

EFFECT OF ENVIRONMENT, VARIETY, AND CLASS OF WHEAT ON ALPHA-AMYLASE AND PROTEASE ACTIVITIES OF MALTED WHEAT¹

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ABSTRACT

The effects of environment, wheat class, and variety on alpha-amylase and protease activities of malted wheat have been investigated. Because of the large variety-station interaction, the effect of variety and station on enzyme activities of hard red winter wheat malts was nonsignificant. Within a given station or variety significant differences were observed. On the basis of the enzyme activities of their malts, the wheat classes were rated in the following order: soft white, soft red winter, hard red winter, durum, and hard red spring.

The barley malting industry has recognized, through its routine surveys, that varieties differ appreciably in their malting properties. Dickson and Geddes (6), Anderson and co-workers (1,2,12) and Kneen and Hads (11) have demonstrated that classes and varieties of barley and wheat vary in their ability to produce satisfactory malts. Dickson and Geddes (6) and Geddes *et al.* (9) rated soft white wheat as the best for malting, followed by soft red winter, hard red winter, and hard red spring wheats.

Kneen and Hads (11) showed that alpha- and beta-amylase activities of malted wheats depended on environment as well as variety. Meredith *et al.* (12), Dickson *et al.* (5,7), and Banasik and Harris (3,10) have also demonstrated the importance of station and crop year. These earlier studies were concerned with varieties now of minor importance. This investigation was designed to evaluate for malting purposes current commercial varieties.

Materials and Methods

The laboratory equipment used has been described (8). Two samples each of several varieties of the soft white winter, soft red winter, durum, hard red winter, and hard red spring classes were used for the study of varietal factors. Portions of each wheat were steeped to 40 and 42% moisture levels and germinated for periods of 2, 4, 6, 8, 10,

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and 12 days at 50°, 56°, 62°, and 68°F. Malts were kilned at 104° F. for 24 hours.

Samples of four varieties of hard red winter wheat from the 1956 crop grown at nine stations in Kansas, Langdon durum wheat grown at three locations in North Dakota, and three varieties of soft red winter wheat grown at two locations in Ohio were used for the study of the effect of environment. The hard red winter wheats were steeped to 42% moisture, germinated at 62°F. for 6 days, and dried at 104°F. for 24 hours. The full range of conditions outlined in the foregoing paragraph was employed in preparing the durum wheat malts. The soft winter wheat samples were steeped to 42% moisture, germinated at 68°F. for 12 days, and dried at 104°F. for 24 hours.

The rate of water absorption during steeping was determined by the modified method of Banasik *et al.* (4,8). Alpha-amylase was determined by the Sandstedt-Kneen-Blish method (15), as modified by Redfern (14). Protease activity was measured by the Miller and Johnson procedure (13).

Results and Discussion

Effect of Variety and Class. The alpha-amylase activities of the malts of the various classes and varieties of wheats studied are shown in Fig. 1. These data are typical for other steep-moisture levels and germination temperatures for the given varieties. The soft white wheats (Elmar and Genesee) produced malts having slightly greater activities than the soft red winter wheats. Seneca malts were appreciably lower in alpha-amylase than other varieties of its class tested. Concho was superior to others of the hard red winter class, while RedChief malts possessed the least alpha-amylase activity. Pawnee, Ponca, and Triumph were intermediate in this group, differing very slightly among themselves. The range of alpha-amylase activities of the durum wheat malts tested was not as great as that of the other classes. Among the varieties of hard red spring wheats studied, Selkirk produced the highest alpha-amylase activity, while Lee, Rescue, and Thatcher were significantly lower.

Protease activities for the same wheat malts are presented in Fig. 2. Differences in protease activities of the soft red winter wheats were slight. The hard red winter wheats exhibited a greater variation in protease activity than did the soft wheats. Concho and Pawnee, followed closely by Ponca, possessed the most protease activity, RedChief showed the least activity, while that of Triumph was only slightly greater. The protease activities of the malted hard red spring wheats were extremely variable. Rescue and Thatcher, which developed lower

