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Icings, Frostings and Fillings: Is Refrigeration Required for Food Safety?

Damla Dag Ertop, Extension Assistant Professor, Department of Food Science
Mark Morgan, Professor and Extension Specialist, Department of Food Science

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Section 1: Introduction

The Tennessee Food Freedom Act (TFFA) 2022, aka Tennessee Cottage Food Law, allowed homemade, non-Time/Temperature Controlled (non-TCS) food items to be produced at a private residence and sold within the state without a food manufacturing license or permit from the Tennessee Department of Agriculture. The 2025 changes in the TFFA now allow certain Time/Temperature Controlled (TCS) foods with additional restrictions. This publication does not cover all TFFA requirements or provide guidance on TCS foods. Instead, it aims to provide guidance on how to make icings, frostings and fillings non-Time/Temperature Controlled (non-TCS) so they can be sold without requiring refrigeration for safety and can be sold via third parties such as grocery stores (according to the TFFA). This publication will also explain how to classify icings, frostings or fillings as either TCS or non-TCS. For more details about the TFFA and information on TCS food regulations, please refer to UT Extension publication PB1909 Tennessee's Food Freedom Act – 2025 Non-TCS vs TCS Homemade Food Items.

Section 2: Definitions

Homemade Food Item: A homemade food item is a food product, including a non-alcoholic beverage, that is produced and (if applicable) packaged at the private residence of the producer.

Microorganisms: They are tiny living creatures that are so small and can only be seen with a microscope. There are many different microorganisms, including bacteria, viruses, fungi (yeasts and molds) and protozoa, and they can be either helpful or harmful.

Non-Time/Temperature Control for Safety (non-TCS) Food: A non-TCS food is a food that does not require time/temperature control for safety to limit the rapid and progressive growth of infectious or toxin-producing microorganisms. Most shelf-stable foods, i.e. those with a low pH, low water activity or adequately preserved, are considered non-TCS. However, these definitions may vary slightly by state, especially when applied in the context of cottage food production.

Pathogenic Microorganism: In the context of food safety, this includes any bacteria, virus, fungi, or protozoa that can cause illness in humans. Some pathogenic microorganisms cause illness when the microorganism itself is ingested while others create toxins that cause illness when the toxin is ingested. Luckily there are only a few pathogenic microorganisms associated with foods. When referring to TCS foods, growth of pathogenic bacteria is the primary concern for safety.

pH: pH is a measure of the degree of acidity or alkalinity of a solution. Values between 0 and 7 indicate acidity, and values between 7 and 14 indicate alkalinity. A pH of 7, the value for pure distilled water, is considered neutral. Food with low pH (below 4.6) is less likely to support the growth of pathogenic bacteria, though molds and yeasts may still grow at these levels. Ingredients such as lemon juice, lime juice and vinegar lower the pH and increase acidity. In contrast, dairy ingredients typically raise the pH, making the product more basic.

Food Spoilage: Food spoilage is a process that results in the loss of quality attributes such as color, flavor, texture, odor, and appearance. Although spoiled foods may still be safe to eat (i.e. they do not contain pathogens or toxins capable of causing illness), the undesirable changes in quality often make them unappealing or unacceptable for consumption.

Time/Temperature Control for Safety (TCS) Food: A TCS food is a food that requires time/temperature control to limit the growth of pathogenic microorganisms or the formation of toxins. Pathogenic microorganisms can easily grow in TCS foods if left at the wrong temperature for too long. These foods must be kept either hot or cold to remain safe to eat. If the foods are in the process of being heated or cooled (or stored without temperature control) then controlling the time the food is held in the danger zone (the temperature range of 41 F to 135 F) is the most critical factor for minimizing their growth.

Vegetative Cell and Spore: A vegetative cell is the actively growing and metabolizing form of a bacterium, while a spore is a dormant, highly resistant structure formed by some bacteria to survive harsh conditions such as high temperature and/or low pH.

Water Activity (Aw): It is a measure of the availability of water for microbiological growth. Water activity ranges from 0.00 (a completely dry product) to 1.00 (pure water). Water activity is related to the equilibrium relative humidity of air around the food product in a sealed package. Aw values < 0.85 can be used to prevent the growth of most bacteria. Water activity can be reduced by adding sugar, salt or by dehydrating a food product. Dairy ingredients typically increase water activity and may raise the Aw of the final product.

Section 3: How to Decide If an Icing, Frosting or Filling is non-TCS?

