Freeze Drying Questions

Q: Did you do any repeated tests comparing products that were blast chilled prior to going in the FD, vs those that relied on the FD for the whole process

A: We did not do a formal experiment with repeated tests comparing the effects of pre-frozen vs. not pre-frozen prior to loading items into the freeze dryer. However, based on multiple preliminary tests in our lab…with a variety of food items (e.g., bread, milk, eggs, cut fruit, cut vegetables), we've determined the freezing and vacuum freezing stages of the in-home freeze dryer were shorter when you load pre-frozen items. In industrial operations, the items are often pre-frozen prior to loading as it helps shorten the whole freeze drying cycle.

Q: What if you took a food and blanched and then blast chilled/froze the product prior to going through the FD process ? That would give you a kill step.... it might not be efficient or make sense from a business sense, but it is a process that could be explored.

A: Yes, blanching or cooking food items prior to freeze drying would give a food manufacturer a "kill step" in their process provided they are blanching or cooking the food items to the proper internal temperatures to kill foodborne pathogens. However, they should still practice GMPs and avoid cross-contamination during loading, unloading, and packaging as they can re-introduce pathogens and spoilage microorganisms onto the blanched/cooked foods before freeze drying or onto the dried foods after freeze drying.

A: Would you recommend for a breast feeding mother to freeze dry breast milk using a at home freeze dryer, is it dangerous? how long can they use it ?

B: I would not recommend freeze drying breast milk at home for the following reasons:

a. Powdered infant formula is made by mixing raw ingredients like milk proteins, fats, and carbohydrates with filtered water to create a liquid formula, which is then heat-treated and spray-dried into a powder. While the manufacturing process includes quality checks, powdered infant formula is not sterile and requires proper preparation with hot water to kill potential bacteria, like *Cronobacter*. The temperatures inside a freeze dryer are much lower than those used in heat treatment and spray drying. Typically, in-home freeze dryers are programmed to operate at 120 degrees Fahrenheit or below…which is cooler than the lowest setting you would achieve in your kitchen stove. At such low temperatures, it would be difficult to kill any bacteria that may have contaminated the breast milk during collection, loading and unloading the dryer, pulverizing the dried milk, and packaging. The milk will be extremely hygroscopic after freeze drying so it could also absorb moisture readily from the air during packaging…and it become not as shelf-stable as you would think once it is packaged. For long term preservation of human breast milk, it may be best to freeze it and store frozen until it is ready for use/consumption.
b. As I mentioned in the webinar, in-home freeze dryers can be difficult to clean. The shelves may not be easily removable and users will need to wipe down the walls and the

back of the freeze dryer, while squeezing their arms and cleaning utensils through tight spots in-between shelves.

c. End consumers (infants) are immunocompromised because their immune systems are still developing. I think it is best to leave long-term preservation of human breast milk to professional milk banks.

Q: Can you describe the risks of freeze-drying non-TCS foods, like candies? It seems some States allow this under cottage foods and others do not. What are your thoughts?

A: Non-TCS foods, especially those that are already shelf-stable should be safe to freeze-dry. To enhance its safety for long-term storage, the lower the pH of the final (dried) product, the better. If the natural pH < 4.6, the better. The final (dried) product should have a water activity below 0.60 to mitigate growth of bacteria, yeasts and molds. I think most candy have high sugar contents that lowers their water activities even before freeze drying. After freeze drying, they should have even lower water activities. As we mentioned in the webinar, cottage food producers should be careful about infringing on a brand's trademark.

Q: Some of the Harvest Right home use machines have owner's manual that indicate to use only warm water, mild detergent, and nonabrasive wiping cloth to clean. They specifically do not want sanitizing chemicals to be used. How would you recommend sanitizing these machines to prevent cross contamination?

A: Excellent question! Yes, I agree…the suggested sanitation procedures and making the equipment easier to be sanitized are areas that manufacturers of in-home freeze dryers could do a better job. A couple of in-home freeze dryer users have told me they've tried to use sanitizers or food-grade ethanol (some have used high proof liquors such as vodka or tequila) to sanitize their freeze dryers and then run a cycle using plain sliced bread afterwards. The bread will absorb any off-odors created by residual sanitizer or ethanol in the dryer. I think this is a good idea…use a diluted bleach solution or 70% isopropyl alcohol to sanitize and then do a bread run afterwards to get ride of off-odors that may come from residual bleach or isopropyl alcohol.

