Flavor Characterization of Breads Made from Hard Red Winter Wheat and Hard White Winter Wheat[1]

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ABSTRACT

Sensory flavor profiles for white pan bread and whole wheat bread made from hard red winter (HRW) or hard white winter (HWW) wheat were developed by a professionally trained panel. The flavors of crust and crumb were studied separately. HRW and HWW white pan breads had toasted, grainlike, wheat, yeasty, sour, and salty flavor notes in common for both crust and crumb. HRW crust was more yeasty than HWW crust and had an astringent character not found in HWW crust. HWW crust had a slightly burnt characteristic and gave a more toasted impression than did HRW crust. HRW crumb was sweeter and more dairylike than HWW crumb. HWW crumb had a phenoliclike note not present in HRW crumb. Although HRW and HWW whole wheat breads had similar flavor characteristics, the order of appearance and intensity of the flavor notes were different, and this gave a different flavor impression for the two breads. The complex flavor of the bran also was different for the two breads; each bread was readily identified by the characteristic flavor of the bran (either red or white).

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Five classes of common wheat are grown in the United States: hard red spring, hard red winter (HRW), soft red winter, soft white, and hard white wheats. Among these, HRW wheat is the major class produced because of its wide adaptation and excellent breadmaking attributes (Reitz 1976). However, in countries where noodles and flat breads are staple items and where a high percentage of the wheat bran is included in flour, hard white wheat is preferred to hard red wheat (Feltner 1988). Most of the hard white wheat in the world market is produced in Australia. Although some white wheats are grown in the United States, they are mostly soft wheats and account for less than 10% of the total wheat production (Paulsen et al 1983). Graham (1988) stated that the United States has not produced any hard white wheats to compete against Australia.

Several advantages claimed for hard white wheat versus red wheat include: higher flour extraction rate, higher protein concentration from closer milling, greater esthetic appeal of white wheat products, more valuable bran, better scoring on the basis of flour color standards, less astringent flavor, and higher export potential (Paulsen and Heyne 1981, Feltner 1988). Those advantages have led to the development of hard white wheats by some private firms and by the agricultural experiment stations of Kansas, Montana, Washington, Oregon, Idaho, and California (R. K. Bequette, *unpublished data*, 1990). Unfortunately, preharvest sprouting is more severe in white wheats than in red wheats, and the breadmaking problems associated with that sprouting pose an agronomic limitation (Swanson 1946, Pyler 1988). Breeding has been used to overcome production constraints, such as disease or insect pests and preharvest sprouting, and to combine highly desirable traits, such as higher protein, larger and more uniform grain, and more desirable color (Feltner 1988).

An experimental hard white winter (HWW) wheat, KS84HW196, recently was developed at the Fort Hays Branch Agricultural Experiment Station, Kansas State University. Milling and baking qualities of KS84HW196 have shown that it has potential as a new HWW variety (Feltner 1988). It has excellent grain test weights and 1,000-kernel weight. The baking qualities of KS48HW196 are comparable to those of Newton, a popular Kansas HRW wheat cultivar. Its gluten strength is slightly weaker than that of Newton, but its bake absorption and loaf volume are similar. It generally has about 0.5% more grain protein than Newton (Feltner 1988). One sensory study found a significant flavor difference but no preference between hamburger buns made with red and white wheats (Lang and Walker 1990). That report gave only limited information on the flavors of the two kinds of buns. Because flavor is critical to consumer acceptance, the flavor of bread made from HWW wheat should be studied.

The objectives of this study were 1) to establish flavor profiles of breads made from HRW and HWW wheats and 2) to compare flavor differences between breads made with the two wheats.

MATERIALS AND METHODS

Flour

A HWW wheat, KS84HW196, harvested in 1988 at the Fort Hays Branch Agricultural Experiment Station, Hays, KS (referred to as HWW88), and a commercial HRW wheat mill mix (Cargill H-Mix) were milled to straight-grade flour on a Miag Multomat laboratory mill (Buhler-Miag Co., Switzerland) in the Department of Grain Science and Industry, Kansas State University. Two different types of HWW and HRW flour were used: straight-grade flour and whole wheat flour. The whole wheat flour was a proportional recombination of all mill streams. Because an off-flavor characteristic not associated with bread was found in whole wheat bread made from HWW88, another HWW wheat, KS84HW196 harvested in 1990 (referred to as HWW90), was used in a follow-up study for whole wheat bread.

