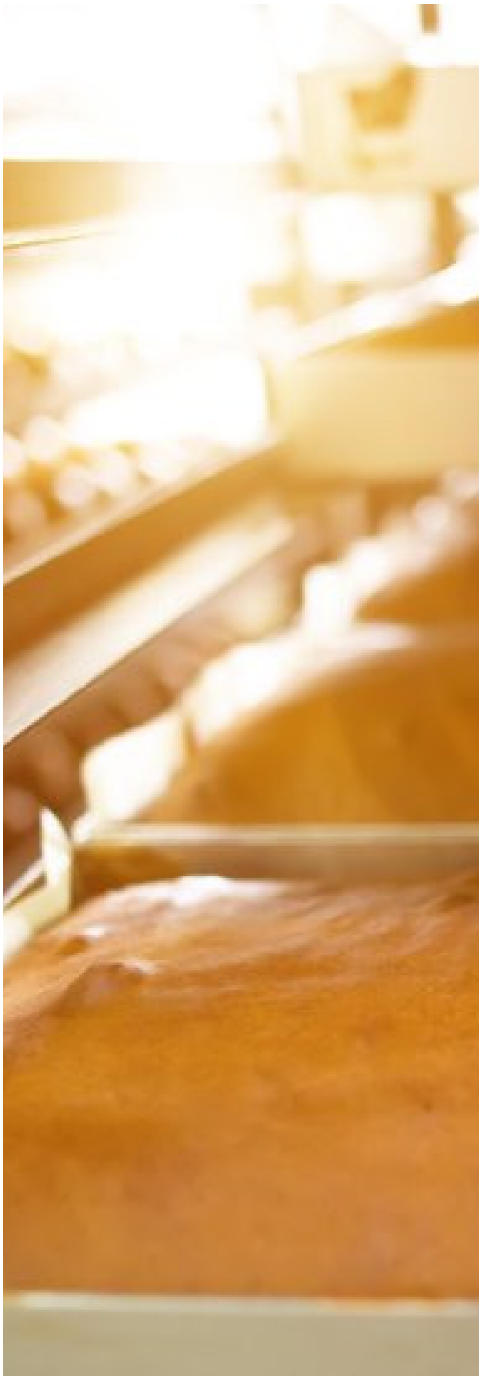
Thermal Profiling for Cake Products

The successful production of cakes, like most bakery products, relies on consistent, repeatable quality that will keep customers coming back. To avoid products that fluctuate in textural attributes like denseness, dryness and crumbliness, mastering and controlling the baking step is crucial. Correct baking time, oven temperature and step profiles can all have a positive impact on cake texture, quality and shelf-life.

However, how do you know if you have the correct settings? Until recently, it was difficult to thermally profile a cake due to batter viscosity and other factors. New developments have helped improve cake thermal profiling techniques, delivering opportunities for better yields and quality.

What is Thermal Profiling?

Thermal profiling refers to product and oven temperature logging in baked goods as they pass through temperature cycles in the oven during production. Bakeries use thermal data recorders to log time-temperature profiles and create a uniform baking process. Furthermore, regular thermal profiling of products—as well as ongoing verification of oven settings and performance—helps maintain and control product quality.



How it Works

The thermal profiler consists of various parts such as a thermal barrier, thermocouple, and thermocouple stand.

The thermal barrier is a stainless steel insulator case that keeps the logger safe and cool through the oven. On completing the baking process, the collected data gets downloaded using profiling software, and produces a user-friendly, time-temperature graph.

Thermocouples are the sensors used in this process. A suitable thermocouple should have a low limit for error, should be easy to insert into the pliable dough (or, in this case, provide batter depth control), and remain stable over the baking temperature range used.

