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**A GUIDE TO CHEMICAL LEAVENING  
AGENTS AND BAKING POWDERS,  
AND THEIR APPLICATIONS IN BAKED  
PRODUCTS**

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# A Guide to Chemical Leavening Agents and Baking Powders, and their Applications in Baked Products

## Introduction

A primary effect of aerating bakery products is to give them a light and palatable texture. The use of chemical leavening agents in the manufacture of baked products is widespread and they have a long history of use. They are employed to generate carbon dioxide gas through the action of heat and food-grade acids and as such may be considered to be the chemical equivalent of carbon dioxide gas production by yeast fermentation as practised in breadmaking. The physical form and sensory qualities of many bakery products are modified and enhanced through the generation of carbon dioxide gas at particular moments in processing. Commonly the aim is to generate the leavening effect during the baking stage and before the structure of the product becomes 'set'. In order to achieve these aims it is necessary to control the moment when the carbon dioxide gas is released and this requires a basic understanding of the chemistry and physics involved in the various reactions. In addition to providing carbon dioxide gas, leavening agents may make significant contributions to product colour and flavour. In the case of the latter it is the components that are left behind in the product – the residual salts – which have the greatest effect.

## The Role of Carbon Dioxide in the Manufacture of Baked Products

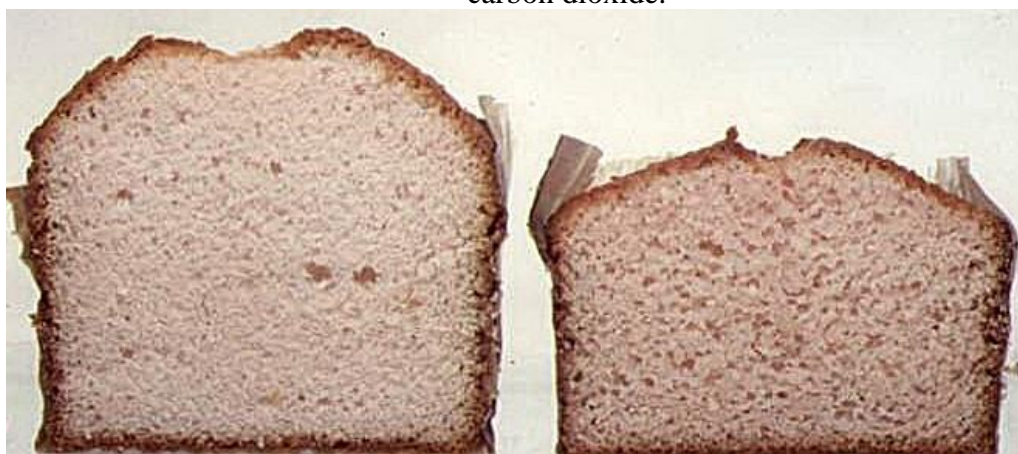
Since the generation of carbon dioxide is a key role for leavening agents, it is appropriate to consider the nature of carbon dioxide and its behaviour in baked products. Some of the key chemical and physical properties of carbon dioxide are summarised in Table 1. The solubility of carbon dioxide has particular relevance in the manufacture of baked products. Once carbon dioxide gas has been generated it can dissolve in the liquid phase of doughs and batters but once this phase is saturated, the carbon dioxide gas will begin to escape into the surrounding atmosphere unless steps are taken to retain it. The high solubility of carbon dioxide gas in cold water can have significant implications for the production of unbaked chilled and frozen doughs (Sluimer, 1981; J-M, Brummer, 1995; Cauvain, 2015), pastes and batters (Lorenz, 1995).

**Table 1: Key physical and chemical properties of carbon dioxide**

Physical form	Colourless, odourless gas
Density	Approximately 1.5 times that of air
Solubility per 100g	In cold water: 171.3 cm <sup>3</sup> In hot water: 90.1 cm <sup>3</sup>
Solid	Condenses to a solid in a snow-like form at -78°C which can be used as a refrigerant – dry-ice.
Chemical composition	1 atom of carbon combined with 2 atoms of oxygen: CO <sub>2</sub>
Sources in baked products	From yeast fermentation. From baking powder reactions (see below).

In the preparation of doughs and batters many air bubbles are incorporated by mixing, kneading and beating actions. These small gas bubble nuclei ( $10\mu\text{m} = 1/1000\text{mm}$ ) provide convenient nucleation sites for the carbon dioxide gas as it is being evolved during fermentation (bread) and from baking powder reaction. As the carbon dioxide diffuses into the entrapped air bubbles they grow in size. Eventually the expanding bubbles grow sufficiently large in size that their outer surfaces touch one another; at this moment coalescence usually occurs and the two or more bubbles become one. The bubbles will continue to grow as long as carbon dioxide is able to diffuse into them and they remain trapped in the dough or batter. Once in the oven the bubbles will also expand because of steam pressure and natural Gas Law expansion. Controlling the rate of evolution of carbon dioxide is an important contributor to the rate of bubble coalescence and therefore final product volume and cell structure, as illustrated by the unit cakes in Figure 1.

**Figure 1:** The contribution of carbon dioxide to unit-cake volume and structure; right, no carbon dioxide.



It has been known for some time that carbon dioxide evolved in doughs and batters is not able to form a gas bubble on its own (Baker and Mize, 1941) and that the presence of trapped air bubble nuclei is therefore key to the expansion mechanism; Handleman *et al* (1961) showed that similar considerations applied in the manufacture of cake batters. Not all trapped air bubbles expand at the same rate in doughs and batters. Surface tension effects dictate that the internal pressures of small trapped air bubbles are proportionally greater than those of larger areas. The practical consequence is that carbon dioxide will diffuse preferentially into gas bubbles with larger diameters (radii) and these grow further than those with small diameter. In fact, the internal pressure in small gas bubbles may become so great that the gas diffuses out of them and they cease to exist. The uneven expansion of air bubbles in dough and batters is commonly referred to under the general heading of ‘disproportionation’.