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WHAT GOES ON IN THE OVEN?

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Bakery products vary in form, texture and eating quality. While breads are very different from cakes, biscuits, cookies and pastries, they share in common the key process that we call baking. In the oven each of the different product types undergoes significant changes in character which converts the various doughs, batters and pastes into more convenient and pleasurable forms for human consumption. We may see the transition externally when we look into the oven, but the internal mechanisms which are driving the observed changes in product size, colour and texture are not easily understood. A key part of the transition in the oven is the loss of moisture, greater with some products than others, but that is only part of the story. The particular physical changes which occur are the result of many recipe and process inputs set in place long before the product reaches the oven.

Heat Transfer in Baking

The transfer of heat by conduction, convection and radiation all contribute to the transformation of doughs, batters and pastes into breads, cakes, biscuits, cookies and pastries. It is important to recognise that when an unbaked product enters the oven, heat received at its surface is gradually conducted through the matrix to the reach the core. This means that the change from unbaked to baked product is not instantaneous throughout the whole product but occurs on a moving heat front from surface to centre. This gradual temperature change throughout the baking time has a critical impact on product structure and eating quality.

Both the thermal conductivity and the dimensions of the product play critical roles in determining how quickly the heat front reaches the core. Doughs and pastes have quite similar heat conductivities, while the higher water contents of batters, results in them having a higher heat conductivity. Thin products with a small distance from surface to core (such as bread rolls) will bake faster than those with a large distance (such as pan bread).

Baking may be described as a heat and mass transfer relationship, in that to release a given mass of water from an unbaked product requires a given amount of heat to be input. The loss of water from unbaked products plays a key role in determining final product structure and eating qualities. The release of large volumes of water vapour as steam, and the pressure which is generated make important contributions to product volume in bread and cakes, and lift in laminated products, biscuits and cookies.

In practical baking we control the heat input through a combination of temperature and time, and we adjust both according to the product needs. Weight losses which are the result of driving off water during baking must be controlled in order to deliver the relevant moisture content in the final product and the important contribution that makes to product eating quality.

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While it is common to indicate a particular temperature at which the oven should be set to bake individual products, it is known in practice that different ovens when set at the same temperature deliver end products with differing characteristics. This occurs because the ratios between the different modes of heat transfer (conduction, convection and radiation) vary in different oven designs. This is especially true for conducted and radiant heat. These heat components both come from the hot surfaces within the oven chamber, but their influence depends on how they interact with the unbaked product. For example, a lot of bottom heat may be used with hearth breads to encourage rapid expansion and bottom crust formation. The hot surfaces of the sides and roof of the oven which radiate heat to the product play key roles in restricting surface expansion and generating crust colour. This is not always a desirable input of heat and is often associated with excessive top crust colour formation – burning. Often referred to as 'flash heat', it delivers a dark crust colour when products enter a hot and empty oven, as illustrated by the loaf on the extreme right. Gradually flash heat dissipates as more products enter the baking chamber, or with the baking of successive batches (despite the likelihood that the chamber temperature remains relatively constant).

Bread

Proving

The structure of yeast-raised breads and rolls depends on the generation of carbon dioxide gas during fermentation and its retention in the dough. A key stage in the fermentation process is the stage known as proof when the dough pieces are placed in a warm and moist atmosphere to encourage expansion. While the temperatures concerned are lower than the dough will experience in the oven chamber, it is appropriate to consider the process of proof along with baking. Not least because proof is also a heat and mass transfer relationship.

One key difference between proof and baking is that the heat transfer mechanism is dominated by convection using warm and moist air. As with baking, in proof there is a heat front travelling from the surface to the core of the product. The differential between the air temperature in the prover and the dough pieces is relatively low, typically less than 20ºC, and the time involved relatively long (commonly around 60 min for a large loaf). This allows for the gradual and relatively uniform expansion of the dough pieces. However, it is important to note that the core temperature of a dough piece as it leaves the prover is often 1-2ºC lower than the surface.