

Issues & Trends

Cereal Foods World, Vol. 64, No. 5

DOI: <https://doi.org/10.1094/CFW-64-5-0056>

Developing Wheat Varieties for Whole Grain Artisanal Baking

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Abstract

Artisanal bakers and organic farmers are leading the revival of healthy whole grains and local grain communities. These innovators are continually exploring new flavors, aromas, and textures. Wheat breeding programs contain a diversity of these traits, but they often focus on the refined flour markets. The University of California Davis recently established an organic wheat breeding program to focus on unique wheat varieties for artisanal and localized grain markets, which requires exploration of new methods for quality evaluation. Selected varieties were evaluated for whole grain and sourdough baking quality, with the goal of identifying varieties of high-quality wheat grown under organic conditions.

Wheat is a staple of the global food system, making up 20% of caloric intake in the human diet and contributing to global food security (6). Commodity markets provide reliable and affordable access to wheat products but depend on the use of highly refined flour that is depleted of fiber, vitamins, and minerals. We now know that consumption of refined flour contributes to detrimental health effects, such as digestive problems, obesity, type 2 diabetes, heart disease, and reduced life expectancy, whereas consumption of whole grains has been shown to provide a variety of health benefits (1,3,4). In response to these findings, the United States is experiencing a nationwide restoration of regional grain communities that want access to healthy, whole grain products with transparent sourcing from crops that improve the environment, soil, and local economies. Artisanal bakers and organic farmers are at the forefront of this grain revival. California is an ideal location for growth of this type of regional grain system. It ranks first in the United States for organic crop land, farms, operations, and sales (7). Organic crop production is one of the most rapidly growing sectors of the agricultural economy. Although most of this production involves vegetables, fruits, and nuts, grains are very

important rotational and dryland crops. The unique climate in California allows for diverse grains to be grown year-round. Every class of wheat is grown in California, from soft winter wheats to hard red spring wheats and pasta wheats. California-grown wheat has some of the highest quality and highest yields in the United States and is prized for its unique terroir, similar to California-grown wines (2).

Table I. Organic wheat varieties used for quality analysis^a

The University of California Davis (UCD) Small

Entry	Variety	Class	Type
White wheat			
1	US exp 1	HWS	Modern
2	US Amarillo	HWS	Modern
3	UC Patwin 515	HWS	Modern
4	India Jammu	HWS	Landrace
5	Sonora	SWS	Landrace
6	Chiddam Blanc	SWS	Landrace
7	Wit Wolkerling	SWS	Landrace
8	UC exp 8	HWS	Modern
9	UC exp 9	HWS	Modern
10	UC exp 10	HWS	Modern
Red wheat			
11	Yecora Rojo	HRS	Modern
12	Yecora Rojo 515	HRS	Modern
13	UC Central Red	HRS	Modern
14	UC Yurok	HRS	Modern
15	UC Lassik	HRS	Modern
16	UC exp 16	HRS	Modern
17	UC exp 17	HRS	Modern
18	UC exp 18	HRS	Modern
19	UC exp 19	HRS	Modern

^a HWS = hard white spring; SWS = soft white spring; HRS = hard red spring; UC exp X = unnamed UC experimental lines; 515 designates the incorporation of rust resistance genes.

