



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

Environmental Health Services

Food Issue

Notes from the Field

Dehydrated and freeze-dried vegetables and fruits intended for sale at Temporary Markets

Request received from:	Vancouver Island Health Authority
Date of request:	November 18, 2022
Issue (<i>brief description</i>):	<p>Vendor (Operator) wishes to produce dehydrated vegetables, at home using a household dehydrator, packaged as soup mix for sale at farmers' markets. However, the Guidelines for the Sale of Foods at Temporary Markets (August 2020) (1) currently lists 'dried fruits' as a lower risk food that may be acceptable for home preparation; dried vegetable soup mixes or other dried food products are not listed. The guidelines do not provide acceptable methods or equipment (e.g., dehydrators or freeze-dryers) to be used for dehydrating fruits prepared at home and intended for sale at temporary markets.</p> <p>In addition, the health authority would like to understand if there is a difference in risk for vegetable and fruits that are dehydrated versus those that are freeze-dried. For the purposes of this request the scope of this issue has been limited to dehydrated and freeze-dried vegetables and fruits (e.g. dried vegetable soup mixes or dried fruits) intended for sale at temporary markets that may be prepared in a home (uninspected) environment.</p>

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Summary of search information:

1. Ovid (Medline) search terms: ((*freeze-dried*) AND (*outbreak*)) AND (*food*): (no publications of interest).
2. On Canadian Recalls and Safety Alerts website (<https://recalls-rappels.canada.ca/en>), *dehydrated* (3 hits); *freeze-dried* (0 hits); *dried* (3 hits).
3. Search of U.S Food and Drug Administration (FDA) (<https://www.fda.gov/search?s=freeze-dried>), *freeze-dried* (3 hits).
4. Google Scholar search for general information related to *drying, freeze-drying and dehydrating food*.

Background information:

Drying food is a method of preservation that is used to extend shelf-life. The process of drying removes moisture and commonly used methods include dehydration and freeze-drying. Sun drying (relying on heat



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from the sun and natural air circulation) is one of the oldest methods for preserving food (2) but this process is highly dependent on weather conditions. Over time a variety of commercial and domestic machines have become available to consumers and these machines allow drying to take place under more controlled conditions (e.g., constant temperature and air circulation). Domestic or household dehydrator machines are now quite common. More recently, domestic freeze-drying machines have become popular as lower costs are now making these machines more accessible to the average consumer for household use.

Dried foods are sometimes referred to as low-moisture foods and the final products are typically considered ready-to-eat (RTE). Although dried fruits and other low moisture foods are considered RTE they typically only undergo minimal processing meaning that pathogens may still survive in the final end products (3). Of concern to public health is that dried fruits, vegetables and even spices have been implicated in outbreaks and recalls due to the presence of foodborne pathogens and other contaminants (2). Dried foods have been linked to both bacterial and viral outbreaks in the past with *Salmonella* spp. identified frequently (2). While bacterial outbreaks appear to be more common some viral outbreaks have also been identified. From 2010 – 2011 Hepatitis A outbreaks were linked to semi-dried tomatoes in the Netherlands and England (2) while seven outbreaks of norovirus linked to dried, RTE seaweed (nori) were identified across Japan in 2017 (4). Contamination during the nori manufacturing process appeared to be the most likely cause with the norovirus outbreaks.

A comparison of sun drying, convective (hot air) drying, and freeze-drying is found in **Table 1**. The drying process reduces the water activity (A_w) of a food to levels that inhibit the growth of microbes (e.g. bacteria and mold); however, the drying process does not destroy all of the microbes that are present. Spores can survive drying processes, including freeze-drying, meaning that toxin-producing bacteria or molds that form spores can still be found in the finished product if additional control measures are not included during food preparation. In fact, **laboratories use freeze-drying as the preferred method for preserving cultures, as the method allows for good survivability of microbes** (2).

