# FOOD SAFETY
# OF FROSTINGS AND FILLINGS

K-STATE Research and Extension

## INTRODUCTION

Foodborne outbreaks from icings and frostings are rare, but they do happen for a variety of reasons: sick food handlers preparing food, use of non-edible ingredients as decoration (such as "luster dust"), or formulating an icing requiring refrigeration for safety but storing at room temperature. While none of these were linked to a fair or exhibition, they show the susceptibility of these products to foodborne illness outbreaks. Some examples include:

**2018.** Rhode Island Department of Health uncovered an unusual outbreak involving copper toxicity from a glittery birthday cake that sickened six people with vomiting and/or diarrhea after attending a 1-year-old's birthday party.

**2013.** Outbreak of norovirus occurred at a Minnesota wedding reception affecting 24 guests. Cake made by a bakery and served at the reception was the likely source. Supporting evidence shows norovirus-positive specimens and illness reports among both wedding guests and bakery patrons. The likely source was an ill food worker who prepared the cake icing.

**2010.** Outbreak of *Staphylococcus aureus* led to 100 illnesses associated with an Illinois bakery linked to a cream cake, fillings, and frostings due to improper bare hand contact.

**2006.** *Salmonella heidelberg* associated with meringue pie in Kansas. Thirteen people became ill, with six being confirmed with *S. heidelberg*. The pie was improperly cooked and cooled.

**2002.** Outbreaks of norovirus occurred with cakes from a Massachusetts bakery among guests of 46 separate weddings. Two bakery employees reported an illness compatible with norovirus which was isolated from the stool of one of these employees.

Baking contests at county and state fairs exhibit a variety of entries from the general public. As most fairs take place during warmer summer months, food safety risks increase for food judges or buyers at bake sales or auctions. This is largely due to using perishable ingredients, such as dairy products and eggs, which may require refrigeration for safety. Other factors include multiple people handling the foods before they are judged and/or sold. Recipes can vary greatly in ingredients and processes used. Therefore, risks from one entry to another can vary greatly.

## PURPOSE OF THIS STUDY

This project was conducted to determine recipes that can be displayed safely at room temperature and those requiring refrigeration. Recipes were submitted by K-State Research and Extension district/county agents and specialists. A total of 49 recipes, some with variations, were submitted and tested in duplicate. Recipes were made in a home kitchen and brought to the Kansas Value Added Foods Lab for analysis. All recipes were tested for acidity (pH), water activity ($A_w$), and percent soluble solids (% Brix). These factors are crucial to determine the overall safety in the storage environment.

This study did not seek to test every kind of cake frosting and filling available, just recipes randomly submitted by county agents and specialists. The recipe examples give information about the ingredients included and are not recipes to be followed. Changes in the recipes will affect the pH, $A_w$, and % Brix values of products, and could change the way some recipes are categorized. Finally, brand names are intended for identification purposes only and are in no way endorsed by K-State Research and Extension.

## Acidity (pH) of Foods

The overall acidity of a food product is expressed as pH, a logarithmic value measured from 0.0-14.0. Generally speaking, pH values below 7.0 are considered acidic, values above 7.0 are basic (alkaline), and pure water has a pH of 7.0. Disease causing bacteria do not grow well in an acidic environment, but molds and yeasts may still grow. Ingredients such as lemon juice and vinegar will lower the pH (more acidic), while ingredients such as eggs and dairy products will increase the pH (more basic).

## Water Activity ($A_W$) of Foods

Water activity ($A_W$) is a ratio of the vapor pressure of food compared to that of distilled water, and indicates the amount of available free water within a food product. The $A_W$ scale ranges from 0.0 to 1.0. Higher Aw values can promote the growth of bacteria, while lower values favor molds. For safety reasons relating to *Staphylococcus aureus*, the U.S. Food and Drug Administration (FDA) has established the $A_W$ value of greater than 0.85 as an indicator of high-risk food products if the pH is not taken into consideration. Adding sugar, salt, or dehydrating a food product can lower the overall $A_W$, while adding water can increase the $A_W$. Fat does not contribute to or raise $A_W$. Dairy based products generally have a higher $A_W$. Their moisture level and sugar content have greater impact on the overall water activity of a product.

## Soluble Solids (% Brix) in Foods

Percent Brix measures the percentage of soluble solids in a food with a range from 0% (no dissolved solids) to 100% (all solid, no water). For sweet foods — like jams, jellies, and icings — it indicates the percentage of sugar in the recipe. Percent Brix is an important measurement when determining the safety of a product as it relates to the $A_W$. The higher the % Brix, the lower the amount of available water for microbial growth. This is because sugar binds with free water in food, making it unavailable for bacteria to use.

