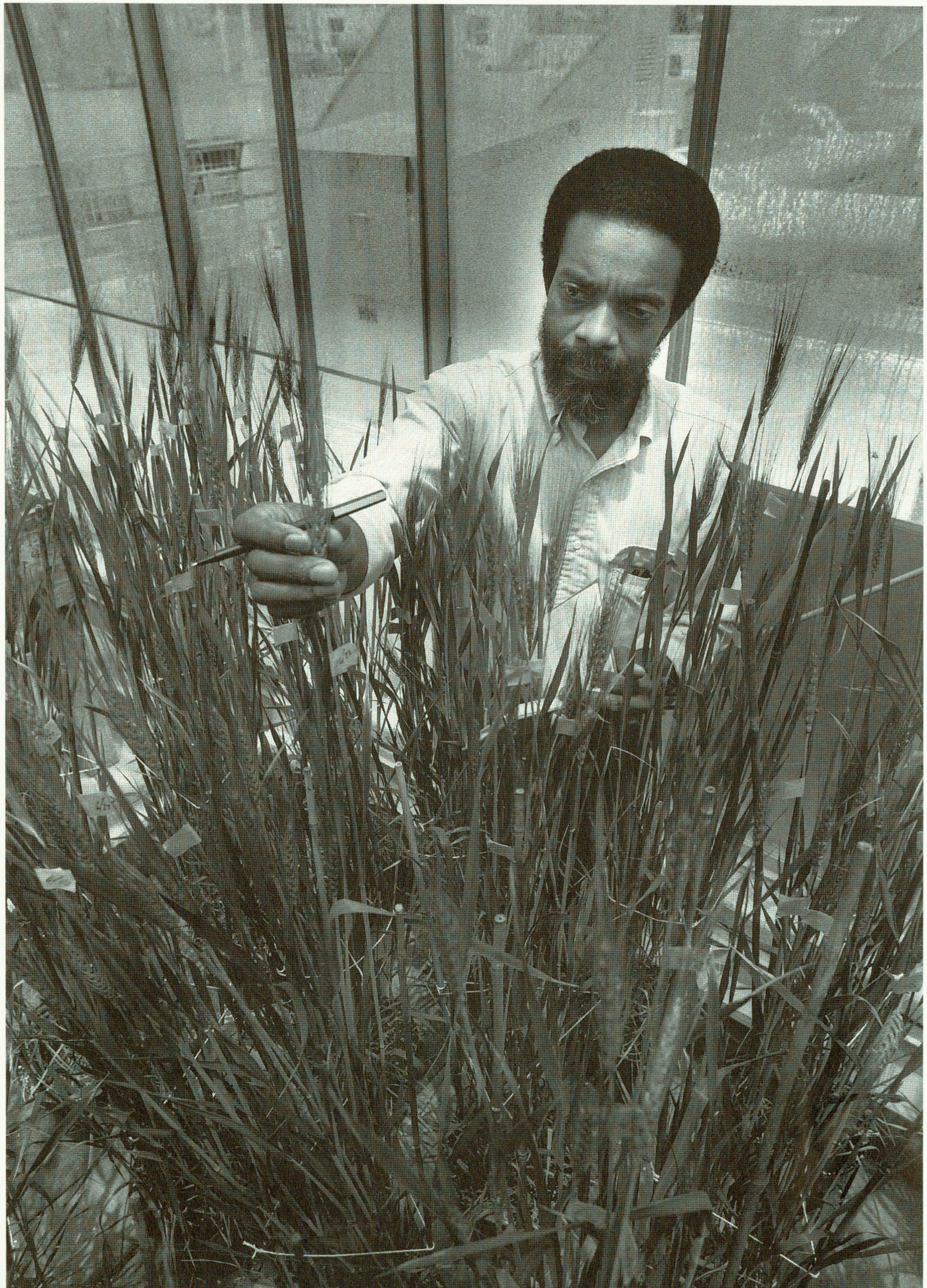
Wheat, Flour, and Bread

Light bread, leavened bread, bread raised with yeast, is nothing new. It was made in ancient Egypt, in Babylonia, in Greece. In Rome, the Emperor Trajan in 100 A.D. started a school for bakers. Then, as now, it was made from wheat, or from a mixture of wheat and rye. The elastic gluten in wheat is essential for bread to rise. But some things have changed in making bread. For one thing, it is mass-produced today. Brews of yeast, made in vats, are mixed continuously with flour, water, and other ingredients at one end of a machine. At the other end, bread dough is extruded and shaped and cut automatically into loaves. The loaves drop into pans, rise, and are baked at the rate of thousands an hour. Similar high-speed machine operations make cookies and crackers and other baked items.