Operators should verify that the finished food product has an A_w of 0.85 or less to ensure that the product is shelf-stable and limits the growth of microbes. For products that require more than six hours of dehydration or freeze-drying, Operators may also need to assess A_w at various intervals (e.g. after two-hours, 4-hours, 6-hours etc.) during the drying process. After six hours, A_w should be decreasing and limiting further microbial growth. If A_w is not trending downwards, then smaller slices of fruits or vegetables must be used to limit microbial growth. Additional measures that can be used to limit microbial growth are summarized in the **Recommendations** section. It is important to note that even after drying, pathogens can survive in low-moisture foods and can also remain present in the production environment.

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Table 1. Overview of common drying methods used to extend the shelf-life of foods (2).

Method	Mechanism for drying	Advantages	Disadvantages	Time required to achieve appropriate Aw
Sun (solar) drying	Heat from sun and natural air circulation under normal atmospheric pressure.	Free or lower cost to implement	Weather dependent, and not usually protected from contamination (open air).	Varies by product type and weather conditions; usually over multiple days.
Hot air or convective air drying (e.g. dehydrator)	Heat and air circulation are generated under normal atmospheric pressure.	Ability to control temperature and air flow more consistently	Limited by size of equipment Domestic or household units may not achieve stated temperatures.	Varies by product type and temperature used; ranges from a few hours to a few days.
Freeze-drying	Freezing followed by sublimation. Sublimation occurs when ice turns into vapour at room temperature under low-pressure conditions. This action removes moisture. Freeze dryers require a separate vacuum pump to operate.	Less degradation of final product when compared to traditional dehydration. NOTE: Commonly used to preserve microorganisms for culturing because of survivability (ability to revive or regrow).	Limited by size of equipment and cost.	Varies by product type and temperature(s) used.

Dried, dehydrated, and freeze-dried products are typically sold as shelf-stable (e.g., vegetable soup mix or dried, ready-to-eat fruits). If drying is the only step used to reduce microbial contamination then the dried food products may present a health risk to the individuals that consume the products. **Table 2** summarizes selected studies that measured the log reduction of different microbes when drying is the only method used to for pathogen reduction. Standards vary depending on the jurisdiction and food product in question but a 5-log reduction (99.999% elimination) of the most resistant pathogen of concern is generally required for a food to be considered safe to eat (5).

In some studies, there was no observable reduction of microbes and in one study with apricots (shown in first line of **Table 2**) the finished food product was observed to have an *increase* in microbial contamination. **As open-air, convective air, and freeze-drying methods are not able to achieve a 5-log reduction when used as a single method of drying the risk level associated with each method appear to be similar.** One study included in **Table 2** (sliced mushrooms) examined the performance of a household dehydrator and noted that the target temperature of 55°C (131 Fahrenheit) was never reached although the machine was adjusted to this setting. The maximum air temperature achieved within the dehydrator

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was 46°C and the maximum internal temperature of the sliced mushrooms never exceeded 43°C. The A_w achieved in the final product was 0.17, which is within the range needed to reduce microbial growth. After 8 weeks of storage the dried mushrooms were soaked for 24 hours at room temperature to simulate how consumers may use the product. All bacteria regrew to $10^7 - 10^8$ CFU/g indicating that surviving cells still have the ability to regrow after hot air drying and 8 weeks of storage at room temperature (6).

Table 2. Select studies examining the reduction of microbes present in fruits and vegetables using a single drying method (2).