Breadmaking

All breads were prepared by the straight-dough method.

TABLE I
Bread Formulas

Ingredients	Percentage[a]	
	White Pan	Whole Wheat
Straight-grade flour[b]	100	0
Whole wheat flour	0	100
Water		
HRW	67	74
HWW88	67	75
HWW90	...	76
Shortening	3	3
Sugar	2	2
Salt	2	2
Yeast	1.2	1.2
Vital gluten[c]		
HWW	0	2
HRW	1	3

[a] All ingredients were on a flour-weight basis.
[b] Hard red winter (HRW), hard white winter from 1988 (HWW88), or hard white winter from 1990 (HWW90).
[c] More vital gluten was added to the HRW bread formulas to make the HRW flour stronger and more comparable to the HWW flour (based on preliminary farinograph tests).

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Ingredients (shown in Table I) were mixed in a Hobart model A-200 mixer (Hobart Manufacturing Co., Troy, OH) to develop the dough (dough temperature, 26.7°C [80 ± 2°F]). The dough was fermented for 2 hr 30 min (30°C [86°F], 85% rh), divided into two 539-g pieces, rested for 20 min, molded into loaves through a Pillsbury Moline bread molder (Pillsbury Co., Duluth, MN), proofed for 1 hr (40.6°C [105°F], 92% rh), and baked for 25 min at 218.3°C (425°F) in a reel oven (Reed Oven Co., Kansas City, MO). Loaves were removed from the oven, allowed to cool for 1 hr at room temperature, sliced, and held in polyethylene bags at room temperature (22–25°C). Breads were made every other day. Three batches of bread were made, and each batch was tested on successive days; thus, the samples used for flavor profile analysis were 16–40 hr old. Preliminary testing indicated that breads at these ages were essentially similar. Caul and Vaden (1972) reported that bread stayed fresh (nonstale) for 2 days and that few flavor differences were found between white breads 24 and 48 hr old.

Flavor Profile Analysis

The flavor panel consisted of six members, who previously had undergone 120 hr of training in all aspects of sensory techniques and analyses. Each of the members had more than 300 hr of sensory testing experience, and all had prior experience testing bread products.

The flavor profile analysis (Caul 1957) included both aroma and flavor-by-mouth and resulted in a chronological tabulation of aroma components and of tastes, feeling sensations, and aromatics detected when bread was taken into the mouth and prepared for swallowing. Postswallowing aftertastes also were noted. First, the panel members individually examined the bread sample and recorded their findings on blank sheets of paper, then a round-table session was opened for reporting and discussion of recorded findings. The interaction allowed panelists to verify judgments. In this open panel, vocabulary differences were resolved; if there were questions, reference standards were brought in and discussed. The closed and open sessions were repeated until unanimity for the flavor profile was reached. Five 2-hr sessions were conducted for white pan bread and then five 2-hr sessions for whole wheat bread. Sessions were divided into 1) orientation (one session)—to become familiar with the flavor of each bread and to generate vocabulary and definitions of terms; 2) vocabulary refinement (two sessions)—to establish a frame of reference for each flavor characteristic and to evaluate the bread samples by comparing with references; 3) profiling (two sessions)—to reach a consensus agreement on descriptors, their intensities, and their order of appearance. The use of the same term to describe a given sensation is absolutely essential in the flavor profile method. Each term listed in a profile tabulation must be understood by all the panel members and can be illustrated through the use of a reference material (Neilson et al 1988). Attributes were rated on a four-point intensity scale:)(= threshold, 1 = slight, 2 = moderate, and 3 = strong. Each could be modified with a plus or a minus; e.g., 2−, 2, and 2+ indicate intensity as low moderate, moderate, and high moderate. respectively. Amplitude was judged on three aspects—the sample's base (body, fullness), its flavor notes (intensity, impact, longevity), and the overall effect of these two together (balance, blendedness). Amplitude was rated as low, moderate, or high and recorded as 1, 2, or 3, respectively (Caul 1957).