Some foods allow pathogenic microorganisms to grow and multiply more easily and rapidly than others when held at certain temperatures. These foods are referred to as Time/Temperature Control for Safety (TCS) foods. By controlling the time and/or temperature at which TCS foods are held, pathogenic microorganism growth and/or toxin formation can be slowed or limited.

To sell homemade food items **at room temperature** or via a third party such as a grocery store under the TFFA, they must be classified as non-TCS foods. These homemade food items do not require time/temperature control for safety.

If an icing, frosting or filling is classified as a **Time/Temperature Control for Safety (TCS)** food, it **MUST BE KEPT REFRIGERATED** during storage, distribution and sale for food safety.

If classified as a **non-TCS food, refrigeration is not required for food safety**, and it may be stored, distributed and sold at room temperature. Refrigeration may still be used to preserve quality.

As shown in the tables below (taken from the Food Code 2022), the interaction of water activity (Aw) and pH can be used to categorize icings, frostings and fillings as either TCS or non-TCS. Certain values, or combinations, of pH and water activity can limit the growth of vegetative bacterial cells and spores in foods. These foods are then considered non-TCS and can be stored and sold at room temperature. However, if a food's pH and Aw combination is listed as PA in the tables, it must be evaluated by a process authority (expert on safe food manufacturing) to determine whether it is TCS or non-TCS.

Table A. Interaction of pH and Aw for control of spores in food heat-treated to destroy vegetative cells and subsequently packaged.

Aw values	pH: 4.6 or less	pH: > 4.6-5.6	pH: > 5.6
≤ 0.92	non-TCS food*	non-TCS food	non-TCS food
> 0.92-0.95	non-TCS food	non-TCS food	PA**
> 0.95	non-TCS food	PA	PA

**TCS food means Time/Temperature Control for Safety Food*
***PA means Product Assessment required*

Table B. Interaction of pH and Aw for control of vegetative cells and spores in food not heat-treated or heat-treated but not packaged.

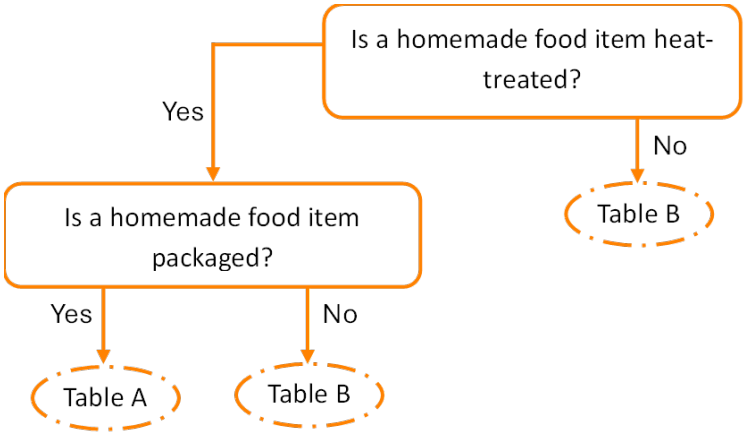
Aw values	pH: < 4.2	pH: 4.2-4.6	pH: > 4.6-5.0	pH: > 5.0
< 0.88	non-TCS food*	non-TCS food	non-TCS food	non-TCS food
0.88-0.90	non-TCS food	non-TCS food	non-TCS food	PA**
> 0.90-0.92	non-TCS food	non-TCS food	PA	PA
> 0.92	non-TCS food	PA	PA	PA

**TCS food means Time/Temperature Control for Safety Food*
***PA means Product Assessment required*

Section 4: Step-by-step Guidelines to Navigate the Tables

Step 1: Determine which table applies to a homemade food item. The chart below may help select the correct table.

- If a homemade food item **is heat-treated** (e.g. cooking or baking), the applicable table depends on whether it is packaged:
  - If it is **heat-treated and packaged**, use **Table A**.
  - If it is **heat-treated but not packaged**, use **Table B**.
- If a homemade food item **is not heat-treated** or contains an icing, frosting or filling that is not heated, use **Table B**.



Step 2: Measure or submit a homemade food item for pH and water activity testing

Accurate measurement of pH and water activity requires the use of specialized instruments: a pH meter and a water activity meter, respectively. While hand-held, relatively low cost, pH meters are available, water activity meters are more expensive. The pH of a homemade food item could be measured at home using a pH meter. Be sure to follow the manufacturer's instructions for proper use. Alternatively, the Food Science Extension program at the University of Tennessee offers pH and water activity testing services for a small fee. To proceed with this option, please visit the Department of Food Science website for the sample submission instructions.