Q: Is the condensate a good environmental sample? Would it be considered a Zone 1 or Zone 2 sample?

A: Yes, the condensate would be a good environmental sample. Like the inside of a kitchen oven, I would consider the condensate as Zone 2 as it is directly adjacent to the shelves – where active drying and direct contact with the food product may occur – but the condensate, which forms on the inside walls of a freeze dryer is not where active drying actually occurs and we don't put the foods to be dried on the inside walls of the freeze dryer.

Q: Are pet foods consistently batch tested for possible foodborne organisms?

A: Yes, in manufacturing freeze dried, raw commercial pet foods, the products are batch-tested for possible foodborne organisms. In fact, most manufacturers of raw commercial pet foods use high pressure processing (HPP) as a "kill-step" to cold pasteurize the pet food prior to freeze drying.

Q: Have you conducted any research on potential for allergen cross-contact between products/runs, specifically with the vacuum?
and
Q: Have you done any studies showing cross contamination inside the machine ie someone does raw eggs on one tray and strawberries on another.

A: Excellent question! But, no, we have not conducted this research. Generally speaking, it is not good practice to mix different products in a freeze dryer run because different products have different intrinsic properties that could affect their eutectic point and drying times. However, if someone did try to freeze dry multiple products in the same run or batch, they will need to make sure they use dedicated utensils to handle the different products and dry one type of product per tray. The only way then for the allergenic proteins to jump from one product/tray to the next is if the proteins are aerosolized and sublimate with the moisture or other essential oils that could sublimate as well.

For example, when we freeze dry strawberries or citrus products, the sublimated moisture would freeze when they hit the cold condenser and is melted at the end of the freeze drying process. The condensate will smell like strawberries or citrus-y. I have not done it but others have told me the same thing happens when you freeze dry peppers – the condensate smells like the pepper! I can imagine that when you freeze dry a sesame product, it is possible for essential oils from the sesame seeds to sublimate with the moisture and pass through food items on the other trays.

I'll have to give this some more thought if we decide to design an experiment about it.

Q. Does the University of Nebraska Extension perform extended shelf life studies for non-industry individuals? Could we refer people to you all?

A. Yes, we conduct shelf-life studies as a fee-for-service. They can contact me (mdanao2@unl.edu) for the studies or even as simple as testing water activity and moisture content of their products, before and after freeze drying.

Q: Can you explain the lethality more in detail

A: I am not sure if there is enough information in this question for me to address. But, generally speaking, in food processing, we want to make sure there are adequate controls (PCs or CCPs) that address biological, chemical and physical hazards that would be in the food. To control for biological hazards, we often PCs or CCPs such as pH, water activity or temperature. In freeze

drying operations, it is possible that a manufacturer or cottage food producer will have a pH > 4.6 that does not adequate control for the biological hazard. They may achieve a water activity below 0.60 after freeze drying that prevents any remaining pathogens or spoilage microorganisms from growing…but they are still present in the food! With freeze drying, the temperatures are too low to kill pathogens or spoilage microorganisms – which is why this process should not be considered a "kill step". In our experiments with freeze drying raw eggs, we only saw a 1-2 log reduction in generic *E. coli*, *L. innocua*, and *E. faecium*. This level of inactivation may not provide adequate lethality – usually we look for a 5-log reduction or 99.999% reduction in bacteria to consider a chosen process as a "kill step".

Q: What CCP would you recommend for freeze drying cheese cake? Would you consider weight loss sufficient?

A: I would look at the final water activity of the freeze dried cheescake. If these are being made under cottage food law, be sure to look at the state's requirements as some do not allow non-TCS foods to be freeze dried. And I would consider cheesecake to be a TCS food as you would normally keep the fresh cheesecake refrigerated to be safe for consumption.

Q: does this process require a third-party process review from a process authority?

