11
Principles of Dough Formation

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11.1. Introduction

The first, basic step in breadmaking is combining water with wheat flour and kneading (imparting mechanical energy to) the mixture to form an elastic dough (Bushuk [1985]; Hoseney [1985]). Flour from wheat, rather than from other cereal grains, is used because wheat storage protein has unique properties; no other cereal storage protein possesses the ability to form a visco-elastic dough when wetted and kneaded. A full explanation at the molecular level for this uniqueness still eludes researchers.

The events that occur when gluten proteins are hydrated and worked are also elusive. Part of the obscurity is due to the complexity of the system. The basic properties of dough are established by the characteristics of the storage (gluten) proteins in the flour. These characteristics, however, are modified by other flour components, both soluble and insoluble, as well as the additional ingredients added to dough. In studying dough formation we are limited to observing physical events on a macroscale, at the supra-molecular level. Numerous techniques that study molecular properties have been applied to dough: X-ray analysis, nuclear magnetic resonance (NMR), differential scanning calorimetry (DSC), electron spin resonance spectrophotometry (ESR) and scanning electron microscopy (SEM), to name just a few. The interpretation of the results, however, is always complicated by the complexity of the system. X-ray analysis, for example, led to a model of the dough matrix (Grosskreutz [1961]) that included gluten proteins, phospholipids and solid (starch) contributions, but there is no way to confirm independently the accuracy of that model. While these techniques each help us clarify certain aspects of dough structure, the concepts that will be set forth in this chapter are of necessity highly speculative. This fact must be kept firmly in mind while reading this or any other publication on dough formation.

The macro-properties of dough change with time. At the end of the mixing process (Chapter 4) the dough has certain visco-elastic characteristics that are considered optimum for subsequent processing. The resting period (floor-time) changes these properties and makes the dough more pliable (relaxed). Dividing and rounding reverses this to some extent and the dough appears more elastic.
An intermediate proof period decreases the elasticity, allowing good molding into the shape of a loaf. During proofing the characteristics are further modified, not only by relaxation but also by changes in matrix composition from the products of fermentation (ethanol, carbon dioxide), by the action of additives (oxidants and enzymes) and possibly by the action of native flour proteases. Again, our understanding of the molecular alterations resulting in these modifications in dough properties is rudimentary, at best.

Governing all our discussions about dough formation (and the breadmaking process) is the fact that the ultimate criterion of ‘good’ or ‘poor’ structures and processes is the final product – a good loaf of bread. The two main contributors to bread quality are volume (stability in the prover or proof-box and good oven spring) and a fine, silky crumb. These desirable outcomes depend, obviously, on certain optimum properties in the dough matrix. Two characteristics define ‘good’ dough:

1. the ability to retain gas (carbon dioxide), generated during fermentation (proofing), in the form of numerous small gas cells;
2. a proper balance of viscous flow and elastic strength so that the loaf can expand adequately during proofing and the early stages of baking, yet retain its rounded form.

Gluten (hydrated wheat storage protein) is the component of dough that determines how well these requirements are met. While other flour components affect gluten functionality, and mechanical energy input during mixing is crucial to developing the proper characteristics, it is still the physicochemical nature of gluten proteins with which we will be mainly concerned in this discussion of dough formation.

11.2. Flour and Dough Components

Wheat flour components (dry basis) can be classified into six groups:

1. starch;
2. storage (gluten) proteins;
3. non-starch polysaccharides (pentosans);
4. lipids;
5. water-soluble proteins;
6. inorganic compounds (ash).

Starch is relatively inert during dough mixing, but plays a role as a ‘filler’ that contributes to increased dough visco-elasticity. (Starch, of course, has a critical influence during the baking process, when it gelatinizes, and during subsequent storage, when retrogradation accounts for the major part of bread staling (see Chapter 10).) Endogenous inorganic materials are relatively unimportant in