Journal of Cereal Science 70 (2016) 123–131

Contents lists available at ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Review

Seventy years of research into breadmaking quality

F. MacRitchie

Department of Grain Science and Industry, Kansas State University, Manhattan, KS, USA

ARTICLE INFO

Article history:
Received 14 January 2016
Received in revised form
3 May 2016
Accepted 13 May 2016
Available online 14 May 2016

Keywords:
Breadmaking
Dough development
Gas bubble stability
Genetics of wheat proteins

ABSTRACT

In the 1940s, research by Baker established fundamental aspects of the breadmaking process while Finney showed that differences of quality resided in the gluten proteins of flour. Different lipid components have been found to affect loaf volume and texture but variation in lipid composition of current wheat varieties does not account for significant quality differences. Fundamental studies by Tipples and Kilborn showed that optimum dough development had two requirements – a critical mixing intensity and a critical amount of imparted energy. Expansion of a fermenting dough depends on two stabilizing mechanisms resulting from the gluten/starch matrix and the liquid lamellae surrounding the gas bubbles. In the 1970s, wheat cultivars were developed with poor baking properties, related to a dearth of insoluble protein, shown to comprise glutenins of large molecular size. Research by Payne and coworkers revealed that dough strength could be related to glutenin subunits and the genes controlling their synthesis. This has opened up new directions for determining composition-quality relationships and, in turn, has enabled strategies to be devised for improving quality based on wheat genetic composition.

Contents

Abbreviations: 1B/1R, wheat/rye translocation lines; HMW-GS, high molecular weight glutenin subunits; LMW-GS, low molecular weight glutenin subunits; MWD, molecular weight distribution; SDS-PAGE, sodium dodecyl polyacrylamide gel electrophoresis.

E-mail address: finlay@ksu.edu.

http://dx.doi.org/10.1016/j.jcs.2016.05.020
0733-5210/

1. Introduction

Understanding of breadmaking quality in wheat flours has been a central problem in cereal science. It might be useful at this time to review how research has progressed over a long period in this area. The history of the topic is one that illustrates rather well how science proceeds by advancing knowledge through the patient efforts of researchers who build on the efforts of previous workers. In the review of research, many who have contributed may not be mentioned but this is the nature of science. The major breakthroughs are often credited to relatively few but these breakthroughs are dependent on the efforts of many, some of whom may not be acknowledged but nevertheless have made important contributions. Breadmaking originated in ancient times. As far back as 2000 B.C., the Egyptians knew how to make fermented bread. It seems likely that the process developed by a trial-and-error procedure. Many types of bread are produced around the world but, in order to maintain a focus, this review will be restricted to Western-style pan bread made from wheat.

2. Early research into quality

2.1. The work of J.C. Baker

Modern research into breadmaking goes back a long time (e.g. Boussingault, 1852) but we are going to begin with J.C. Baker (Baker and Mize, 1946), whose research revealed some of the fundamental aspects of breadmaking. It was shown that occlusion of air in the form of tiny bubbles occurred during the later stages of dough development (usually carried out by mixing). Incorporation of air was monitored by measuring the decrease in dough density. This was shown to be a vital step in breadmaking. The gas (carbon dioxide produced by yeast fermentation) dissolved in the aqueous phase of the dough before diffusing into the gas bubbles, which then acted as nuclei for dough expansion. The gas bubble structure was essential for dough inflation, as shown by the lack of expansion when dough was mixed in a vacuum. After completion of mixing, no more air is introduced into the dough. However, subsequent steps in the breadmaking process, such as punching and moulding, can remove some of the occluded air and make the gas cell size smaller and the size distribution more uniform, thus enhancing the final crumb grain. Changes in gas cells of dough during breadmaking have been studied by Shimiya and Nakamura (2007).

2.2. The work of K.F. Finney

Karl Finney developed methods for fractionating and reconstituting wheat flours in order to identify the components responsible for differences in breadmaking potential (Finney, 1943). An important criterion for the reliability of this approach is that the functionality of the fractions is not altered by the procedures. Starch, gluten protein and water solubles (soluble proteins and carbohydrates) were separated and interchanged between wheat varieties of different baking quality. It was shown that gluten protein was responsible for the differences and lipid removal did not alter this result. Protein contents of flours from three varieties were varied by addition of gluten protein or starch fractions from the same flours. Loaf volume in an optimized baking test was found to be a linear function of flour protein content, at least in a range of approximately 8–20 percent.

Finney and Barmore (1948) carried out a survey of the breadmaking quality of flours from wheat cultivars with a wide range of protein content. The variation in protein content was elegantly obtained by growing the cultivars at different locations. The results confirmed the conclusions found from the experiments in which flour protein content had been changed by additions of fractions. Two main conclusions were demonstrated by the results: (i) loaf volume increased linearly with increasing flour protein content and (ii) the slopes of the loaf volume-flour protein relationships were characteristics for each cultivar. Thus, cultivars with the highest slopes were considered to have the best quality.

2.3. Extension and confirmation of Finney's work

Finney's pioneering research, using direct methods to pin-point flour components responsible for differences in baking quality, has been followed up by others. In reconstitution and interchange work, the number of combinations required to reveal the origin of quality differences is given by the simple equation:

$$\text{Number of combinations} = x^{n}$$
$$\text{where } x = \text{number of flours}$$
$$n = \text{number of fractions}$$

In the case of two flours, each separated into three fractions, the number is $2^3 = 8$. Two of these combinations are simply the flours reconstituted to their original compositions.

Interchange experiments between three pairs of flours, members of each pair differing in quality, confirmed the conclusion of Finney that gluten protein was the principal source of the difference