High Altitude Cooking, Baking: Some Tips for the Housewife

BY KLAUS LORENZ

Cooking and baking processes are affected by atmospheric pressure, as women of families settling in the high altitude region of the United States have found out. They discovered that it took considerably longer to cook such staples as potatoes and beans and that their favorite cake recipes, well balanced for use at sea level, produced cakes which would rise too high in the oven and then flow over the top of the pan.

The difference in atmospheric pressure is the cause of all these difficulties. As altitude increases, the air pressure becomes less. This has to be compensated for. Just as the pressure of water is greatest at the bottom of the sea and becomes lighter near its surface, so does the pressure of the atmosphere decrease as elevation increases.

Problems in high altitude food preparation are encountered in many states. Some states and cities where adjustments due to elevation have to be made are given in the table on page 283.

This high altitude region comprises more than one-third of the United States geographically. Although these areas are sparsely populated, about 15 million people make their home there.

Problems of high altitude food preparation have been studied for many years at Colorado State University. The equipment and the laboratory which make these investigations of the effects of altitude possible are shown in a photograph with this chapter. The laboratory itself is a steel cylinder seven feet in diameter and nine feet high. It can be ventilated and the temperature and humidity controlled.

Atmospheric pressure inside this laboratory can be adjusted and maintained to simulate altitudes between sea level and 12,000 feet.

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High altitude chamber used for Colorado studies on the effects of atmospheric pressure in food preparation.

The laboratory is equipped to conduct baking and cooking experiments at different elevations. This not only helps people in the high altitude region of the United States, but also makes it possible to respond to the many requests for information which are received every year from countries located in the high altitude regions of South America, Asia and Africa.

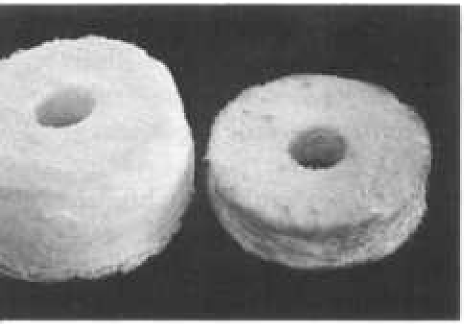
Essentially, three types of problems have to be considered when preparing foods at high elevations:

- The greater expansion of leavening gases which affects all baking processes
- The difference in temperature at which water boils, which affects both baking and cooking
- The faster rate of evaporation of moisture from foods at reduced atmospheric pressures

So Cakes Won't Fall

Since air pressure is less at higher elevations, the leavening gas in a cake batter expands more. So a correspondingly smaller weight of carbon dioxide or other leavening gas is required to perform the same amount of leavening as the atmospheric pressure decreases.

This applies to all baked products whether they are leavened with carbon dioxide, as in the case of cakes, baking powder biscuits, muffins, and quick breads; or with air, as in angel food and sponge cakes; or with steam, as in popovers and cream puffs.



Angel food cakes baked at 5,000 feet. Cake on left was baked from recipe adjusted for altitude. Cake at right was baked from a sea level recipe.

High Altitude Table of Cities and Towns

State	City	Elevation feet
Arizona	Tucson	2,390
	Flagstaff	6,886
Colorado	Boulder	5,347
	Colorado Springs	5,985
	Denver	5,309
	Fort Collins	4,994
	Pueblo	4,657
	Trinidad	5,982
Idaho	Boise	2,880
	Idaho Falls	4,742
Montana	Billings	3,117
	Bozeman	4,754
	Helena	4,108
Nebraska	North Platte	2,826
	Scotts Bluff	4,662
Nevada	Reno	4,484
New Mexico	Albuquerque	5,008
	Las Vegas	6,398
	Sante Fe	6,998
South Dakota	Rapid City	3,196
Texas	Amarillo	3,691
	El Paso	3,767
Utah	Ogden	4,307
	Salt Lake City	4,345
Wyoming	Casper	5,101
	Cheyenne	6,105
	Laramie	7,159

A cake's structure is very delicate, and increased pressure resulting from additional expansion of the carbon dioxide within the cells causes them to expand too much. This makes the grain of the cake coarse, or, if the cells are expanded still more, they will rupture and a fallen cake will result.

