III 7 BREEDING FOR GRAIN QUALITY
W.D. BEVERSDORF AND D.J. HUME
Crop Science Department, University of Guelph, Guelph, Canada N1G 2W1

1. INTRODUCTION

This chapter has been written to provide information for scientists interested in genetic engineering and is not an exhaustive review of the literature on breeding for grain quality. In it, quality is defined, examples are provided of grain quality in several crops, but principally in wheat, maize and soybeans, and effects of genetic and environmental variables on quality are reviewed. Then breeding for grain quality characteristics is discussed, pointing out to researchers involved in genetic engineering some of the approaches, difficulties, pitfalls and opportunities.

For further reading on grain quality and breeding of specific crops, readers are referred to general reviews (1 - 3), plant breeding textbooks (e.g. 4,5); and detailed reviews for wheat (6,7), maize (8), and soybeans (9,10).

The quality of grain crops affects their value, their ultimate use, how they are processed, and also affects the humans or livestock consuming the grain. The term quality is difficult to define because the grower, the processor, and the ultimate user have different criteria for quality. Quite simply, quality means how good the grain is. To a grower, for example, grain which will sell for top price is high quality. This may mean grain that is clean, bright, free of diseases, has sound kernels, and high weight per volume. To a miller, these same criteria are important, but for a different reason. Milling quality of wheat refers to the amount of flour which can be extracted from the wheat and the ease of extraction. To the baker, quality refers to the usefulness of the flour in specific baking applications. Baking quality may refer to bread-making quality, pasta quality, or cookie and pastry quality. To the end user, particularly in developing countries, quality may have different meanings, such as storability,
taste or texture. To a nutritionist, quality may be a measure of the content of constituent amino acids or vitamins.

1.1. **Examples of Grain Quality Parameters by Commodity**

1.1.1. **Wheat.** Compared to other grains, quality in wheat for breadmaking is a complex set of characteristics, usually measured by a large number of individual tests. For example, Bushuk (11) lists some 95 tests of milling and baking quality which a breeding line would be subjected to over a minimum of 5 years before the line could be grown commercially in Canada. The wheat kernels are tested for characteristics such as grade, test weight (weight/volume), kernel size, protein content, ash content, flour yield, and falling number, which is a measure of the soundness (freedom from sprouting) of grain. After milling, the flour is subjected to a battery of tests designed to determine the quality of the flour for bread-making.

Wheat flour is used to produce a range of products, depending primarily on the protein content of the wheat. In bread wheats, high protein content is desirable. Most bread wheats range from 12 to 15% protein. The protein content is usually linearly related to the gluten content in the wheat. Gluten, which is the yellowish, elastic material remaining after starch and water-soluble material is washed away, constitutes about 85% of the total protein of bread wheat flour. Bread wheats contain 'strong' gluten, which, when incorporated into dough, absorbs large amounts of water and permits a large loaf of even consistency to form. The proteins of gluten can be separated into gliadin, which is soluble in ethanol, and glutenin, which is ethanol-insoluble. Gliadin is elastic and can be stretched whereas glutenin is not easily stretched. The properties and contents of these two components control the elasticity, and viscosity of the gluten, which determine its quality. Although the protein content of wheat is a useful indicator of gluten strength, protein content of wheat is affected greatly by environmental factors, such as soil fertility, rainfall, temperature and the prevalence of diseases. Gluten strength on the other hand, is mainly an inherited characteristic (12).

Another aspect of wheat quality is its nutritional quality for humans. In developed countries, nutritional quality is not of major importance because supplements are added to the flour and because consumers usually eat a diet including well-balanced animal protein.