Grains Breeding program (<https://dubcovskylab.ucdavis.edu/breeding>), UCD Plant Breeding Center Student Collaborative Organic Plant Breeding Education (SCOPE) project (<https://plantbreeding.sf.ucdavis.edu>), and California Wheat Commission (CWC) (<http://californiawheat.org>) have partnered to establish an organic grain breeding program to provide organic farmers in California with unique varieties to grow and market. The UCD breeding program is a major developer of public wheat varieties for growing in California that have superior performance, disease resistance, and grain quality. The SCOPE project is a student led organic plant breeding program operating in collaboration with the Organic Seed Alliance (OSA) (<https://seedalliance.org>). The CWC has an on-site milling and baking quality laboratory run by experts to ensure the development of high-quality varieties for growing in California. The milling and baking quality laboratory is developing methods for identifying quality parameters preferred by the whole grain and artisanal markets. Established methods are primarily applicable for products made from refined (white) flour that require high protein and very strong dough strength. This type of flour is not ideal for artisanal bakers who use lean formulations (only flour, water, salt, and microbial leavening), longer fermentation times, and gentle mixing and value aspects of the flour such as aroma, flavor, open crumb, and crispy crust (5). As unique flavors are being explored, many are looking to older, heritage wheat lines. The value of flavor contributed by traditional varieties has been recognized in vegetables and fruits and is at the center of the local food movement, but grains have lagged behind this trend. In addition, the UCD breeding program is releasing a new variety in 2019, UC Amarillo, with a restored yellow pigment gene from an older variety that increases lutein content but that was bred out of modern wheat varieties in favor of whiter flour.



Fig. 1. Whole wheat sourdough loaves of white (top left, samples 1–10) and red (bottom left, samples 11–19) varieties. Sample numbers and descriptions are provided in Table I. Top right: gluten strength and elasticity during folds are examined using the windowpane test. Middle right: a whole wheat sourdough baker's loaf formulated with Yecora Rojo. Bottom right: divided and preshaped dough after fermentation.

Table II. Wheat grain and quality test results using AACCI Approved Methods^a**Quality Evaluation**

Test	HRS	HWS	SWS
Number of varieties	9	7	3
Grain quality			
Protein (14%)	11.9	11.8	12.5
Ash (14%)	1.6	1.7	1.8
Moisture (%)	9.0	9.0	9.8
Test weight (lb/bu)	64.0	63.3	64.2
Thousand kernel weight (g)	37.2	35.0	33.8
Hardness	78.6	79.2	38.1
Flour quality			
Falling number (sec)	370.1	380.9	372.7
Flour protein (14%)	11.7	11.6	12.1
Moisture (%)	10.0	10.2	10.2
Wet gluten (14%, mb)	24.5	23.7	33.1
Gluten index	93.0	97.1	54.2
Absorbance (%)	67.6	67.0	64.3
Peak time (min)	4.3	5.3	2.2
Peak integral (%TQ × min)	136.5	170.7	71.8
Bread quality			
Average loaf volume (g)	792.2	780.4	779.2
Bread color (<i>L</i>)	40.0	49.2	49.4
Bread color (<i>A</i>)	4.9	2.9	3.2
Bread color (<i>B</i>)	14.6	19.4	19.9

^a HRS = hard red spring; HWS = hard white spring; SWS = soft white spring.

The CWC Quality Lab evaluated the agronomic traits of 34 wheat varieties grown on certified organic land in Davis, CA. Nineteen varieties (Table I) were chosen to be tested for whole grain quality and sourdough baking parameters (Fig. 1). Wheat was milled into whole grain flour (Laboratory Mill 3100, Perten Instruments). Grain and flour quality analyses (Table II) were performed using AACCI Approved Methods (<http://methods.aaccnet.org>).

All samples were baked using the CWC standard whole grain sourdough pup loaf baking method adapted from Nan Kohler of Grist and Toll (www.gristandtoll.com) (Fig. 2). For the CWC sourdough baking method 500 g of whole grain flour, 60 g of starter, 450 g of water, and 10 g of salt were used. Flour, water, and starter were mixed on a 10 qt Hobart mixer at low speed for 1 min, followed by 1 hr of rest, after which time salt was added and mixed until developed. The dough was allowed to rest for 2.5 hr, with 3 folds at 30 min intervals, and remain rested until the end of bulk fermentation. After bulk fermentation, the dough was divided into two 400 g portions, molded, panned, and proofed in a refrigerator for 12–16 hr at 40°F, after which time the pans were placed in the proofing cabinet at 85°F and 30% RH and proofed to 1 cm above the rim of the pan. Sample loaves were baked at 400°F for 35 min, cooled, and measured for loaf volume 1 hr after baking.