Because bread crust and crumb differ widely, they were examined separately. Top crust samples were removed from the bread slices at the point where rounding of the upper loaf began, and the top crust was then "peeled," leaving no more than a 0.5-cm crumb attached. To prepare crumb samples, the side and bottom crusts were cut off 1 cm from the edges of the slices and discarded. The remaining crumb was cut into eight cubes, each approximately 2 × 2 cm. Both crust and crumb samples were served in small glass bowls covered with watch glasses. Reverse-osmosis, deionized, carbon-filtered water was used to rinse the mouth between samples. Unsalted crackers were also provided.

TABLE II
Flavor Vocabulary, References, and Intensities of References for Bread Profiles

Term	Description and Reference
Aromatics	The volatiles or odor of a substance perceived when passed into the nasal area from the mouth.
Astringent	The chemical feeling factor on the tongue described as puckering or dry and associated with tannins and alum. Reference: Welch's grape juice (2−)[a].
Bitter	Fundamental taste factor. Reference: 0.06% caffeine solution (2).
Bran (red)	The aromatic associated with red wheat bran, described as grainy, slightly dusty (a dry impression), brown, and slightly sweet. (A part of the grain complex.) Reference: red wheat bran (2+).
Bran (white)	The aromatic associated with white wheat bran, described as grainy, slightly musty (a damp impression), lightly brown, slightly raw, and slightly sweet. (A slightly petroleumlike aromatic was associated with the HWW88 wheat bran.) (A part of the grain complex.) Reference: white wheat bran (2+).
Brown	A sharp, caramel, almost-burnt aromatic. (A part of the grain complex.) Reference: Caramel color, double strength, (D. D. Williamson & Co., Inc., Louisville, KY) (3).
Burnt	A dark brown, over-baked impression. (Sharp, acrid) Reference: 20-min-baked flour: 125 g all-purpose Gold Medal flour baked at 350°F (176.7°C) in a 9 × 13-in. glass pan (3−).
Dairy (sweet)	A general term associated with the aromatics of products made from cow's milk. (Somewhat sweet in character.)
Grain complex	An overall grainy impression that may or may not be accompanied by the following individually identifiable flavor notes: Bran (red), bran (white), brown, and sweet.
Grainlike	A general term used to describe the dusty or musty aromatics associated with grains such as corn, oats, and wheat. Reference: Stonebuhr seven-grain cereal (Stonebuhr Milling, Division of Arnolds Food Co. Inc., Greenwich, CT) (3).
Numbing	A feeling factor on the tongue described as devoid of sensation.
Note	A perceptible factor that is recorded in its descriptive term. Notes are listed in their order of perception, and the intensity of each note is also recorded.
Petroleumlike	The aromatic associated with a petroleum product, described as clean, heavy, and oily. Reference: Vaseline petroleum jelly (3).
Phenoliclike	The aromatic described as damp, musty, and like animal hide. Reminiscent of a tack room. Reference: 0.08% *p*-hydroxyphenyl acetic acid (2+).
Salty	Fundamental taste factor. Reference: 0.4% sodium chloride solution (1+).
Sour	The overall impression of the basic taste factor and the aromatics associated with the peception of sharpness. Reference: 0.03% citric acid solution (1).
Sweet (aromatic)	Aromatics associated with the impression of sweet substances such as fruit or flowers.
Sweet	The overall impression of the basic sweet taste and aromatics associated with grain. (A part of the grain complex.) Reference: 0.5% sucrose solution (1).
Toasted	A moderately brown, baked impression. Reference: 10-min-baked flour, 125 g all-purpose Gold Medal flour baked at 350°F (176.7°C) in a 9 × 13-in. glass pan (2+).
Wheaty	A light, baked, wheat flour aromatic. Reference: 5-min-baked flour: 125 g all-purpose Gold Medal flour baked at 350°F (176.7°C) in a 9 × 13-in. glass pan (1+).
Yeasty	A fermented yeastlike aromatic. Reference: Product made with 292 g of water, 300 g of Gold Medal all-purpose flour, and 8.2 g of Red Star quick rise yeast, baked at 375°F (190.6°C) for 40 min (3−).