Product	Drying process	Conditions	Microbes examined	Log reduction (cfu/g)
Apricot	Open-air solar drying	38°C day/29°C night for 182 hours	Mesophilic bacteria, yeasts and molds	Increase in microbial contamination
Apple slices	Convective air drying	62.8°C for 6 hours	<i>E. coli</i> 0157:H7	2.5 - 3.1
Carrot slices	Convective air drying	60°C for 6 hours	<i>S. Typhimurium</i>	1.7 - 2.4 1.6 - 1.7
Carrot sticks	Convective air drying	60°C for 10-12 hours	<i>S. anatum</i>	3.3 - 4.2
Cabbage slices	Freeze-drying	60°C at 100 Pa for 15 hours	Standard plate count	No reduction
Unpeeled ginger	Open-air solar drying	30.8°C (average) for 11 days	Total aerobic count	No reduction
Green onion	Convective air drying	47.8°C for 20 hours	Hepatitis A	1
Sliced mushrooms (6)	Convective air drying (household dehydrator)	<45°C for 8 hours	<i>L. monocytogenes</i> ; <i>B. cereus</i> ; <i>S. Typhimurium</i>	2.5; 1.2; 2.6

What are the risks associated with dehydrated or freeze-dried vegetables?

Nine recalls and safety alerts were found in U.S. and Canadian databases over the last 10 years, as described in **Table 3**. Based on these alerts, the risks associated with consuming dried foods generally falls into the following categories:

1. **Source ingredients that are already contaminated**, e.g., freeze-dried blueberries contaminated with lead. If the ingredients for the food product do not have a robust safety or quality monitoring program they may be contaminated at the source and persist in the end-product. Source ingredients include drinking water that is used to wash food. Some products are natural reservoirs for bacteria e.g., *Salmonella* spp. can be found in eggs, poultry, and other meats while others such as mold spores are found in nearly all environments. Microbes that remain in the final food product can be revived during the rehydration process.

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2. **Improper food handling.** This can occur when temperature controls are not in place. For example, histamine can form in fish when it is stored at room temperature. When food is not protected from contamination when it is being processed, the final product could also contain insects. Proper cleaning and sanitation will also help minimize risk (for example, handwashing, cleaning, and sanitizing food contact surfaces). Consumers should also wash their hands regularly when handling food.
3. **Undeclared ingredients.** All ingredients used to make a product must be declared in the ingredients list, especially allergens as these can pose an immediate health risk.

Table 3. Recalls and food safety alerts linked to freeze-dried and dehydrated foods

Year	Hazard category	Hazard detail	Health risk identified	Country	Product description
2022(7)	Physical (Extraneous material)	Presence of insects	No significant health risk identified, however the presence of insect parts may be undesirable to some consumer groups (e.g. individuals avoiding animal products).	Canada (QC)	Dehydrated bananas
2019(8)	Physical (Fire and burn hazard)	Overheating, melting and burns	Injury (burns) due to contact with hot surfaces and melted materials. 4 incidents of minor burns to hands and feet reported in this recall.	Canada	Domestic dehydrator
2019(9)	Chemical (Allergen)	Undeclared sulphites	Undeclared ingredients present risks to consumers with allergies.	Canada (AB, BC, ON)	Dehydrated mango
2022(10)	Chemical	Presence of histamines	Histamine can form when fish is kept in the danger zone (4-60 degrees Celsius) for extended periods of time. Ingestion can cause symptoms such as peppery or metallic taste, oral numbness and other symptoms very rapidly. (See previous BCCDC Food Issue Note on Tuna and histamine risks (11) for additional information).	Canada (AB and online)	Dried fish
2022(12)	Chemical	Presence of ochratoxin (mycotoxin)	Ochratoxin is a toxin formed by some species of mold (mycotoxin). Ingesting mycotoxins can lead to serious health affects.	Canada (ON)	Dried figs
2012(13)	Chemical (Allergen)	Undeclared sulphites	Undeclared ingredients present risks to consumers with allergies.	Canada (AB, MB)	Freeze-dried fruit chips (various)
2018(14)	Biological	Salmonella	Risk of Salmonella infection.	U.S.	Freeze-dried beef (pet food/treat)

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Year	Hazard category	Hazard detail	Health risk identified	Country	Product description
2022(15)	Chemical	Presence of lead (heavy metal)	Lead is toxic and can cause serious health problems. (See the BCCDC Lead & Mercury page for more information)	U.S.	Freeze-dried blueberries
2020(16)	Biological	Potential for botulism	Recall initiated due to product exceeding size restriction. Multiple botulism outbreaks have been documented in the U.S. and Canada from dried fish products (see Additional information on botulism).	U.S.	Freeze-dried sardines (pet food/treat)

