets include favorable serum LDL cholesterol and triglyceride concentrations, and favorable plasma beta-carotene levels.^{5,6} However, these diets are also associated with lower vitamin B-12, low lycopene, lower HDL and dental erosion from food acidity.⁵⁻⁷ No clinical evidence supports use of raw food diets to persons with cancer, with physicians recommending oncologists counsel patients on these types of diets.^{7,8}

What are the risks associated with raw food diet recipes?

Ingredients of concern in raw food diet recipes include seeds or seed powder, raw organic spices, fresh and dried fruits and vegetables. Other ingredients that are often used include sea salt, honey, and less common ingredients such as water kefir and chlorella (a source of B12).⁹ To determine if any of these ingredient types are a concern, we reviewed CFIA recalls affecting BC on-line from Jan 1, 2014 to Mar 1, 2016 for *Salmonella*, *E. coli* O157, *Listeria*, and *Staphylococcus aureus* (see Appendix 1). The principal hazard of concern was *Salmonella*, which was found in 16 incidents and associated with 27 recalls, followed by *Listeria* in 3 incidents and recalls. Neither *E.coli* O157 nor *S. aureus* was associated with a recall affecting a raw food ingredient during this period. Foods contaminated by *Salmonella* included a variety of raw nut spreads (almond, cashew, and hazelnut), flax seeds and powder, chia seeds and powder, sunflower seeds, spices (paprika and black pepper) and carob powder. Sliced apples, smoothie blends and whole fruits contaminated by *Listeria monocytogenes* were found during this recall review. This information adequately established that the biological hazard, *Salmonella*, is a concern in raw food diet recipes.

Salmonella is known for its ability to persist in low moisture environments, and for high heat tolerance in these environments.¹⁰ This makes *Salmonella* a problem in dried foods such as nuts, seeds, spices and chocolates.¹¹⁻¹⁵ Heat resistance of *Salmonella* is known to increase when moisture is removed from foods as well, through a stress response that releases osmoprotectants.¹⁶ For these reasons, recommendations to control pathogens affecting low moisture foods include preventing contamination through hygiene and sanitation in the process.¹⁷

During the dehydration process for raw foods, issues to consider include the amount of amplification of *Salmonella* when either the water activity or acidity in the recipe is insufficient to control growth, how long these conditions persist before growth is limited (i.e. how long before the water activity falls below the threshold for bacterial growth at the specific temperature and pH of that recipe), if the dehydration process reduces the amount of *Salmonella* present, and by how much (i.e. potential log reduction) of dehydration. When modelling the dehydration process, limitations in estimating the issues associated with hazards present in the recipe include:

- Model programs such as Combase are limited by allowable inputs. The maximum temperature that can be entered is 40°C for growth and non-thermal survival (Combase); water activity values are restricted for growth (enter between 0.973 and 1.0) and non-thermal survival (0.78 to 0.96), and dynamic modelling is not an option for non-thermal survival (Combase). There is no option to input a variable for water activity.
- Recipes received for raw food diets have not identified starting pH, water activity values provided with recipes measure the end-point of the dehydration, when hourly water activity values would be required to assess potential log reductions, and dehydration times vary between 10 and 24 hours for many recipes.

With these restrictions, we can use Combase to estimate reduction in the number of *Salmonella* during a non-thermal process. When temperature is set at 40° and pH at 6.0, the maximum reduction varies

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between a high of $-0.368 \log \text{ conc/h}$ at an A_w of 0.78 to a low of $-0.007 \log \text{ conc/h}$ at an A_w of 0.96. This is equivalent to a one log reduction in *Salmonella* requiring between 2.7 to 141 hours. At A_w of 0.97 and above, growth of *Salmonella* will occur, for e.g., at 40°C , pH 6 and A_w of 0.973, a one log increase of *Salmonella* will occur in 43 minutes.