[a]Intensity, in which 1 = slight, 2 = moderate, and 3 = strong. Plus and minus modify the level, indicating "high" or "low," respectively.

RESULTS AND DISCUSSION

A glossary of terms agreed upon by the panelists for description of aroma and flavor sensations of the breads studied is given in Table II. Specific references with associated intensities also are included. These references should be helpful in any descriptive analysis of baked products. Some of the terms used in this study, such as sweet, yeasty, wheaty, salty, bitter, and sour, also were reported in the flavor study of white bread conducted by Caul and Vaden (1972). The consensus aroma and flavor findings of breads are reported in Tables III and IV by amplitude, individual character notes, and postswallowing aftertastes according to order of appearance and intensity.

Flavor Comparison Between HRW and HWW White Pan Breads

Crust. HRW and HWW white pan breads had several characteristics in common for crust, such as toasted and grainlike attributes in aroma; toasted, wheaty, sour, and salty attributes in flavor; and toasted and salty notes in the aftertaste (Table III). Differences were also noted. HRW bread crust had a complex of yeasty and sour notes in aroma; yeasty and astringent notes in flavor; and sour, bitter, and astringent character notes in aftertaste. HWW bread crust had a burnt (not color related) impression in aroma, burnt and bitter notes in flavor, and a longer-lasting toasted-character aftertaste (still noticeable at 60 sec). HWW bread had slightly higher amplitudes for both aroma and flavor of crust than did HRW bread because the attributes were more balanced and blended in HWW bread crust.

Crumb. HRW and HWW white pan breads had many flavor characteristics in common for crumb. HRW crumb had almost all of the characteristics in the flavor profile of HWW crumb, except for a brief phenoliclike note. HRW crumb had a sweet aromatic note in aroma; sweet dairy (brief), bitter, and sweet notes in flavor; wheaty and bitter notes in aftertaste at 15 sec; and a bitter note in aftertaste at 60 sec; none of these were found in HWW crumb. HWW crumb had a brief phenoliclike note in both aroma and flavor and a sour note in aftertaste at 60 sec, none of which were in HRW crumb. The brief phenoliclike note found in both aroma and flavor of HWW crumb may be related to the phenolic acids present in the wheat bran. Wetzel and Pussayanawin (1989) reported that more ferulic acid, a phenolic acid, was found in flour with higher extraction rates because of the specific morphological deposition of ferulic acid in the aleurone cell walls of the wheat kernel. The extraction rate of HWW straight flour was 72.3%, which was slightly higher than that of HRW straight flour (71.3%). The amplitudes for aroma and flavor were slightly higher for HRW crumb than for HWW crumb, but both were in the low range.

Flavor Comparison Between HRW and HWW Whole Wheat Breads

Crust. HRW and HWW90 breads had identical aroma and flavor characteristics for their crusts (Table IV). They both had burnt, toasted, brown, and grainlike notes in the aroma and burnt, toasted, brown, grainlike, sour, salty, and bitter notes in the flavor. However, the order of appearance and intensity of these notes differed in the two bread types. Both crusts had burnt, grainlike, and bitter notes in aftertaste at 15 sec, but HWW90 crust had brown, salty, and tongue-numbing notes in aftertaste, which were not found in HRW crust. HRW crust had a sour aftertaste at 15 sec, which was not in HWW crust. In HWW90 crust, all of the aftertastes at 15 sec, except for the salty taste, were detected at 60 sec as well, but their intensities were decreased. In HRW crust, only burnt and bitter notes remained in the aftertaste at 60 sec. HWW90 bread had slightly higher amplitudes for both aroma and flavor of crust than HRW bread.