For food service, the FDA has developed a table relating pH and $A_W$ values to food safety. The 2017 FDA Food Code defines a Potentially Hazardous Food as those foods requiring Time/Temperature Control for Safety (TCS) and provides guidance in the table below to help identify such foods based on pH and $A_W$ values (Table 1).

Recipes in this project were separated into three categories based on their measured pH and $A_W$ values. Note that cooking does not necessarily make a food safe at room temperature. A full list of recipes tested can be found at *rrc.k-state.edu/judging/index.html*.

## TCS Foods – Time/Temperature Control for Safety Foods

Due to their high pH and Aw values, these recipes are defined by the 2017 FDA's Food Code in Table 1 below as needing PA to further determine their microbial safety. TCS Foods held at temperatures between 41-135°F may allow pathogens to grow at a high rate and possibly produce toxins. In the absence of PA studies, the safety of these foods requires temperature control, outside the 41-135°F temperature danger zone, by refrigeration or heat.

***Table 1.*** Interaction of pH and $A_W$ for control of vegetative cells and spores in food not heat-treated or heat-treated but not packaged.

| $A_W$ 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*

### TESTED RECIPE EXAMPLES FOR TCS FOODS:

#### Chocolate Ganache (2) (Cooked)

**Ingredients:** 4 ounces semi-sweet chocolate, ½ cup heavy whipping cream

**pH:** 5.5, **Water Activity:** 0.88

#### Red Velvet Cake Frosting (1) (Cooked)

**Ingredients:** 4 heaping tablespoons flour, 1 cup milk, ½ cup butter, ½ cup shortening, 1 cup sugar, 1 tsp vanilla.

**pH:** 6.2, **Water Activity:** 0.92

#### Low-fat Cream Cheese Frosting for Carrot Cake

**Ingredients:** 8 ounces nonfat cream cheese, 3 ounces Neufchatel cheese, 1½ cups powdered sugar, 1 tablespoon orange zest.

**pH** 5.2, **Water Activity:** 0.91

## NON-TCS FOODS

These had pH and $A_w$ values not conducive to pathogen growth. Non-TCS Foods are generally considered safe at room temperature. However, they are susceptible to microbial spoilage by bacteria, molds, or yeasts over time.

### TESTED RECIPE EXAMPLES FOR NON-TCS FOODS:

#### Simple Buttercream Frosting

**Ingredients:** 2 cups unsalted butter (softened), 8 cups powdered sugar, ½ teaspoon salt, ¼ cup heavy cream, 2 teaspoons vanilla.

**pH:** 4.6, **$A_w$:** 0.83

#### Coconut Pecan Frosting (Cooked)

**Ingredients:** 12 ounces evaporated milk, 1½ cups granulated sugar, ¾ cup margarine, 4 egg yolks, 1½ teaspoons vanilla, 7 ounces coconut, 1½ cups chopped pecans.

**pH:** 5.2, **$A_w$:** 0.79

#### Lemon Deluxe Bars (filling) (Cooked)

Ingredients: 4 eggs, 2 cups sugar, ⅓ cup lemon juice, ¼ cup orange juice concentrate, ½ cup flour, 1 teaspoon baking powder, ⅛ tsp salt.

**pH:** 4.3, **$A_w$:** 0.79

## NON-TCS FOODS WITH CONDITIONS

Some recipes qualify as Non-TCS Foods based on Table 1 above. But with $A_w$ values above 0.85, and due to the lack of validation studies on frostings and fillings, production of toxins by *S. aureus* is possible.

*S. aureus* is a bacterium commonly found on the skin and hair of many people, but it does not generally cause illness in healthy individuals. The bacterium is a weak competitor with other bacteria. In pre-cooked foods where other bacteria have been killed, *S. aureus* may contaminate food by food handlers. With no other bacteria present, foods with a high pH and $A_w$ greater than 0.85, then left at ambient temperature, *S. aureus* will multiply and create heat-stable toxins that lead to food poisoning. The control of *S. aureus* requires prevention, by practicing proper hand hygiene when preparing and consuming food, keeping equipment clean, and keeping foods outside the temperature danger zone.

### TESTED RECIPE EXAMPLES FOR NON-TCS FOODS WITH CONDITIONS:

#### Lemon Curd (Betty Crocker)

**Ingredients:** 1 cup sugar, 1 tablespoon finely shredded lemon peel, 1 cup lemon juice, 3 tablespoons cold butter, 3 large eggs (beaten).

***Cooked**
**pH:** 3.2, **$A_w$:** 0.94

#### Chocolate Brownie Cake Ganache (Microwaved)

**Ingredients:** 1 cup heavy whipping cream, 12 ounces semi-sweet chocolate morsels.

**pH:** 5.2, **$A_w$:** 0.85

#### Basic Sugar Glaze

**Ingredients:** 1½ cups powdered sugar, 2 tablespoons milk, 2 teaspoons vanilla.

**pH:** 5.9, **$A_w$:** 0.85

## CONCLUSION

This study was not aimed at performing individual product assessments to determine the final safety of each recipe due to lack of time and cost. Instead, intrinsic factors associated with foods commonly entered at fairs and exhibitions were analyzed to

make recommendations based on FDA guidelines and microbial growth requirements.