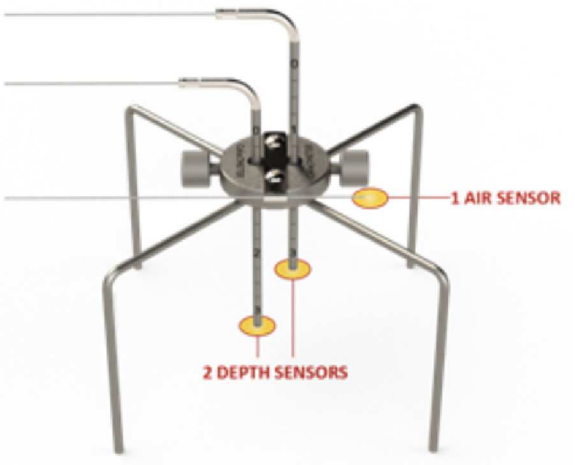
Getting the Perfect Bake

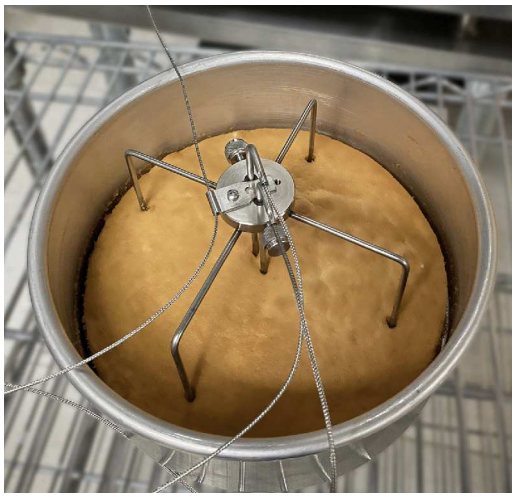
While temperature and time adjustments are crucial for an even and proper bake, the type and quality of ingredients used, mixing time, and humidity levels in the baking environment can all affect the cake's final outcome. Proper equipment maintenance, recipe standardization, and quality control checks are essential to maintain consistent and high-quality products.

Thermal Profiling for Cakes

Cake batter has a low viscosity that is too thin to support many existing thermocouple sensors which have generally been used for more viscous, dough-like products. So, the low viscosity of cake batter requires a thermocouple stand to hold the sensor(s) in place. The thermocouple must remain within the batter while not touching the metal cake pan, as metals react differently than the baking product and have a different temperature profile due to conduction.

Pans have various widths and heights, so the thermal probe and supporting stand should be adjustable to accommodate multiple pan sizes, shapes and batter depth. A second depth sensor corroborates production consistency, while an ambient sensor validates oven repeatability throughout bake time, ensuring a consistent measurement profile.





THE SOLUTION: CakeOMETER

1. Loosen the two thumb screws and press Channel 2 and 3 depth gage sensors into the CakeOMETER base.

2. Place the 4-legged probe base such that Channel 2 depth gage is located in the center of the pan. Press Channel 2 depth sensor all the way down till it hits the pan, then slightly raise it. Tighten the thumb screw.

3. Raise Channel 3 depth sensor higher in the pan to confirm consistency, though still submerged, prior to tightening its thumb screw.

4. Channel 1 (for the sake of software data consistency) is the oven ambient sensor. Push it through the holding clip to extend past the outer edge of the pan.