Additional information on botulism:

Botulism is a very serious and often fatal foodborne illness. The toxin is formed by the bacteria species *Clostridium botulinum*, which is capable of growing under low oxygen conditions (e.g., in canned products or products that are immersed in oil.) It is commonly found in soil as well as freshwater and marine environments, which means it can naturally be present in various food products. The bacteria is unique in that it can survive and grow under low oxygen conditions.

- A maximum size of 5 inches for salt-cured, dried, or fermented un-eviscerated fish is stated in guidelines by the U.S. FDA as products that exceed this size have been linked to outbreaks of **botulism poisoning** (16).
 - An international outbreak was observed in 1987 and included two U.S. cases which were later linked to six cases (including one death) in Israel (17).
 - In Canada (Ontario) there was an outbreak in 2012 where three individuals were treated for botulism after consuming a salted, dried fish product(18):
- **Type E botulinum toxin was detected in both of these outbreaks. In addition to marine environments *C. botulinum* has also been detected in the internal organs of fish and marine mammals** (19).
 - See [Botulism in British Columbia: The Risk of Home-Canned Products](#) (20) for information on the history of botulism in BC.

Previous guidance on this topic from British Columbia

The current advice in the [Guidelines for the Sale of Foods at Temporary Markets](#) (August 2020 version) (1) indicate that dried fruits may be acceptable for home preparation if proper food safety procedures are in place. BCCDC has not commented on freeze-dried foods in any previous food reviews. BCCDC has commented on the practice of dehydration in a previous Food Issue note, [Raw food handling to limit existing hazards](#) (21). Key points from this review include:

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- Fruits and vegetables should be purchased whole, and cleaned and rinsed in potable water before use.
- A recipe, food safety plan, and sanitation plan must be followed and sanitation and hygienic handling of food practices must be in place. Frequent hand-washing, good personal hygiene and not working while ill are important.
- Include complete labels including ingredients used, best before date, nutrition facts label, and allergen information where appropriate
- Use food grade materials and containers to prepare all foods.
- Some products may need to be flipped half-way through dehydration process in order to dry faster. Refer to the manufacturer's instructions on how to do this safely.
- **ACIDIFICATION:** Prior to dehydration, acidify the sliced fruits or vegetables to a pH (Hydrogen ion concentration) of 4.6 or less, to prevent the 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), citric acid, malic acid, tartaric acid and succinic acid (occurs in fruits and vegetables).
- **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 will allow for optimal quality and shelf-life.

BCCDC has also commented on dehydration of egg yolks to make [egg yolk parmesan](#) (22), and determined that a cook step to provide adequate log reduction for *Salmonella* is still required even when the yolk is dehydrated to an A_w of 0.85 or less.

Previous guidance on this topic from elsewhere

Systematic review of materials and policies from other jurisdictions was out-of-scope for this review but it was noted that some provinces refer to the BCCDC [Guidelines for the Sale of Foods at Temporary Markets](#) (1) when providing lists of acceptable foods for temporary food markets. No specific mention of freeze-drying of foods were found from other provinces.

However, the [Chester County \(Pennsylvania\) Farmer's Market Guidelines](#) (23) states that while dehydrated fruits and vegetables are considered non-potentially hazardous foods **these products must be processed in licensed facilities only.**

Conclusion:

Based on the evidence included in this Food Issue, it appears **that there is no difference in risk for vegetable and fruits that are dehydrated versus those that are freeze-dried.** When performed correctly these processes neither increase nor decrease the microbial risks associated with the final finished product. However, the quality of the ingredients and the hygiene practices described in the

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Recommendations section should be in place to ensure products produced can be considered lower risk. Additional steps such as cooking, boiling, immersion in a food grade sanitizer and other control measures should be used in combination with dehydrating or freeze-drying vegetables and fruits to achieve a greater reduction in the number of microbes present in the final product.