Step 3: If the pH and water activity of a homemade food item match a combination labeled as non-TCS in the appropriate table (identified in Step 1), and it is not specifically prohibited under the TFFA, then it is classified as non-TCS and may be stored, distributed and sold at room temperature. This doesn't mean the product can't spoil. Refrigeration may still be used for non-TCS foods to delay the spoilage and extend quality and shelf-life but is not required for safety.

Example: Buttercream Frosting

Ingredients: Unsalted butter, powdered sugar, heavy cream and vanilla extract. The homemade food item is not heat-treated and not packaged. Its pH is 4.6 with a water activity of 0.83.

Step 1: The homemade food item is not heat-treated and not packaged. Use Table B.

Step 2: Measure or get your product tested for pH and water activity.
- pH = 4.6
- Aw = 0.83

Step 3: Locate the appropriate row and column in Table B:
- Column: pH 4.2-4.6
- Row: Aw < 0.88

According to Table B, this combination is classified as non-TCS. Therefore, the buttercream frosting would be considered non-Time/Temperature Control for Safety (non-TCS) and does not require refrigeration for safety.

Aw values	pH: < 4.2	pH: 4.2-4.6	pH: > 4.6-5.0	pH: > 5.0
< 0.88	~~non-TCS food*~~	non-TCS food	non-TCS food	non-TCS food
0.88-0.90	non-TCS food	non-TCS food	non-TCS food	PA**
> 0.90-0.92	non-TCS food	non-TCS food	PA	PA
> 0.92	non-TCS food	PA	PA	PA

***PA means Product Assessment required*

Section 5: Typical Ingredients Used in Recipes of Non-TCS Icings, Frostings and Fillings

The use of some ingredients, such as dairy products and fresh/raw fruits and vegetables, in icings, frostings and fillings recipes requires careful consideration. In general, the addition of dairy ingredients or fresh produce into a recipe tends to increase either the pH, water activity or both in the final product. **To ensure food safety, non-TCS homemade food items, regardless of ingredient composition, must match a pH and water activity combination labeled as non-TCS in the corresponding table.**

Recipes for non-TCS icings, frostings, fillings and similar food items may be either heat-treated or not. For simplicity, the rest of this document will refer to items as either cooked or uncooked for heat-treated and not heat-treated, respectively. For recipes that do not undergo heat treatment (such as uncooked frostings or fillings), only pasteurized ingredients, e.g. pasteurized dairy products and heat-treated flour, are recommended. Researchers from Rutgers University studied the effectiveness of killing pathogenic bacteria in wheat flour by baking in a household oven. According to the study, these instructions could be used to heat-treat flour at home for use in an uncooked frosting or filling:

- Preheat the oven to 400 F.
- Spread the flour 3/4 inches deep or less.
- Bake for 6 minutes.
- Alternatively, bake the flour for 9 minutes at 350 F or 10 minutes at 300 F instead of 6 minutes at 400 F.

Typical ingredients used in icings, frostings and fillings are listed in Table 1, along with recommendations for use in cooked or uncooked recipes.

Table C. Typical ingredients in non-TCS icings, frostings and fillings, with recommendations for use in cooked and uncooked recipes. The final homemade food item must meet the pH and water activity requirements outlined in Section 3 to be classified as non-TCS.

Typical ingredients (not exhaustive list)	**Uncooked** icings, frostings and fillings	**Cooked** icings, frostings and fillings
Pasteurized milk (unpasteurized milk is not allowed under the TFFA)	✓	✓
Evaporated milk	✓	✓
Powdered milk	✓	✓
Butter	✓	✓
Pasteurized heavy or light cream	✓	✓
Cream cheese *	✓	✓
Fresh eggs	X	✓
Liquid pasteurized egg	✓	✓
Meringue powder (dehydrated egg white)	✓	✓
Raw/not heat-treated flour	X	✓
Heat-treated flour	✓	✓
Vanilla extract	✓	✓
Any meat (only poultry is allowed under the TFFA)	X	X
Raw/fresh fruit*	✓**	✓
Raw/fresh vegetables*	X	✓

** When using cheese or raw/fresh fruits and vegetables as fillings in baked goods, the filling should be baked along with the food item to lower water activity. The final cooked filling must also meet the pH and water activity requirements described in Section 3.*

***When raw/fresh fruit is used without cooking, its pH should be below 4.2. For example, bananas have a pH > 4.2 and would not meet this requirement.*

Section 6: Ensuring Safety Without Water Activity Testing

Percent Brix (% Brix) is a measure of the percentage of soluble solids in foods, ranging from 0 percent (no dissolved solids) to 100 percent (all solids). For sweet foods such as jams, jellies, icings and frostings, % Brix primarily indicates the sugar content. There is an inverse relationship between % Brix and water activity: as the % Brix increases, water activity decreases. This is because sugar binds with water in the food, reducing the amount of free water available for microbial growth.