A: I am not aware that the process has required third-party process review. In my state, the Nebraska Department of Agriculture has reviewed or provided guidance to cottage food producers on whether the product they are trying to freeze dry is okay to produce under the state's cottage food law and, in some cases, they have reviewed the initial and final pH and water activities.

Q: Could you bake the FD product in the oven at the end of the process to count as the kill step? Temperature of oven would be165F.

A: Maybe there is a food application where you can do this, but people typically choose freeze drying over dehydration in an oven, dehydrator, or smokehouse because they are trying to preserve a heat-sensitive component in their food product. Exposing a freeze dried food product to high heat after freeze drying may not be desirable.

Also consider that most freeze dried food products are fragile – they are highly porous and crunchy. Because they are already dry and thinly-sliced to aid the freeze drying process, they will burn (likely) if they are cooked in the oven afterwards for lethality.

Q: Can any oxygen scavenger packets be used? Or are there specific food grade packets?

A: That's a really good question...one that I had not thought of before. Most oxygen scavenger packets sold on Amazon and readily available to cottage food producers are food-grade. If

purchasing in bulk, it is good to remind consumers to check that the intended application of the packets (also called “deoxidizers”) is for food preservation.

Q: Is there anything not recommended for freeze drying?

A: Yes, high fat food items that are already shelf-stable (e.g., peanut butter, chocolate, butter, etc.) typically do not dry well in a freeze dryer. They do not have enough moisture in them to be freeze dried. They tend to puff up, much like freeze dried candy. Freeze drying creates a lot of surface area making high fat food items more susceptible to lipid oxidation. Thus, they tend to go rancid much faster than the non-freeze dried format.

Q: Is there a typical weight reduction you should look for?

A: Instead of aiming for low moisture content, one should aim for a low water activity, below 0.60, to mitigate microbial growth. Lipid oxidation rates tends to be minimized once you reach a water activity of 0.40, but could increase when water activity is further reduced to 0.30 or lower.

Q: If freeze drying non-tcs foods, should we be concerned about pathogens? For example, raw strawberries? If non-tcs we aren't concerned in its natural state, so should we be concerned after its freeze dried?

A: Generally speaking, you are correct. Non-TCS foods are shelf-stable, so freeze drying them should also lead to a shelf-stable food item. However, it really depends on how the freeze dried item is intended to be used. If a non-TCS food has been sliced prior to freeze drying and it is meant to be rehydrated prior to consumption, then the end user needs to be careful that the item is properly stored or prepared after it has been rehydrated.

Given your example, whole fresh strawberries are not typically considered a TCS food. They do fine without refrigeration. However, in order for them to freeze dry properly, they are often sliced. Sliced fresh strawberries would be considered a TCS food as they can support the growth of pathogens. Freeze dried sliced strawberries are shelf-stable and are often eaten as a snack. So long as good GMPs were followed during slicing and freeze drying…and the dried product has a water activity below 0.60, we probably do not have to worry about pathogens. However, if a consumer rehydrates freeze dried sliced strawberries and intend to snack on the rehydrated product, they will need to treat it as a TCS food and refrigerate any leftovers.

Q: Freeze drying cheese recommended and healthy?

A: It depends. Some hard cheeses that are not TCS foods are probably not going to change much after freeze drying due to their low moisture content and water activity to begin with.

However, cheeses that are fairly wet (e.g., fresh cheeses) would have a different texture and, potentially, a more concentrated flavor than expected.

Note that freeze drying removes moisture from the product so the nutrients will get more concentrated and flavor profiles more intense after freeze drying.

I once had a manufacturer of gummy vitamins ask me about freeze drying their gummy products because freeze dried gummy bears are “trending” with kids. I cautioned them from doing this because any active component in the gummy vitamin supplement would be concentrated after freeze drying to the point that (a) the concentration of the active component could be toxic for kids or (b) they will need to make their gummies so small to ensure that the active component dose per serving (and usually 1 gummy = 1 serving) remains low and safe for consumption.

The same can be said for freeze dried cheese. If you enjoy eating stilton or blue cheeses, maybe a cube of it tastes fine, but once you concentrate that flavor in one cube, it may no longer taste fine for the average consumer.