Taste tests were performed the following day by an untrained sensory panel consisting of 10 professionals in wheat research, using descriptors (i.e., moist, chewy, nutty, earthy) and a selection of the top-performing varieties for flavor, texture, and aroma. The three most recent publicly available UC varieties (UC Patwin 515, UC Central Red, and UC Amarillo) were included in a panel of lines tested in sourdough formulations by professional baker Keith Giusto of the Artisanal Baking Center (ABC) in Petaluma, CA (<https://centralmilling.com>).



Fig. 2. Cross-section of sourdough test loaves. Ten white (top two panels) and nine red (bottom two panels) wheat varieties (samples 1–19) are shown. Samples 1–19 are shown from left to right and top to bottom (as shown in Figure 1). Sample numbers and descriptions are provided in Table I.

Findings

Although there were clear differences between varieties, varieties listed in Table II are grouped into market classes. Hard wheats generally contain strong gluten, making the dough more elastic and ideal for bread applications. Soft wheats contain weak gluten, giving dough a crumbly texture suitable for pastries and biscuits. The percent wet gluten represents the protein, while the gluten index indicates the strength or weakness of the protein. Overall, harder varieties with a higher gluten index performed the best in sourdough baking tests. A unique trait was observed in Sonora wheat, a landrace variety classified as soft, which gained strength and acted more like a hard wheat after fermentation (Whole Grain Connection supplied landrace varieties [<http://wholegrainconnection.org>]). Taste tests revealed many different preferences, and results could be improved by reducing the number of varieties tested. Yecora Rojo, an older “modern” wheat, consistently stood out as a favorite among panelists. The results of the agronomic and quality tests will be used to select traits that can be combined to create new varieties (e.g., the flavor and nutrition of a heritage line with the disease resistance and yield potential of a modern line). This method will continue to be used for evaluation of quality in the breeding program.

There is currently no strict set of specifications established for artisanal bakers, and there may never be one given the multitude of variables to consider (e.g., milling type, extraction rate, mixing time, length of fermentation, type of culture, etc.). Both artisanal bakers and organic farmers are continually adapting methods to provide healthy, quality grains with complex flavors and textures. Breeders, researchers, farmers, millers, and bakers working together can create new and interesting varieties that are economically viable for farmers and cherished by bakers.



Allison Krill-Brown is an associate specialist and plant breeder at the University of California

Davis, working to develop small-grain varieties for organic farmers and artisanal bakers. She has been involved in grain breeding in the Northeast, Midwest, and West Coast for various crops, including corn, wheat, oats, and barley. Allison has an M.S. degree in plant breeding and genetics from Cornell University, as well as a B.S. degree in environmental science and a B.A. degree in music from Kutztown University of Pennsylvania.



Teng Vang received his B.S. degree in food science in 2006 from the University of California Davis.

In 2007, soon after graduation, he joined the California Wheat Commission (CWC) as the lab assistant. On May 1, 2016, Vang became the lab manager for the CWC. His role at the CWC is to ensure that the lab runs smoothly, to generate California wheat crop quality data, and to provide lab services to the wheat industry. With his many years of experience, he maintains the lab equipment and continues running the wheat quality testing with accuracy and precision.



Claudia Carter started her education in Buenos Aires, Argentina, studying food engineering and

moved to the United States in 2008. She attended North Dakota State University (NDSU) in Fargo, ND, where she completed her B.S. degree in food science (2010) and M.S. degree in cereal science (2014). While in school, Claudia spent two years as a food technology specialist in the NDSU Durum Quality Lab. In June 2014, Claudia moved to California to become the Milling and Baking Lab director at the California Wheat Commission (CWC). Two years later, on June 20, 2016, Claudia became the executive director of the CWC. Her role at the CWC is to continue leading the research on and marketability of California wheat and to help develop and maintain domestic and international markets.

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