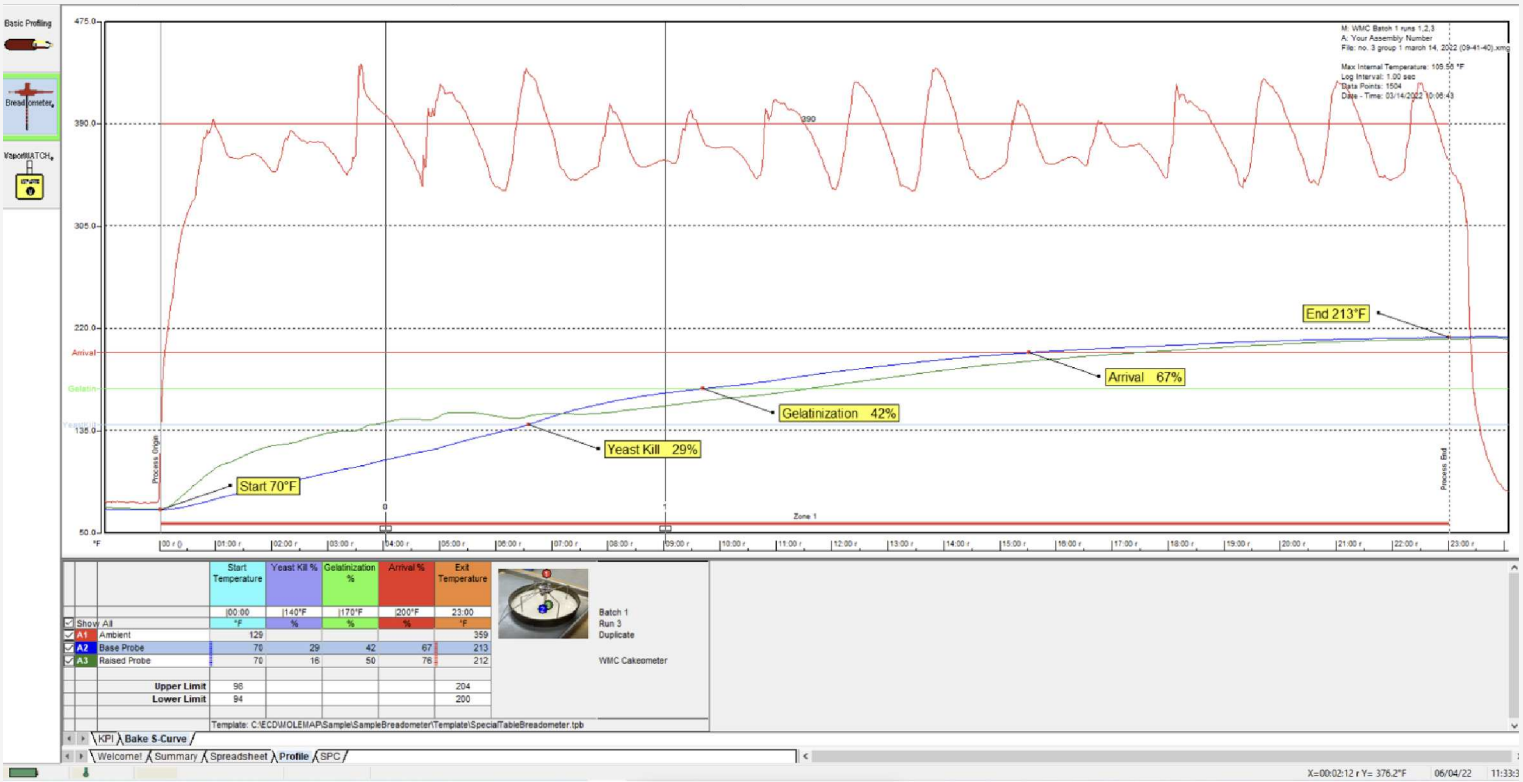
5. The stand helps keep all of the measurement probes stationary within the batter and maintains this stability throughout the baking cycle to ensure the reliability and repeatability of the analyzed data.

CASE STUDY:
RUNNING A CAKE THERMAL PROFILE

Traditionally, thermal profiles were limited to dough products (breads, biscuits, crackers & snack goods), due to issues with probe placement during the baking cycle. However, new technology by ECD BakeWATCH makes cake profiling possible. The unique design for the CakeOMETER allows accurate data to be collected.

When integrated with a 6-channel thermal profiler, it provides accurate cake temperature data to be captured for simple download to evaluate baking time and temperature, delivering repeatable results.

SAMPLE CAKE THERMAL PROFILE



NOTE: *The red-blue-green sequence of Thermocouple channels correlate to ambient Ch. #1, base batter probe Ch. #2 and mid-level batter probe Ch. #3 data.*

CONT.