Another change is what goes into a loaf of bread today. Besides the "enriched bleached bromated wheat flour" listed first on the wrapper of a loaf of cracked wheat bread, there are the following ingredients: water, cracked wheat, high fructose corn syrup, yeast, soybean oil, nonfat milk, salt, whey, calcium sulfate, sodium stearoyl-2-lactylate, and sodium caseinate. The wrapper also explains that wheat flour contains, besides wheat, malted barley flour, niacin, iron, thiamine mononitrate, riboflavin, and potassium bromate.



In his greenhouse at the Western center, chemist Frank Greene checks development of wheat grown for protein studies. The aim is to enhance bread-making qualities.

U.S. Wheat Classes

There are many varieties of spring and winter wheat, but they are grouped into only five official classes, reflecting hardness and color of kernels and planting time.

Hard Red Winter is a major bread wheat that accounts for more than 40 percent of the U.S. wheat crop and wheat exports. It is planted in the fall in the Great Plains.

Hard Red Spring, also an important bread wheat, has the highest protein content. It is spring-seeded in the north central States.

White Wheat is preferred for noodles, flat bread, and other nonleaf bakery items. A low-protein wheat, it is grown in the Palouse, in the Pacific Northwest.

Soft Red Winter is a fall-seeded, high-yielding wheat, grown in the eastern States. Relatively low in protein, it makes flour for cakes, pastries, crackers, and snack foods.

Durum, the hardest U.S. wheat, provides semolina for pasta. Seeded primarily in the spring in the same northern areas as hard red spring, it is also winter-sown in small quantities in the Southwest.

With the exception of soft red winter, each class of wheat has several subclasses, which often grow side-by-side in the same field. The variable properties of these wheats pose difficulties for millers and bakers in producing standardized products. These problems are the subject of continuing research at the Northern and Western regional centers.

WRRC chemist John Bernardin (foreground) studies banding patterns of wheat proteins exposed to various temperatures, while geneticist William Inwood extracts protein from wheat endosperm.

Mass production and the use of additives in baking have created special problems for the baker, miller, and farmer. Even the same classes of wheat can vary significantly in baking qualities, and when these differences are great enough, they can cause havoc in a bread factory. And each new additive in flour or bread can also affect baking qualities. For 50 years, chemists at two regional laboratories—the Northern and Western—as well as at other ARS laboratories including the U.S. Grain Marketing Research Laboratory at Manhattan, Kansas, have been working with all segments of the industry to help them provide consumers with uniform, flavorful, nutritious bread and other wheat products.

Among other things, regional scientists identified and isolated proteins in wheat not previously known to exist. NRRC researchers separated wheat gluten into two fractions—gliaden and glutenin—and they showed that these proteins contain a specific chemical structure, the sulfhydryl group, that affects the mixing properties of flours in forming doughs. They discovered the role of fatlike constituents in flour in controlling the volume of bread and size of cookies. They found that certain water-soluble proteins, known as albumins, are as essential as gluten in producing a good loaf of bread.

A specialized milling technique for fine grinding and air classification of wheat flour provided a new way to adjust the composition of cereal flour. Developed at the Northern lab, it produced fractions higher or lower in protein content than the original flour. The fractions could be used as blending agents for fortifying bread flours and for specialty flours for cakes and cookies.

Over the years, NRRC technologists have baked thousands of loaves of bread to test different wheat flours and to determine the effects of each new additive. As new analytical techniques have become available, more and more detailed information about wheat has been added to the pool of knowledge, to the benefit of wheat breeders, farmers, and industry. In the 1980's, for example, WRRC scientists scanning flour samples with near-infrared wave lengths of light discovered the surprising fact that NIR data correlated very well with the potential

Finding the "Sour" in Sourdough

San Francisco sourdough bread, a heavy, crusty product with a faintly sour taste, was for many years unique to the Bay Area. Made with a starter dough, or mother, local bakers insisted that sourdough bread couldn't be duplicated farther than 50 miles from the center of San Francisco. They didn't know why; it just couldn't.

