Dough Rheology and Baked Product Texture

DOUGH RHEOLOGY AND BAKED PRODUCT TEXTURE

Edited by

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Foreword

Cereal chemists are interested in rheology because the dough undergoes some type of deformation in every phase of the conversion of flour into baked products. During mixing, dough is subjected to extreme deformations, many that exceed the rupture limit; during fermentation, the deformations are much smaller and therefore exhibit a different set of rheological properties; during sheeting and molding, deformations are at an intermediate level; and, finally, during proofing and baking, the dough is subjected to a range of deformations at varying temperatures. Accordingly, the application of rheological concepts to explain the behavior of dough seems a natural requirement of research on the interrelationships among flour constituents, added ingredients, process parameters, and the required characteristics of the final baked product. At any moment in the baking process, the rheological behavior, that is, the nature of the deformation, exhibited by a specific dough derives from the applied stress and how long the stress is maintained. The resulting deformation may be simple, such as pure viscous flow or elastic deformation, and therefore easy to define precisely. Moreover, under some conditions of stress and time (i.e., shear rate), doughs behave as ideal materials and their behavior follows theory derived from fundamental concepts. Under usual conditions encountered in baking, however, the rheological behavior is far from ideal; shear rates vary widely and sample size and dimensions are ill-defined. Because of the highly variable and complex conditions of deformation and sample dimensions, a wide gap persists between technologically practiced and theoretical rheology as applied to bread doughs.

Significant progress has been made in the development of theory and appropriate instrumentation for research on the fundamental aspects of dough rheology; this progress is the subject of the first six chapters of *Dough Rheology and Baked Product Texture*. New fundamental equations have been developed, and instruments have been perfected to measure the necessary parameters. Computers have become an integral part of the instruments and are used for data processing; the ability to process the results rapidly facilitates on-line measurements. The remaining chapters deal with aspects of rheology applied to the processing of cereals into specific consumer products.

Developments in applied dough rheology have followed innovations in instrumentation. Because the common approach to instrument development has been to imitate the breadmaking process, the instruments are highly empirical. Many of the empirical instruments have been very useful in practical quality control, but they have had limited value in generating fundamental data. On the other hand, instruments that lead to the determination of fundamental parameters have not found general use in the mill or bakery laboratories. Accordingly, research is needed to fill the gap between theory and practice.

In reviewing the history of applied dough rheology, one cannot help but be impressed by the breadth of the contributions of one person, Carl Wilhelm Brabender (1897–1970). He has left a legacy of a series of high-quality instruments designed to measure physical properties of doughs at all stages of the baking process. His contributions to cereal chemistry go far beyond the development of instruments. His three-phase concept of breadmaking, formulated in the 1950s and published in *Cereal Foods World* (1965), has withstood the test of time. For each of the three phases—mixing, fermentation and machining, and baking—he developed an instrument to measure the rheological properties of the dough: the farinograph for the mixing phase, the extensograph for the fermentation and machining phase, and the amylograph for the baking phase. Brabender postulated that if two or more flours gave the same results by the three instruments, they would give the same result by the baking test. Accordingly, it became possible to define flours in terms of quantitative parameters determined with each instrument. This approach has become common practice in many countries.

Furthermore, Brabender showed that deviations from specifications can readily be corrected by changing the wheat mix to adjust the farinogram, by adding oxidizing improvers to adjust the extensigram, and by adding diastatic malt or changing the wheat mix to adjust the amylogram. Subsequent modifications in the farinograph with the development of the high-shear model and the Do-Corder made it a useful instrument in the modern mechanical development of breadmaking processes. The extensograph and the amylograph have remained virtually unchanged for over 50 years.

So far, the complexity of the dough system and the variability of the baking process have prevented the rheologists from developing a rigorous equation of state based on composition, deformation, time, and temperature. This is the challenge for future dough rheologists.

W. BUSHUK
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Preface

This book contains 16 chapters of concise and up-to-date review of various aspects of dough rheology and baked product texture. It is the most comprehensive review ever published on the subject and we hope that it will be used worldwide as a reference by researchers, baking technologists, food scientists, engineers, quality control staff of bakeries, students, and others working in the baked product manufacturing industries.

Since the 1950s, the production plants of the large bakers have become bigger, more automated, and, most importantly, less tolerant of variations in the functionality of ingredients and of changes in processing conditions. Variabilities that could have been absorbed easily 30 years ago today cause serious manufacturing problems that affect both product quality and operating profits. This volume is intended to fill a technical gap that exists in our industry. We hope that it will help the baking industry to appreciate the science of dough rheology and to apply the know-how needed to minimize day-to-day manufacturing problems.

Our sincere thanks to the distinguished experts from industry and academia who contributed manuscripts to this volume. Our thanks are also extended to the editorial staff of Van Nostrand Reinhold, Inc., and Beehive Production Services for their excellent suggestions and editing of the text.

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