As dehydration times in raw food diet recipes are variable, and can be as short as 10 hrs, this suggests there will be limited value in reducing *Salmonella* numbers until below a water activity of 0.90 (17 hrs to achieve a one log reduction). In a BCIT student study with a raw food cracker, data suggests that dehydration at 48°C for 14 hours may result in an approximate 2-log reduction of *E. coli* (from 6.63 to $4.02 \log_{10} \text{ CFU/g}$)¹⁸. Therefore, while growth may be minimal during dehydration, reduction of bacteria during this process is also expected to be minimal. Further, remaining *salmonellae* bacteria in the food are likely to be stressed, and able to persist in dried raw foods for extended periods.

Previous guidance on raw food diet recipes from British Columbia

BCCDC has been contacted about raw food diet recipes and dehydration on at least three separate occasions in the past, and about dehydration of various foods, such as fruits, granola and nut butter (see Table 1). In these consults, recommendations included to

- to purchase raw nuts and seeds with a certificate of assurance (COA) ensuring ingredients are tested free of *salmonella*
- to rehydrate seeds with potable water in the refrigerator
- to dehydrate at 63°C for the first 60 minutes, or to otherwise acidify the recipe below a pH of 4.6
- dehydrate fruits to below an A_w of 0.65
- dehydrate nut butter and granolas to below an A_w of 0.85
- include a nutrition facts and allergen labelling with the product

Additionally, a food issue note that focused on production of raw carob chocolate reviewed general safety of specific raw food process steps.¹⁹ This note summarized that raw food process steps must be designed to limit amplification of potential bacterial hazards. Examples of process steps that increase likelihood of bacterial hazards multiplying in raw foods include:

- Soaking dry ingredients in water at temperatures above 4°C
- Dehydrating raw food mixtures in the temperature danger zone: i.e., between 4°C and 55°C
- Not providing anaerobic conditions for lactic acid fermentation to occur properly

Previous guidance on raw food diet recipes from other jurisdictions

The CFIA Reference Database for Hazard Identification (RDHI) can provide general listings of hazards for broad categories of ingredients for consideration. Hazards that are identified for raw food ingredient categories are shown in Appendix 2. Hazards in this list that have not been discussed in this issue note include those arising from mycotoxins (in dried fruits), from pests, from chemical contamination, from

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sanitizing/cleaning agents, container coatings, or pesticides, and physical hazards (e.g., stones, pits, 'extraneous material'). No specific guidance is given on this topic from CFIA or Health Canada, however.

Very little information is published in the scientific literature on raw food diets. When entering a search string into PubMed "raw food diet", only 18 items were returned, and all but five discussed issues associated with raw pet food diets. A search of Web of Science also produced very little useful literature. While numerous articles again focused on raw pet food diet issues, only three articles were found that discussed cultural food security perspectives on use of ethnobotanicals and fermentations, however, none addressed food safety of raw food diets.

Recommendations from BCCDC

Raw food diet dehydration recipes do not have a kill step (critical control point or CCP). This is not unique, as other foods without true CCPs are also routinely made, such as cold smoked salmon. However, for raw food dehydration there is very little information available about the parameters that control microbial growth during this process (e.g. water activity or pH at the start or during dehydration). This knowledge gap does not allow a proper assessment of the risk of lack of pathogen inactivation (or pathogenic growth) during the dehydration process when it is conducted below 63°C. Given this uncertainty, the risk of foodborne illness arising from dehydrated raw food cannot be excluded. Food safety advice that can be given is to perform processes in a way that limits growth of potential biological hazards, e.g., *Salmonella*, and to source ingredients, insofar as this can be achieved, that are not contaminated. Good premises sanitation and hygiene are critical to limit potential contamination.

Recommendations are given in two sections. In the first section, BCCDC provides recommendations on this issue. In the second section, recommendations specific to raw food diet recipes are provided.

SECTION 1 RECOMMENDATIONS

1. BCCDC should review handling of raw food diet recipes with the Food Safety managers.
2. Recommendations provided in section 2, once reviewed and approved by Food Safety managers, should be used to make an industry best practices document.
3. BCCDC should inquire with other food safety experts if modelling programs exist to dynamically model effects of dehydration (i.e. decreasing water activity) on pathogen growth. This could be used to provide a more precise critical limit on the amount of time product can be left out of temperature control conditions.
4. BCCDC should request that UBC or similar food technology institution undertake this research, as it very little work appears to have been conducted in this area. Questions that need to be answered include maximum acceptable thickness of a food product to achieve adequate dehydration during a defined period; assessing decreasing water activity levels over a typical dehydration (measurements every hour, for example); and assessing log growth and log reduction during the process.