The key factor for frostings and fillings safety is the $A_w$ level. Most TCS Foods in this study had dairy products such as milk, cream cheese, butter, and cream as primary ingredients, but not enough sugar to lower the $A_w$ below 0.85. For example, in recipes using cream cheese, some require refrigeration, some do not. Therefore, as a general rule, no cream cheese based frostings or fillings will be allowed at Kansas fairs and exhibitions. Adding water as an ingredient will increase the $A_w$ of a product. TCS frostings and fillings need refrigeration. Individuals should always practice proper hand hygiene, and maintain clean equipment and work spaces during preparation, handling, and consumption of foods.

Therefore, for Kansas fairs and exhibitions, we will continue to NOT allow the following ingredients or products:

- Raw eggs in uncooked frostings or fillings
- Raw flour in uncooked frostings or fillings
- Cream cheese frosting or filling
- Chocolate ganache
- Heavy cream frosting
- Lemon curd
- Fresh cut fruit or vegetables as garnishes
- Custard pie
- Cream pie
- Chiffon pie
- Fresh (unbaked) fruit pie
  (ex: fresh strawberry pie)
- Any meat
- Friendship bread starter, not refrigerated

## Recommendation for Kansas Fairs and Exhibitions

Recipe variations and the variability in $A_w$ and % Brix make this complex. A choice to ensure stability at room temperature, without $A_w$ testing, is to use a frosting or filling recipe with a minimum of 65% sugar by weight. If using corn syrup, it is only 70% sugar and the rest is water. The calculations below do not factor the sugar found naturally in fruit or other ingredients such as sweetened coconut or chocolate chips.

A metric kitchen scale helps make calculations easy by measuring weight in grams. Measure ingredients using household measuring utensils, then weigh each measured ingredient. A number of websites provide weight equivalents for household measurements of common ingredients. Examples include:

*bakingcalculators.com/convertrecipe/Default.aspx*

*kingarthurbaking.com/learn/ingredient-weight-chart*

*thecalculatorsite.com/cooking/cooking-calculator.php*

Alternatively, conduct an internet search for the specific ingredient, the amount, and to convert to grams. Some examples to show how to calculate % sugar are below.

**Example 1: Simple Buttercream Frosting**

| Ingredients | Weight in grams |
|---|---|
| 2 cups unsalted butter | 454 |
| 8 cups powdered sugar | 960 |
| ½ teaspoon salt | 3 |
| ¼ cup heavy cream | 59 |
| 2 teaspoons vanilla extract | 8 |
| **Total Weight** | **1430** |

**% sugar:** (960/1430) x 100 = 67.1 %

**This frosting is more than 65% sugar and considered stable at room temperature.**

**Example 2: Filling for Lemon Cheese Filled Cake**

| Ingredients | Weight in grams |
|---|---|
| 8 ounces cream cheese | 227 |
| ¼ cup sugar | 50 |
| 1 teaspoon lemon juice | 4.79 |
| 2 teaspoons water | 9.86 |
| ½ cup coconut | 40 |
| **Total weight** | **331.65** |

**% sugar:** (50/331.65) x 100 = 15%

**This frosting is below 65% sugar and therefore not stable at room temperature because of the high amount of dairy ingredients.**

**Example 3: Fudge Frosting (Betty Crocker)**

| Ingredients | Weight in grams |
|---|---|
| 2 cups granulated sugar | 400 |
| 1 cup baking cocoa | 80 |
| 1 cup milk | 245 |
| ½ cup butter | 113 |
| ¼ cup light-colored corn syrup (70% sugar) | 59 (41.3 g sugar) |
| ¼ teaspoon salt | 2 |
| 2 ½ to 3 cups powdered sugar | 360 (based on 3 cups) |
| 2 teaspoons vanilla | 8 |
| **Total weight** | **1267** |

**% sugar:** (801.3/1267) x 100 = 63.2%

**This frosting is below 65% sugar and therefore not stable at room temperature because of the high amount of dairy ingredients.**

**Example 4: Cream Cheese Frosting**

| Ingredients | Weight in grams |
|---|---|
| 8 ounces cream cheese | 227 |
| ½ cup butter | 114 |
| 1 teaspoon vanilla | 5 |
| 3 ½ cups powdered sugar | 420 |
| Total Weight | 766 |

**% sugar:** (420/766) x 100 = 54.8%

**This frosting is below 65% sugar and therefore not stable at room temperature because of the high amount of dairy ingredients.**

## REFERENCES:


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