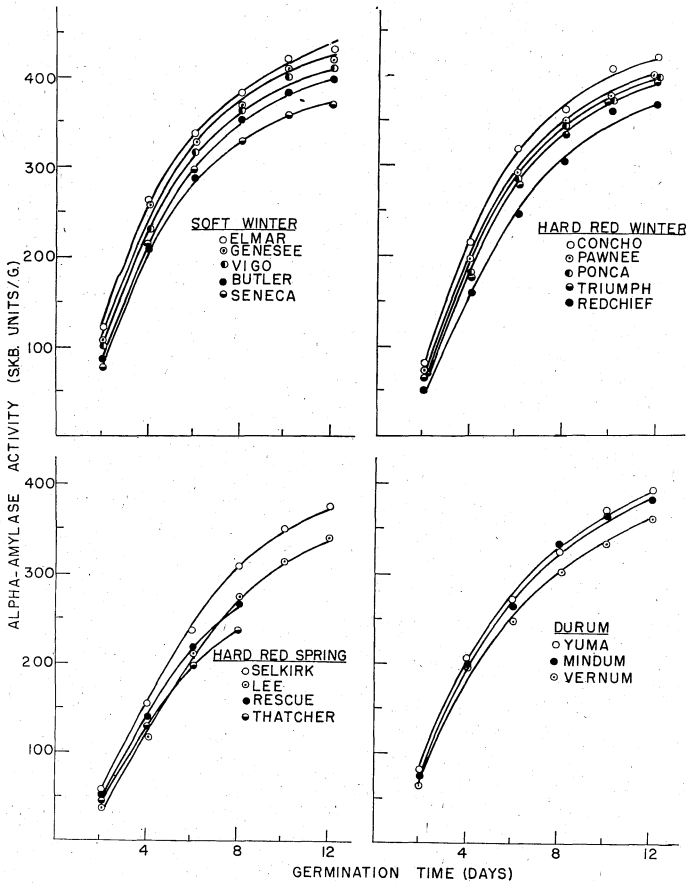


Fig. 1. Effect of variety and class of wheat on alpha-amylase activity of the malted grain.

amounts of alpha-amylase, had the highest protease activity. Lee had the lowest protease activity of all the hard red spring wheats tested. In the durum class, Mindum was higher in protease than Yuma and Vernum.

The average protease and alpha-amylase activities for the various wheat classes are given in Fig. 3. The soft white wheats were superior as a class to all others. They were not only pre-eminent to the others when malted under the given conditions, but also excelled when germinated at lower temperatures (Table I). Genesee wheat malted at 50°F. for 4 days had enzyme activities approximately equivalent to those of Concho wheat germinated for 6 days. Eight-day Genesee malt

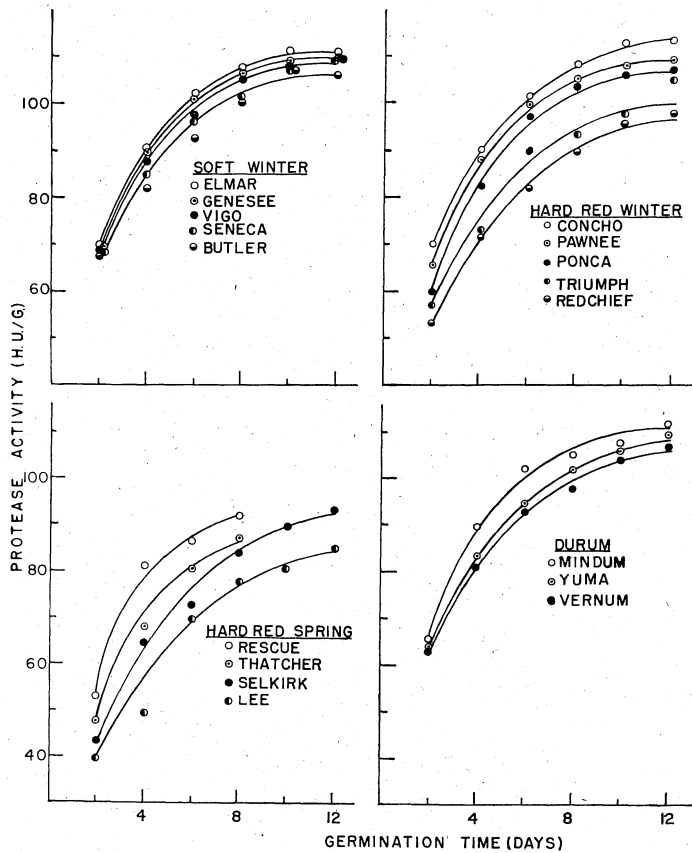


Fig. 2. Effect of variety and class of wheat on protease activity of the malted grain.

had enzyme activities equal to those of Concho germinated for 10 to 12 days.

The average protease and alpha-amylase activities of the soft red winter class were less than those of the soft white wheats (Fig. 3). The differences between these classes, however, were slight compared with those between the soft and hard red spring wheats. The hard red winter wheat class was superior to the hard red spring wheats in alpha-amylase and protease activity. The enzyme activities of the durum were similar to those for the hard red winter wheats. These data agree with those of Dickson and Geddes (6).