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SECTION 2 RECOMMENDATIONS

General food safety advice for raw food diet recipes

1. Purchase seed, nut, spice and other ingredients from suppliers who can provide COAs that products are tested for *Salmonella*, *E.coli* O157, *Listeria* and/or other pathogens as appropriate to that food category.
2. Fruits and vegetables should be purchased whole, and cleaned and rinsed in potable water before use.
3. Seeds should be rinsed in potable water prior to use. Seeds must be sprouted in potable water, using properly cleaned and sanitized equipment, and handled in a hygienic manner.
4. Seed sprouting must be performed in a refrigerated environment, at or less than 4°C.
5. Other food preparation processes, where-ever possible, should be performed in a refrigerated environment.
6. Areas used for preparing raw diet recipes, whether in a restaurant kitchen, commercial kitchen, or at home must be separated from other processes to limit potential for cross-contamination.
7. Raw foods that are prepared for retail sale must be prepared in a commercial kitchen.
8. A recipe, food safety plan, and sanitation plan must be followed. Premises sanitation and hygienic handling of foods must be in place. Frequent hand-washing, good personal hygiene and not working while ill are important.
9. Include a best before date, nutrition facts label, and allergen information where appropriate.
10. Use food grade materials and containers to prepare all foods.

Dehydration specific food safety advice

1. Keep crackers thin and flip half-way through dehydration process to dry faster.
2. **ACIDIFICATION:** Prior to dehydration, acidify recipes to at or less than a pH of 4.6, to prevent growth of potentially harmful bacteria, such as *Salmonella*. Natural acidulants can be employed to lower the pH of a recipe. These include: acetic acid (vinegar, common in fermenting foods and fruits), citric acid, malic acid, tartaric acid and succinic acid (occurs in fruits and vegetables).
3. **WATER ACTIVITY:** Dehydrate to a water activity at or below 0.85, to 0.65 for foods containing fruits, to 0.6 for foods containing mushrooms. Water activities below 0.6 for foods, e.g., crackers, nut butters, and granola will allow for optimal quality and shelf-life.
4. **TIME AND TEMPERATURE:**
 - a. Our recommendation is to start dehydration at 63°C for the first hour to remove harmful bacteria that may be present in the foods. This would be considered a CCP. If this process is used, acidification of the recipe is not required.
 - b. Dehydration at temperatures below 63°C would require acidification of the recipe to a pH of 4.6 or below, without time as a control.
 - c. Dehydration at temperatures below 63°C without acidification would require time as a control. We recommend that raw foods be dehydrated to a water activity of 0.85 or less within 2 to 4 hours. We recommend using higher temperatures (above >55°C) over lower temperatures (between 40 to 55°C), as dehydration below 55°C may lead to pathogen growth.

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Fermentation specific food safety advice

1. Use a standardized recipe.
2. Remove the outer layer on the produce before starting the fermentation (e.g. remove outer leaves of cabbage).
3. Produce should be fully submerged under the brine liquid during fermentation.
4. Each fermentation should begin fresh – do not “top up” previous ferments with new product.
5. Salt content in lactic acid bacteria fermentations are typically 2-3% of weight of vegetables. Do not reduce the amount of salt in the recipe. Salt is needed to promote growth of beneficial bacteria during the ferment.
6. A healthy fermentation should occur within 24 to 72 hours, and the process should be consistent from batch to batch. A pH of less than 4.6 must be achieved within the first 72 hours, otherwise harmful bacteria that are acid resistant may have an opportunity to establish.
7. Check each batch visually for spoilage. If there are no bubbles with 48 to 96 hours, or if produce is spoiling, discard entire batch.
8. Do not ferment food products to below a pH of 3.2
9. Refrigerate fermented products once fermentation cycle is completed.
10. Boiling water (open kettle) canning is recommended after fermentation to ensure the best seal between the glass jar and lid for product quality.