Crumb. In their aromas and flavors, HRW crumb had a grain-complex impression associated with red wheat bran and HWW90 crumb had a grain-complex impression associated with white wheat bran. In HRW crumb, a brown impression was part of

TABLE III
Flavor Profiles[a] of White Pan Bread Crust and Crumb
Made from Hard Red Winter (HRW) and Hard White Winter (HWW) Wheat Flours

	Crust				Crumb			
	HRW		HWW88[b]		HRW		HWW88	
Aroma	Amplitude	2−	Amplitude	2	Amplitude	1+	Amplitude	1
	Toasted	1+	Burnt (brief)	1+	{Yeasty[c]	2−	Phenoliclike (brief)	1+
	Grainlike	1	Toasted	2	{Sour	1+	{Yeasty[c]	1+
	{Yeasty[c]	)(+	Grainlike	1	Wheaty	1	{Sour	1
	{Sour	)(+			Sweet (aromatic)	)(+	Wheaty	1−
Flavor	Amplitude	2−	Amplitude	2	Amplitude	1+	Amplitude	1
	Toasted	2−	Burnt (variable)	1	Dairy (Sweet) (brief)	)(+	Phenoliclike (brief)	1
	Wheaty	1+	Toasted	2	{Yeasty[c]	2−	Sour (lingers)	1
	Sour	1	Wheaty	1	{Sour	1+	Yeasty	1
	Yeasty	)(+	Sour	1−	Salty	1	Salty	1−
	Salty	1−	Salty (variable)	1−	Wheaty	1	Wheaty	1−
	Astringent	)(+	Other[d]		Other[d]			
			Bitter	)(+	Bitter	)(+		
					Sweet	)(+		
Aftertaste (15 sec)								
	Toasted/Wheaty[e]	1−	Toasted	1	Yeasty	1	Sour	1
	Sour	1−	Salty	)(	Wheaty	1−	Yeasty	1−
	Salty	)(+			Sour	1	Salty	)(
	Other[d]				Salty	)(+	Astringent	1
	Bitter	)(			Astringent	1		
	Astringent	)(			Bitter	)(		
Aftertaste (60 sec)								
	Sour	)(+	Toasted	)(	Astringent	)(	Sour	1
	Astringent	)(+			Bitter	)(+	Astringent	1

[a] Attributes rated on a four-point scale:)(= threshold, 1 = slight, 2 = moderate, 3 = strong. Plus and minus modify the level, indicating "high" or "low," respectively. Amplitude was rated on a three-point scale: 1 = low, 2 = moderate, 3 = high.
[b] HWW wheat from 1988.
[c] Attributes within brackets were close in their order of preception and formed a tight complex.
[d] Attributes were not perceived by all panelists.
[e] Attributes on the same line appeared at the same time and could not be perceived as separated.

TABLE IV
Flavor Profiles[a] of Whole Wheat Bread Crust and Crumb Made from Hard Red Winter (HRW) and Hard White Winter (HWW) Wheat Flours