Liquid in a cake batter also evaporates more rapidly at higher elevations, causing the dissolved sugar in the cake batter to become more concentrated. Excessive sugar weakens the structure of the cell walls of a cake. Thus, reducing the sugar, and/or increasing the liquid slightly, provides stronger cake cell walls which are less likely to collapse.

Generally, no changes in formulation are required up to an elevation of approximately 2,500 feet. A cake recipe adjustment guide for elevations higher than 2,500 feet is given in a second table.

Cake Recipe Adjustment Guide for High Altitudes

Adjustment	3,000 feet	5,000 feet	7,000 feet
Reduce baking powder For each tsp., decrease	1/8 tsp.	1/8-1/4 tsp.	1/4 tsp.
Reduce sugar For each cup, decrease	0-1 tbsp.	0-2 tbsp.	1-3 tbsp.
Increase liquid For each cup, add	1-2 tbsp.	2-4 tbsp.	3-4 tbsp.

These suggestions for adjustment shown in the second table have been established through baking experiments with many different recipes at different elevations. But contrary to popular opinion, there are no set rules for modifying a cake recipe for higher elevations. Needed changes depend on the type of cake and relationship of the ingredients to each other. Quite frequently the proper recipe adjustments have to be worked out by trial and error using the suggestions in the second table as a starting point.

With biscuits, muffins, and quick breads, the baking powder may be decreased slightly, but structure of the products is such that it generally will stand the increased internal pressure at higher elevations quite well. Cookies usually do not need adjustments for altitude, although a slight reduction in baking powder and sugar may improve them.

Cake doughnuts made from sea level recipes are frequently cracked, too high in fat absorption, and too compact and dark. To remedy this, decrease the leavening, sugar and fat.

Angel Food and Breads

In angel food cakes the leavening agent is air. At higher elevations the amount of air beaten into the batter will expand to a larger volume than at sea level and, therefore, less air is needed. Sugar in the recipe also should be reduced, and a higher baking temperature for a shorter time will generally give better results.

Cakes baked at 7,500 or 10,000 feet do not brown as much and as rapidly as cakes baked at sea level at the same oven temperature. Caramelization of sugar in the cake recipe is responsible for crust color formation and depends upon the temperature. The faster rate of evaporation at higher elevations causes a drop in temperature in the cake crust.

This temperature drop continues until the heat absorbed by water evaporation is equal to the heat transferred to the crust. The lower the atmospheric pressure, the lower the crust temperature. That accounts for the recommendation to increase the baking temperature to compensate for the reduction in crust temperature caused by evaporation.

For popovers, the amount of egg in the dough should be increased and the shortening reduced. This makes a stronger batter which will be able to retain the steam long enough for a crust to form. Popovers made by sea level recipes lose the steam too rapidly, both by expansion and evaporation, and turn out more like muffins.

A cream puff batter, being rather heavy, holds the steam well and does not require any corrections for altitude.

Baking of bread is affected by altitude just as the baking of cakes and sweet goods. However, fewer changes in the recipe, dough preparation and dough handling are required to adopt a bread recipe for baking at reduced atmospheric pressures.

Bread doughs rise more rapidly at high altitudes and may become overfermented or overproofed if not watched carefully. Less yeast may be used. However, most bakers and many housewives in the high altitude region prefer to decrease dough fermentation and proofing times rather than reducing the yeast.

Because flour dries out faster at high altitudes, it may be necessary to use more liquid to compensate for this loss and make the dough the proper consistency.

When a liquid is heated, vapor begins to form. The bubbles of vapor, being lighter than the liquid, rise upward, but they cannot reach the surface until the pressure within each bubble just exceeds the atmospheric pressure on the liquid's surface.

Temperature at which bubbles reach the surface and break is known as the boiling point. This is the temperature at which pressure of the saturated vapor within the liquid is equal to the outside atmospheric pressure on the surface of the liquid.

Since at high altitudes the atmospheric pressure is less, the pressure of the vapor necessary for the liquid to boil is less and will be reached at a lower temperature. For this reason, liquids boil at lower temperatures at high altitudes. Lowering of the boiling point of water amounts to about 1.9° F for each 1,000 feet increase in altitude, as seen in the table.