Juices and smoothies

1. Juice and smoothie recipes should be formulated to achieve a pH of 4.6 and below.
2. Preparation of juices and smoothies should occur in refrigerated conditions, at or below 10°C.
3. Storage of juices and smoothies must be at or below 4°C

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Table 1. Food safety advice given on raw food product recipes in past consultations

Raw Food Product Examples	Potential Hazards	Processing Steps	Critical Limits
Fruit Leather	<p>Biological:</p> <ul style="list-style-type: none"> - Molds/yeasts in apples, bananas - Patulin (mycotoxin associated with apples) 	<ul style="list-style-type: none"> - Purchase fruit - Select fruit - Clean fruit - Cut fruit into strips - Dehydrate - Package - Label 	<ul style="list-style-type: none"> - Pre-wash and sanitize apples. Use undamaged fruits - To limit growth of biological hazard after dehydration, and for preservation, process should ensure water activity is <0.65 - Include a best before date, nutrition facts label (Food and Drugs Act)
Granola	<p>Biological:</p> <ul style="list-style-type: none"> - Salmonella or STEC in raw pumpkin, sunflower or hemp seeds, spices - Molds/yeasts/ patulin in apple puree - <i>C. botulinum</i> spores in unpasteurized honey 	<ul style="list-style-type: none"> - Purchase seeds & other ingredients - Soaking seeds - Mix with other ingredients - Dehydrate - Mix with other ingredients - Package - Label 	<ul style="list-style-type: none"> - Purchase raw ingredients with COA ensuring seeds and spices are tested free of <i>Salmonella</i> and <i>E.coli</i> - Use potable water during soaking period - Soak seeds in refrigerator, or below 10°C - Dehydrate for the first hour (60 min) at 63°C, otherwise, add an additional hurdle by acidification of recipe to a pH of ≤4.6 prior to dehydration at temperatures below 55°C. - To limit growth of biological hazards after dehydration, process should ensure water activity is <0.85 - Include a best before date, nutrition facts label, and allergen information (Food and Drugs Act)
Almonds nut butter	<p>Biological:</p> <ul style="list-style-type: none"> - Salmonella in raw almonds - Aflatoxin (<i>Aspergillus</i> associated with nuts) 	<ul style="list-style-type: none"> - Purchase raw almonds - Soak almonds - Grind into butter - Package - Label 	<ul style="list-style-type: none"> - Purchase raw ingredients with COA ensuring nuts are tested free of <i>Salmonella</i>, otherwise include a kill step for heating or pasteurizing nuts - Use potable water during soaking period - Soak nuts in refrigerator - To limit growth of biological hazards after dehydration, process should ensure water activity is <0.85 - Include a best before date, nutrition facts, allergen info

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Appendix 1. Recalls related to raw foods and raw food ingredients

Based on search of CFIA food recall warnings affecting BC from Jan 1, 2014 to March 1, 2016 for *Salmonella*, *E.coli* O157, *Listeria*