Recipe variations can significantly affect water activity and % Brix. When water activity testing is not feasible, using a recipe that contains at least 65 percent granulated sugar (sucrose) by weight can generally ensure shelf stability at room temperature (i.e. classification as non-TCS) without requiring water activity measurement. However, it is important to account for substitutions of granulated sugar with other sweeteners such as powdered sugar or corn syrup. These alternatives do not contain 100 percent sugar:

- Powdered sugar typically contains about 97 percent sugar, with the remainder made from anticaking agents such as cornstarch.
- Corn syrup contains approximately 70 percent sugar, with the rest being water.

These percentages can vary by brand, so it is important to confirm the ingredient composition with the manufacturer. The worksheet on the next page is provided to assist in calculating the total percentage of granulated sugar (sucrose) used in a recipe. The worksheet is not intended for use with other sugars, sweeteners or sugar substitutes since they may not lower the water activity as much as granulated sugar does at the same concentration.

Additionally, the Kansas State University Agricultural Experiment State and Cooperative Extension Service has compiled a list of tested recipes that align with non-TCS classifications based on pH and water activity combinations. Please refer to the non-TCS recipes in their publication at the link in Online Resources below.

Section 7: Additional information

For further information on the classification of TCS vs non-TCS foods, or assistance with pH and water activity measurement, please contact:

University of Tennessee
Food Science Department
2510 River Drive, Knoxville, TN, 37996
Email: foodsci_ext@utk.edu
Website: foodscience.tennessee.edu/food-science-extension/

Section 8: References

- Blakeslee, K., et al. *Food Safety of Frostings and Fillings*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, December 2020. Available at: https://bookstore.ksre.ksu.edu/download/food-safety-of-frostings-and-fillings_MF3544
- Jung J. and Schaffner D. W. (2022). Thermal Inactivation of *Salmonella enterica* and Nonpathogenic Bacterial Surrogates in Wheat Flour by Baking in a Household Oven. *Journal of Food Protection*. 85:1431-1438.
- U.S. Food and Drug Administration. Food Code 2022. Accessed from: https://www.fda.gov/food/fda-food-code/food-code-2022

Section 9: Online Resources

UT Extension publication PB1909 Tennessee's Food Freedom Act – 2025 Non-TCS vs TCS Homemade Food Items: tiny.utk.edu/pb1909

UT Department of Food Science Extension Services: foodscience.tennessee.edu/food-science-extension/

Kansas State Research and Extension Food Safety of Frostings and Fillings: bookstore.ksre.ksu.edu/download/food-safety-of-frostings-and-fillings_MF3544

Worksheet for Icings, Frostings and Fillings Formulations

List all the ingredients and weight in grams. Conversion to grams from cups or tablespoons can be found at :**kingarthurbaking.com/learn/ingredient-weight-chart**

(This link is provided for educational purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned)

Ingredients	Weight in grams
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
Line 1: Total weight	
Line 2: Weight of sugar (from above)*	
Line 3: Weight of sugar (Line 2) divided by total weight (Line 1)	
Line 4: Multiply Line 3 by 100 for the percent of sugar	

Is Line 4 higher than 65%? YES or NO

If YES, this recipe is considered safe to be stored at room temperature and can be considered non-TCS.

* When substituting granulated sugar with powdered sugar or corn syrup, it is essential to adjust the formula. These alternatives as well as other sugar substitutes do not contain 100 percent granulated sugar. Powdered sugar is typically 97 percent sugar, with the remaining 3 percent consisting of anticaking agents like cornstarch. Corn syrup contains only 70 percent sugar, with the rest being water. These percentages can vary by brand, and it is important to confirm the composition with the manufacturer.

For example, if using powdered sugar containing 97 percent sugar, multiply Line 2 with 0.97 (97 percent). Total weight is still calculated with the weight of the powdered sugar.

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