CASE STUDY
DATA & RESULTS

	Oven Temp.	Baking Time	Batter Start Temp.	Cake Gelatinization Point	Arrival to 200°F	Exit Temp.
Control	390°F	23	70°F	42	69	213°F
Variable	350°F	26	70°F	51	85	207°F

	Specific Volume	Moisture Content	Firmness Day 1	Firmness Day 3	Delta Firmness
Control	2.81	36	1803	2114	311
Variable	2.93	36.88	1188	1209	21

RESULTS & CONCLUSION

The suggested bake temperature of the control cake sample was high, at 200°C/390°F for 23 mins. Therefore, gelatinization was quicker at 42% vs 51% for the variable. The variable was baked at a slightly lower temperature for a longer period of time, at 176°C/350°F for 26 mins. A later gelatinization delayed the setting of the cake. Therefore, the variable expanded more, resulting in higher specific volume. A higher specific volume means that more air bubbles are contained within an area and a softer cake.

Therefore, over three days, the firmness data from a texture profile analysis showed the variable remained the softest with a lower staling rate. So, this experiment shows that thermal profiling has the ability to optimize cake baking time and temperature, creating a softer cake that remains soft over shelf-life.

TOP TIP: While developing a new baking protocol, baking at the lowest possible temperature ensures good shelf-life and sensory qualities. Longer baking time at low temperature allows the batter a long time to expand and constitutes a higher volume. Conversely, higher baking temperatures result in firmer, more compact cakes.

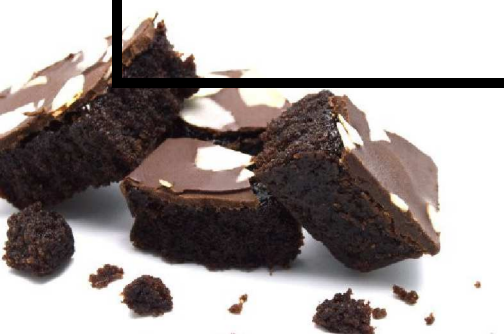
BENEFITS OF USING THERMAL PROFILING

Equipment variation: All baked products have a temperature gradient during the baking process. The temperature displayed as the oven temperature is usually from the thermal sensor of the oven and may not be consistent throughout the oven. Moreover, the larger the oven, the bigger the gradient. When using an ambient probe, equipment defects can be identified by verifying the oven temperature.

New Lines: The product probes help in adapting alternate processing lines quickly. Every processing line is different, and hence, the time-temperature combinations alter with the alternating processing lines. While developing a new line, the baking time and temperature must be the same as the control condition. This method also aids when upscaling from pilot plant scale to large-scale manufacturing.

Quality Control: Thermal profiling is a vital tool used for quality control and analysis. It removes baking time guesswork. The difference in the thermal profiling graph between the two samples indicates the quality of the two batches.

Gluten-Free Baking: Chemical leavening is highly affected by the product temperature. An alternate ingredient replaces the elastic property of gluten. So, temperature control is critical to ensure proper baking without damaging the functional ingredients. Gluten-free processes are even more temperature-critical compared to conventional baking.



How many probes should you use when thermal profiling, and where should they be placed?

The exact number of probes depends upon the type and size of your oven. A rule of thumb is to use three pairs of probes to triplicate the measurement in different parts of your oven. The critical thing about thermal profiling is the repeatability of the data. Therefore, the probes should be placed in identical locations every time to observe any differences in baking time-temperatures. Standardizing probe locations in pans on different racks also helps understand the oven's temperature profile.

What is the cause of staling in my cake?

The inter-bonding of starch molecules causes staling in cakes. High sugar ingredients, emulsifiers, and fats prevent this bonding. Water evaporation increases the space between starch molecules, sugars, and emulsifiers, so they bond stronger. Therefore, moisture driven out of this system is the leading cause of staling.

Baking at higher temperatures reduces the specific volume—the ratio of cake volume to weight. The thermal profiling evaluation mentioned earlier showed that baking at a lower temperature for an extended time yielded more expansion and later arrival, resulting in a higher specific volume. A better emulsification and processing system can further achieve higher volumes that reduce the staling rate.

What is the arrival temperature we should be considering for the measurements with cake?

A longer baking time lowers arrival temperature, helps ensure a longer shelf-life, and produces an airy sponge. Currently, no research is available on arrival temperature, but this can be qualitatively regarded as the temperature of a complete batter change in a porous sponge. Users can manipulate the arrival temperature according to the desired texture, shelf-life, and baking time.