Ingredient	Hazard	Date	Source
Sprouted flax seed powder and Chia & Flax seed powder (Organic Traditions)	<i>Salmonella</i>	Feb 17, 2016	CFIA Recall
		Feb 8, 2016	CFIA Recall
Chia seeds (Salba brand)	<i>Salmonella</i>	Dec 9, 2015	CFIA Recall
Nut spreads (Jem raw organic). Varieties include “Cashew cardamom”, “Hazelnut raw cacao”, “Cinnamon Red Maca” and “Superberry Maqui Camu” (almond spreads).	<i>Salmonella</i>	Dec 3, 2015	CFIA Recall
Chia seed powder (Back 2 the Garden, Now Real Food)	<i>Salmonella</i>	Nov 16, 2015	CFIA Recall
		Nov 4, 2015	CFIA Recall
		Nov 3, 2015	CFIA Recall
Sliced apples (Sun Rich Fresh Foods)	<i>Listeria</i>	Apr 29, 2015	CFIA Recall
Cranberry Health Mix (Aurora brand)	<i>Salmonella</i>	Mar 21, 2015	CFIA Recall
Garlic powder (Organic)	<i>Salmonella</i>	Mar 19, 2015	CFIA Recall
Walnuts (Raw, organic, Trader Joe’s)	<i>Salmonella</i>	Mar 17, 2015	CFIA Recall
Kalonji (fennel seeds)	<i>Salmonella</i>	Feb 28, 2015	CFIA Recall
Sprouted sunflower seeds (Go Raw Brand, 100% organic)	<i>Salmonella</i>	Jan 28, 2015	CFIA Recall
Smoothie blend (Fresh Start)	<i>Listeria</i>	Jan 18, 2015	CFIA Recall
Spicy seed mix (Go Raw Brand)	<i>Salmonella</i>	Jan 15, 2015	CFIA Recall
Whole Peaches, Plums, Nectarines and Pluots (Cutler)	<i>Listeria</i>	Aug 1, 2014	CFIA Recall
Sprouted flax seed powder and Chia & Flax seed powder (Organic Traditions)	<i>Salmonella</i>	Oct 21, 2014	CFIA Recall
		Sep 27, 2014	CFIA Recall
		Sep 11, 2014	CFIA Recall
Raw almond butter (Marantha)	<i>Salmonella</i>	Aug 21, 2014	CFIA Recall
Paprika powder (organic Ecoato)	<i>Salmonella</i>	Jul 28, 2014	CFIA Recall
Carob powder (organic Earth Circle, Harmonic Arts)	<i>Salmonella</i>	Jul 23, 2014	CFIA Recall
Chia powder seeds	<i>Salmonella</i>	May 30, 2014 & others	CFIA Recall & 6 updates
Black pepper corns (organic Frontier, Simply Organic, 365 Everyday value)	<i>Salmonella</i>	Apr 5, 2014	CFIA Recall

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Appendix 2. Hazards identified in the CFIA reference database for food ingredients

Type of Hazard	Hazard
FRUIT - DRIED OR CANDIED	
Chemical	Presence of undeclared / non-permitted / exceeding food additives (e.g., sulphites)
Chemical	Presence of mycotoxins
Chemical	Presence of environmental contaminants (e.g., pesticides / herbicides)
Chemical	Contamination from cleaners / sanitizers / lubricants
Chemical	Presence of undeclared allergens could impact on sensitive individuals (e.g., nuts, peanut, sulphites)
Physical	Presence of hazardous extraneous material
SALT (NaCl)	
Chemical	Contamination by non-food chemicals (e.g., non-food grade)
Chemical	Contamination by excess of food additive
Physical	Presence of hazardous extraneous material
SEED HONEY	
Biological	Presence of pathogenic bacteria (e.g., Clostridium botulinum)
Chemical	Metal ion contamination (e.g., tin, lead)
Chemical	Unapproved coatings on pail container of seed honey
Physical	Presence of hazardous extraneous material
SEEDS (FOR SPROUTING)	
Biological	Presence of pathogenic bacteria (e.g., Salmonella spp., Escherichia coli O157:H7)
Biological	Presence of visible contamination (e.g., pests, insects, rodent droppings)
Chemical	Contamination from environmental contaminants (e.g., heavy metals, pesticides, hazardous wastes)
Chemical	Usage of wrong type of seeds (e.g., non-food grade, seeds not intended for sprouting)
Physical	Presence of hazardous extraneous material
VEGETABLES - DRIED	
Biological	Presence of bacterial pathogen due to too high Aw
Chemical	Presence of environmental contaminants (e.g., pesticides, herbicides)
Chemical	Contamination by non-food chemicals (e.g., cleaners, sanitizers and lubricants)
Chemical	Presence of undeclared, not permitted or exceeding allowable limits of food additives
Chemical	Presence of undeclared allergens could impact on sensitive individuals (e.g., sulphiting agents)
Physical	Presence of hazardous extraneous material

<http://www.inspection.gc.ca/food/safe-food-production-systems/food-safety-enhancement-program/rdhi/eng/1384900871739/1384900941583>

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