Baking with Altitude

Ever baked a cake that puffed-up then cratered? One that was tough? Or one that tenaciously stuck to the pan?? It's nice to know that you weren't to blame. There actually are scientific reasons for these unappetizing results.

At approximately 5,000 feet above sea level, Guatemala City is blessed with a temperate climate high above the humidity and oppressive heat of surrounding lowland areas. While the moderate temperatures feel great, the altitude can wreak havoc in the kitchen, especially when baking. Whether you've been living in Guatemala City for years, or are new in town, the following is an explanation of why you've had to, or will have to, modify some of your recipes, as well as some tips and recommendations for the challenge of high-altitude cooking and baking.

Areas with altitudes of 3500 feet or more above sea level are considered to be high-altitude areas. The main culprit for culinary woes at these heights is the change in atmospheric pressure. The blanket of air is thinner at higher elevations meaning atmospheric pressure is lower than at sea level or more normal elevations. (Approximately ½ pound less pressure for each 1,000 feet increase above sea level.)

So how does this affect your pasta and cakes? While water boils at 212˚F at sea level, at 5000 feet it boils at about 203˚F, because there is not as much air pressure to inhibit the boiling action. (For approximately every 500 feet of ascent, the boiling point is lowered 1˚F). This means that it takes longer to cook foods by boiling since they are actually cooking at a lower temperature. (Coffee really isn't as hot here as it is at the beach.) In addition, lower air pressure causes water to evaporate more rapidly meaning more liquid is required. Beyond a certain altitude some foods cannot even be prepared without a pressure cooker. Take dried beans for example. At extremely high altitudes the boiling point of water is so low that without a pressure cooker the water will just keep steaming off at a temperature that doesn't even begin to cook the beans.

But it is baking that really takes the hit from decreased air pressure. In baking recipes, each ingredient bears a definite relationship to the others, and the quality of the finished product depends upon a delicate balance of ingredients. High altitudes throw this precise balance askew.

Heat rises from the bottom of an oven, but since there isn't sufficient air pressure from above to balance this upward pressure, cakes tend to rise too rapidly. This rapid rising is compounded by the fact that at 5,000 feet 1 teaspoon of baking powder produces 20% more volume than at sea level. Thus a cake's cell structure expands before it "sets". At best cakes may have a coarse texture. At worst, cell walls may over-expand and break, causing cakes to fall. Or cake batter may rise so high during this expansion that it spills over the top of the pan. Because water in batters evaporates more quickly, there is more concentration of sugar in the recipe, which can weaken the cell structure, and result in a dry cake. Or cakes can remain underdone if the temperature is not raised to adjust for the lower boiling point. Added to all of this, cakes have a greater tendency to stick to pans!

What is a high-altitude baker to do?

High Altitude Baking Tips

- Reduce baking powder by 1/8 – 1/4 per teaspoon
- Reduce sugar by 0 – 2 TB per cup
- Increase liquid by 2 – 4 TB per cup to counterbalance rapid evaporation of liquids
- Use cold water and large cold eggs to give cake extra strength
- Don't over beat eggs to prevent too much air being added
- *Generously* grease and flour cake pans to prevent cakes from sticking - with the exception of angel food and sponge cakes which should always be baked in ungreased pans
- Fill pans 1/3 to *no more than* 1/2 full to avoid batter overflow caused by rapid cake expansion
- Increase oven temperature by 25° to help "set" the batter before it over expands
- Reduce baking time about 20% to prevent over-baking at the higher temperature
- For yeast cakes watch dough carefully since they rise more quickly judge rise time by change in dough's bulk, not by amount of time it takes

You can always play it safe with the high-altitude modifications on cake, brownie, and cookie mix boxes. Or be brave and make a cake from scratch incorporating the adjustments on the previous page for Guatemala City's 5000 feet elevation.

When adapting a recipe for high altitudes, always start out with the smallest adjustment and add more only if necessary. Any or all of the adjustments may be required but only repeated experiments with recipes can give the most successful proportions to use.

Being extremely fond of light, fat-free Angel food cakes and having heard that they can be quite difficult to bake at almost mile-high altitudes, I decided to take the challenge and see if I could overcome the low air pressure obstacles. Angel food cakes use air for leavening, but it is important not to beat too much air into the eggs. They should be beaten only until they form a peak that falls over, not until stiff and dry. Over-beating expands air cells too much and causes angel food cakes to fall. Using less sugar, more flour and a higher baking temperature will strengthen the cell structure of angel food cakes.

I used the following modified recipe and met with very acceptable results. The cake did not fall, was not under or over done, and had a nice flavor. Even my very discriminating husband approved. But it was slightly dense, not quite as light as I remember angel food cakes to be. I'll have to try again for more perfect results.

Good luck and happy baking!

- The Editor

For those of you wanting more information on high-altitude cooking, check out *The New High Altitude Cookbook*, by Beverly M. Anderson & Donna M. Hamilton. It can be ordered through amazon.com for $20.97.

Information for this article came from *Cooking A to Z: The Complete Culinary Reference Tool*, California Culinary Academy and a number of web sites: allrecipes.com, arapcsuext.org,

High Altitude Angel Food Cake

1 ½ cups + 2 TB of flour

1 ½ cups sugar

14 egg whites

pinch of salt

½ tsp. of cream of tartar (optional)

2 tsp. Vanilla extract

½ tsp. almond extract

1 tsp. fresh lemon juice

Photo of Editor's "from scratch" angel food cake with strawberry sauce.

1. Preheat oven to 325° F. Sift flour into a dry mixing bowl. Sift sugar into a separate bowl and set both bowls aside.
2. In a copper or stainless steel bowl, beat egg whites to peaks that fall over; add salt when whites are just foamy (if bowl is stainless, add cream of tartar at this point as well.) Gently fold in sugar with a rubber spatula; fold in flour in 2 batches, then add vanilla and almond extracts and lemon juice. When all is completely incorporated, pour batter into a 10-inch tube pan and smooth top.
3. Bake until cake is a pale, creamy brown color, top springs back when gently touched with finger, and a wooden skewer inserted in center comes out clean (about 40 minutes). Cool upside down. (I tried cooling mine upside down and it fell almost immediately over the bottle on whose neck it was balancing! So it cooled un-panned.)
4. To serve, gently remove from pan (if necessary). Decorate and serve as desired.

Serves 10 to 12

I topped the cake with strawberry sauce: mash 2 pints of strawberries with ¼ - ⅓ cup of sugar until juices are released. Let sauce sit at room temperature for 1 hour before spooning over cake.