	Crust						Crumb					
	HRW		HWW90[b]		HWW88[b]		HRW		HWW90		HWW88	
Aroma	Amplitude	2−	Amplitude	2	Amplitude	2	Amplitude	2	Amplitude	2	Amplitude	2−
	Burnt	2	Burnt	1+	Toasted	2	Grain complex	2	Grain complex	2	Grain complex	2−
	Toasted	1	Brown	2−	Brown	1	Bran (red)	2	Sweet (aromatic)	1−	Bran (white)	1+
	Brown	2−	Toasted	2	Grainlike	2−	Brown	2−	Bran (white)	1+	Petroleum	)(
	Grainlike	1+	Grainlike	1+	Sweet (aromatic)	)(+	Sweet (aromatic)	1	Toasted	1	Brown	1−
							{Yeasty[c]	1	{Yeasty[c]	1+	Sweet (aromatic)	1−
							{Sour	1	{Sour	1	{Yeasty[c]	1
											{Sour	1
Flavor	Amplitude	2−	Amplitude	2	Amplitude	2−	Amplitude	2	Amplitude	2	Amplitude	2−
	Burnt	2	Burnt	1+	Toasted	2−	Grain complex	2+	Grain complex	2	Grain complex	2
	Toasted	1	Brown	2−	Grain complex	2−	Bran (red)	2	Sweet	1−	Bran (white)	2−
	Brown	2−	Toasted	1	Bran (white)	1+	Brown	1+	Toasted	1	Petroleum	1+
	Grainlike	1+	Bitter	1	Petroleum	1−	Sweet	1	Bran (white)	2−	Brown	1−
	Sour	1	Grainlike	1	Brown	1	{Yeasty[c]	1	Yeasty	1+	Sweet	1−
	Salty	1−	Sour	1−	Sour	1	{Sour (lingers)	1+	Sour	1	{Yeasty[c]	1
	Bitter	1	Salty	1	Salty	1	Salty	1	Salty	1−	{Sour (lingers)	1+
					Bitter	)(+	Bitter	1			Bitter	)(+
											Numbing	1−
Aftertaste (15 sec)	{Burnt[c]	1+	Brown	1	{Toasted[c]	1	Grainlike	1+	Grainlike	1	Grainlike	1
	{Grainlike	1−	Burnt/Bitter[d]	1−	{Grainlike	1	Sour	1	Sweet	)(+	Petroleumlike	1−
	Sour	1−	Grainlike	1−	Sour	)(+	Bitter	1−	Yeasty	)(+	Sour	1−
	Bitter	)(+	Salty	)(+	Other[e]				Sour	1−	Bitter	)(+
			Numbing	1−	Salty	)(			Salty	)(	Numbing	1−
Aftertaste (60 sec)	Burnt	1	{Brown[c]	)(+	{Toasted[c]	1−	Grainlike	1	Grainlike	1−	Grainlike	)(+
	Bitter	)(+	{Burnt	)(+	{Grainlike	1−	Sour	1−	Sweet	)(	Petroleumlike	)(+
			{Bitter	)(+			Bitter	)(	Sour/Yeasty[d]	)(+	Sour	)(+
			Grainlike	)(+							Numbing	1−
			Other[e]									
			Numbing	)(+								

[a] Attributes rated on a four-point scale:)(= threshold, 1 = slight, 2 = moderate, 3 = strong. Plus and minus modify the level, indicating "high" or "low," respectively. Amplitude was rated on a three-point scale: 1 = low, 2 = moderate, 3 = high.
[b] HWW wheat from 1990 or 1988.
[c] Attributes within brackets were close in their order of perception and formed a tight complex.
[d] Attributes on the same line appeared at the same time and could not be perceived as separated.
[e] Attributes were not perceived by all panelists.

the grain complex, whereas in HWW90 crumb, a toasted impression was part of the grain complex. Yeasty and sour notes were perceived in both the aroma and flavor of HRW and HWW90 crumbs. As in the crust, more aftertastes remained in HWW90 crumb than in HRW crumb. HRW and HWW90 crumbs had amplitudes at the same level for both aroma and flavor.

Flavor Comparison of HRW and HWW90 with HWW88 Whole Wheat Breads

HWW88 whole wheat bread had a petroleum character in both crust and crumb that is incompatible with wheat. Although the specific cause of the petroleum aroma and flavor was not absolutely determined, it was suspected that the grain was contaminated with machine oil during bagging.

The flavor profiles of the HWW88 whole wheat bread are mentioned because they were somewhat different from those of HRW and HWW90. In general, the HWW88 bread was more numbing (crumb) and bitter than HWW90 bread and less bitter than HRW bread. The flavor of the crust in HWW88 was predominantly a grain complex, unlike the crust flavors of either HRW or HWW90, which were more brown and toasted and less branlike. Whether those differences are attributable to contamination of HWW88 or to variations in growing location and/or year of production is unknown.

CONCLUSIONS

Although breads made from HRW and HWW wheats exhibited many common flavor attributes, some were different. HRW white pan bread was sweeter, yeastier, and more astringent and dairylike than HWW bread, which was more toasted. HWW white pan bread had a phenoliclike flavor character not present in HRW bread. Perhaps the most distinctive difference in the whole wheat breads made from the two wheats was the character associated with the specific bran obtained from each flour type. Although differences existed, both flour types produced products with little deviation from characteristics commonly found in bread. The information from this study should be useful to wheat breeders in looking for improved qualities in their crosses.

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