Boiling Temperatures of Water at Various Altitudes

Altitude (feet)	Boiling point of water Degrees F	Degrees C
Sea Level	212.0	100.0
2,000	208.4	98.4
5,000	203.0	95.0
7,500	198.4	92.4
10,000	194.0	90.0

Time and Tenderness

Foods cooked in boiling water require a longer cooking time to become tender. It is difficult to give any definite cooking rules for vegetables since even with the same kind of vegetables, there are so many variations in size, variety, stage of maturity, and so on. In general, the time must be increased from 4 to 11 per cent per 1,000 feet, depending on the vegetable.

Eggs and meat, such as stews and pot roasts, must also be cooked for an increasingly longer period with higher altitude.

A pressure cooker is a great convenience at high altitudes for cooking meats, beans, and other vegetables which require relatively long cooking. By increasing the pressure, the temperature at which water boils is raised and the food is cooked more quickly.

However, the steam within the pressure cooker is also affected by the altitude. Boiling temperature of the water inside at 15 pounds pressure is not as high at 5,000 feet as it is at sea level.

To reach the same temperature, the pressure must be increased about 1 pound for each 2,000 feet of elevation. For example, at 5,000 feet a pressure of 17.5 pounds will give the same internal temperature as 15 pounds at sea level. If the pressure cooker has a gage graduated in 1-pound divisions, such an adjustment can be made easily.

Unfortunately, the gages of some pressure cookers do not go above 15 pounds; when using them, it may be necessary to lengthen the time given for cooking a particular food. An increase of 1 to 2 minutes is sufficient for most vegetables. Beets, whole potatoes, and sweet potatoes require about 5 minutes longer at 5,000 ft.

Canning is another phase of food preparation which is affected by the lower boiling temperature of water at high altitudes. The time needed to process fruits and acid vegetables in a hot water bath should be lengthened with increasing altitude.

Add one-half pound to the gage pressure for each additional 1,000 feet in altitude, as illustrated in the table below.

Steam Pressure at Different Elevations

Degrees F	Degrees C	Steam pressure (pounds) at an altitude of			
		Sea level	4,000 ft.	6,000 ft.	7,500 ft.
228	109	5	7	8	9
240	115	10	12	13	14
250	121	15	17	18	19
259	126	20	22	23	24

With this increase in pressure, the sea level processing times may be used satisfactorily.

Lowering of the boiling point because of high altitude also causes difficulty in making candy and frosting. If the old-fashioned cold water test is used (soft ball, hard ball, crack, and so on), the candy will be cooked to the proper consistency.

However, in recent years the candy thermometer has come into widespread use since it is more exact and not subject to variations of individual judgment. It must be remembered that at high altitudes a sugar solution, like water, boils at a lower temperature. If sea-level directions are followed, the sirup will be too concentrated by the time the prescribed temperature is reached, and the resulting candy or frosting will be too hard.

Better results are obtained if for each 1,000 feet of altitude, the temperature is lowered 1.9° F. If desired, before making the candy, the exact boiling point of water may be determined, and the difference between it and 212° F subtracted from the temperature called for in the recipe. For example, if the boiling point of water at 5,000 feet on a particular day is 202.5°; then 212° — 202.5° = 9.5° is the correction. Suppose the temperature for fondant at sea level is 239°. In this case 239° — 9.5° = 229.5°, which is the temperature to be used for fondant at 5,000 ft.

When the boiling point of water is checked in this way, any day-to-day variations in atmospheric pressure caused by weather conditions will be compensated.

The same corrections used for candy-making should be applied to frostings.

If a thermometer is used in jelly-making, the same temperature corrections should also be used. By being aware of the problems of high altitude cooking and baking and making necessary adjustments, every housewife should succeed in the kitchen regardless of the altitude at which her home is located.

Colorado State University, through the Altitude Laboratory of the Department of Food Science and Nutrition in the College of Home Economics, has conducted research in high altitude food preparation for over 40 years. Some results of these studies are available in the bulletins *Mile-High Cakes, Quick Mixes, Basic Cookie Mixes for High Altitude, Making Yeast Breads at High Altitudes,* and *Wheat-Gluten-Egg and Milk-Free Recipes for Use at High Altitudes and Sea Level.* These may be obtained at a small cost through the Bulletin Room, Office of Printing and Publications, Colorado State University, Fort Collins, Colo. 80521.