Researchers at the Western center across the Bay from San Francisco decided in the late 1960's that there had to be a scientific answer to the mystery of sourdough bread. Like most scientists, they didn't like unsolved riddles. One puzzling thing about the bread was its high acetic acid content, which contributed to its sour taste. Yeasts customarily used to make bread rise can't tolerate acetic acid.

Obtaining samples of starter doughs from five local bakeries that were making the bread, a scientist found in all five a bacterium never before discovered. Naming it *Lactobacillus sanfrancisco*, he spent several months and tried 30 different substances before he could find a medium to grow the bacterium. The other thing he found was a yeast, *Saccharomyces exiquus,* that was unusually tolerant of acetic acid. It worked with the bacterium in a symbiotic relationship to produce the bread's unusual flavor, crust, and texture. Comments the scientist: "It was a happy marriage between two noncompetitive bugs."

As a result of the WRRC research, San Francisco-style sourdough bread today can be baked anywhere in the world. And the discovery wasn't all bad news for local bakeries unwilling to share their secrets. Pure cultures of *L. sanfrancisco* are now grown commercially and are commonly used by San Francisco bakers to control the quality of their product.

In subsequent research, ERRC scientists and industry jointly developed a simple new procedure for making the bread, using sour whey and vinegar instead of bacteria as sources of acetic and lactic acids. When the acids are added to a French bread formula in the quantities and proportions found in the traditional product, the resultant bread has a resilient body, robust flavor, coarse structure, and crisp chewy crust comparable to San Francisco sourdough bread. The procedure, according to ERRC, can be adapted to any bakery equipped to make hearth breads and eliminates the need for frequent starter dough transfers and the 20- to 22-hour fermentation period.

volume of loaves of bread. NIR then became yet another standard technique in the wheat scientist's analytical toolbox.

Fifty years of regional research on wheat and wheat flour presents a historian with an embarrassment of riches. A brief selection of research findings during the last 10 years may illustrate the scope, originality, and importance of this scientific work. Americans today, unlike the residents of other developed countries, have reversed a long-time trend and are eating more bread than ever. That fact alone suggests that commercially baked bread and rolls taste better than they once did. Part of the credit for that belongs to the researcher, as it does to the grower, the miller, and the baker.

In Peoria, a chemist reports that with samples as tiny as half a kernel, he can help wheat breeders analyze a type of gluten protein—gliadin—that may provide some of the qualities that bakers want in their flour, including the property of producing uniform loaves of bread with just the right crumb texture.

Despite all that has been learned in the past about wheat, research is accelerating today. In Peoria, a chemist reports that with samples as tiny as half a kernel, he can help wheat breeders analyze a type of gluten protein—gliadin—that may provide some of the qualities that bakers want in their flour, including the property of producing uniform loaves of bread with just the right crumb texture.

"When breeders are building new wheats to resist the latest strain of a disease," says the chemist, "we can check on the proportion of gliadin in kernels from the most promising plants. That can give us an early indication of how the flour will mix and bake." The analysis is carried out with a high-tech procedure called reversed-phase high performance liquid chromatography. "It provides us," the researcher says, "with an incredible amount of information. And it gives it to us in a day instead of in months or years."

At the Western center, scientists have been working with glutenin, the other important protein in wheat gluten. Some scientists speculate that heavy glutenins with high molecular weights add strength and elasticity to bread doughs. Both are considered desirable characteristics by bakers. A team of chemists in Albany is exploring the structure of glutenins of assorted molecular weights, shapes, and sizes. The research could help in the genetic engineering of glutenins that can outperform those in today's wheat varieties.

Another WRRC team has shown that when summer temperatures reach 99^{0}F or more (not uncommon in wheat-growing states), the genes that produce glutenin stop working. But genes that control the other major class of gluten proteins, the gliadins, stay on the job until the temperature hits 113^{0}F. The result is that on many hot days, wheat kernels end up with a higher ratio of gliadins to glutenins. And that is the opposite of what's best for breadmaking.

To find a remedy, WRRC scientists are trying to splice the "on-off switch" in a gliadin gene to the genes in wheat that produce glutenin. If they are successful, wheat should keep on producing glutenin until the thermometer climbs to 113^{0}F, a far rarer occurrence than a 99^{0}F day.

In Peoria, scientists are studying the size of particles in flour after milling various types of wheat. Flour from hard red spring wheat, for example, has a different distribution of particle sizes than flour from hard red winter wheat. Researchers use air-streams of different speeds to separate the flour particles by size. Scientists say that the technique can be used to judge hardness of any wheat.