Recommendations from BCCDC:

Environmental Health Officers should reassess at-home preparation of dehydrated or freeze-dried fruits and vegetables for sale at temporary food markets. As stated in the **Conclusion** section there does not appear to be an increase or decrease in microbial risks when comparing dehydration vs. freeze-drying technology, however, this means that it is especially important to ensure other measures are in place to reduce microbial risk. Factors such as ensuring the quality of the ingredients and good hygiene practices will help reduce the food safety risks associated with dehydrated or freeze-dried fruits and vegetables.

- Dried fruits and vegetables (including dehydrated or freeze-dried) can be considered lower risk foods per the [Guidelines for the Sale of Foods at Temporary Markets](#) (1) if the appropriate food safety procedures are in-place. Recommendations will vary by the ingredients used, preparation steps involved, final finished product, the type of packaging used, instructions to the consumer around storage and handling, and other factors. Some or all of the following may apply to food products intended for sale at temporary markets:
 - Source ingredients, including potable water, must be from approved sources.
 - To remove external contaminants on foods, operators have three options:
 - **Option 1:** A cooking, boiling or blanching step should occur before drying or freeze-drying is included to reduce the quantity of microbes present.
 - **NOTE:** While blanching can remove some surface dirt and microbes it is not considered a ‘kill step’. It is typically used to stop enzyme actions which helps preserve the quality (e.g. flavour, colour, texture) of the product (24).
 - **Option 2:** Immersion in a diluted, food grade sanitizer may be appropriate. See [Guidelines for the Use of Chlorine Bleach as a Sanitizer in Food Processing Operations](#) (25) or [Farm Food Safety: Choosing a Sanitizer for Washing Fresh Produce](#) (26) for more information.
 - **Option 3:** Exceptions may be made for products with a natural pH value of 4.6 or less (e.g., some fruits). Acidification through the addition of natural acidulants (e.g., acetic acid (vinegar) or citric acid etc.) can also be used to lower the pH value of the dried fruit or vegetable product.
 - For foods that are dried in a convective air dehydrator (using heat) the recommendation is to operate the machine at a minimum of 55°C (131°F) for the time period required to achieve a A_w of 0.85 or less(5). If drying time exceeds six hours operators may need to modify their process (e.g. use smaller slices) to reduce the time required.

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- **NOTE:** A_w recommendations vary depending on the exact ingredients used. Per the previous BCCDC recommendations on [Raw food handling to limit existing hazards](#) (21):
 - A_w of 0.65 or less is recommended for foods containing fruits
 - A_w of 0.6 or less is recommended for foods containing mushrooms
 - A_w values below 0.6 will allow for optimal quality and shelf-life
- Dried or freeze-dried fruits and vegetables should only be prepared using commercial or domestic machines intended for this purpose. Users should follow the manufacturer's instructions and ensure their machines are in good working order and not subject to any safety recalls.
 - **CAUTION:** Household dehydrators may not always achieve the temperatures stated. A calibrated thermometer should be used to verify the temperature that can be achieved. Adjust settings on the machine as required.
- Testing through a certified laboratory should be completed to verify that a food product has a A_w of 0.85 or less or and/or a pH value of 4.6 or less. For additional information refer to the [Guidelines for the Sale of Foods at Temporary Markets](#) (1).

NOTE: There can be occasions that a food product may still be considered higher risk even if all of the recommendations have been met. Please contact your local health authority for more information about a specific product or application.

Additional advice:

- **Dried fish products are considered high risk due to the risk of botulism and histamine formation.** These products are not acceptable for sale at temporary markets if they are prepared at home.
- **Dried or freeze-dried pet treats also pose similar risks** and vendors wishing to make and sell these products at temporary markets are recommended to follow similar control measures.
- The sale of lower risk foods at temporary food markets **does not automatically confer approval for sale at retail/commercial food stores.**

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