Effect of Variety and Environment. A study of the effect of environment and variety on the enzyme activities of hard red winter wheats is indicated by the data in Tables II and III. There were no

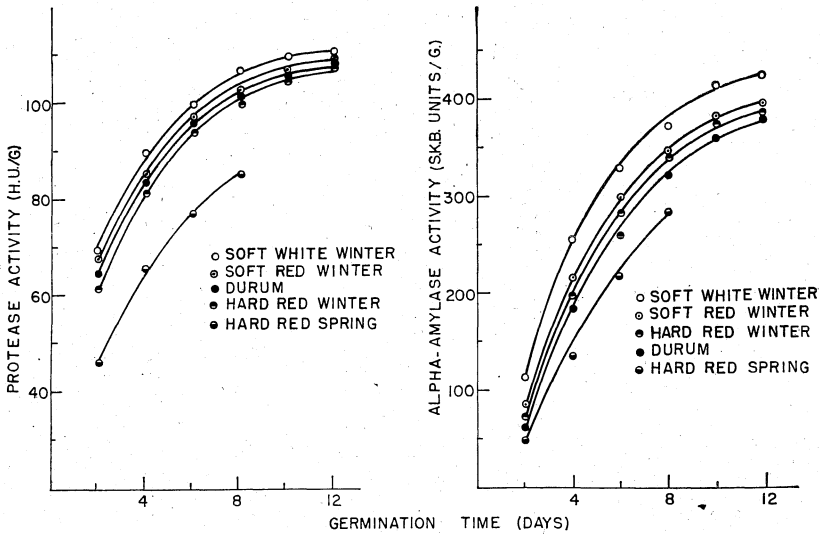


Fig. 3. Effect of class of wheat on alpha-amylase and protease activities of the malted grain.

TABLE I
ALPHA-AMYLASE AND PROTEASE ACTIVITIES OF
CONCHO AND GENESEE WHEAT MALTS
(Steep moisture 42%)

VARIETY	GERMI-NATION TEMP.	PROTEIN %	GERMINATION PERIOD (DAYS)					
			2	4	6	8	10	12
			Protease (HU/g of malt)					
Concho ^a	50	12.7	40.3	54.7	68.5	80.0	87.8	91.5
Genesee ^b	50	10.4	49.7	66.0	80.6	90.1	95.6	99.6
Concho	62	12.7	56.4	77.0	87.8	96.7	102.2	107.1
Genesee	62	10.4	66.3	80.8	94.3	102.0	105.9	108.9
			Alpha-amylase (SKB units/g of malt)					
Concho	50	12.7	27	52	106	176	240	288
Genesee	50	10.4	46	105	182	239	291	316
Concho	62	12.7	79	203	297	358	381	424
Genesee	62	10.4	103	243	314	360	402	422

^a Hard red winter.
^b Soft white winter.

significant variety or station differences compared to within-variety and station variance for either alpha-amylase or protease activities. However, within a given station or variety, significant differences were observed in many cases.

TABLE II
EFFECT OF ENVIRONMENT AND VARIETY ON THE ALPHA-AMYLASE
OF MALTED HARD RED WINTER WHEATS OF THE 1956 CROP
(Wheat steeped to 42% moisture and germinated at 62° F. for 6 days)

STATION	VARIETY				Average
	Ponca	Pawnee	Triumph	RedChief	
	<i>SKB</i> <i>units/g</i>	<i>SKB</i> <i>units/g</i>	<i>SKB</i> <i>units/g</i>	<i>SKB</i> <i>units/g</i>	<i>SKB</i> <i>units/g</i>
Belleville	215	241	207	198	217
Canton	196	238	214	195	211
Columbus	217	190	209	183	200
Garden City	182	208	183	183	189
Hutchinson	235	239	219	200	223
Manhattan	214	224	217	213	217
Mankato	222	209	202	197	208
Mound Valley	205	224	196	206	208
Thayer	197	205	193	177	193
Mean	209	219	204	195	
Least significant difference = 10					

ANALYSIS OF VARIANCE

Source of Variation	D.F.	Mean Square
Variety	3	3353
Station	8	1735
Variety × station	24	396 ***
Replications, same station	9	1013 ***
Replications × variety, same stations	27	43.9 ns
Remainder	72	13.3

Pawnee tended to be highest in alpha-amylase, being equivalent or superior to Ponca at all stations except Columbus and Mankato. Ponca generally was ranked second to Pawnee. Triumph was third in this group in alpha-amylase, while RedChief was never significantly higher than any other variety at any station. The wheats grown at Belleville, Hutchinson, and Manhattan, followed rather closely by those grown at Mankato, Mound Valley, and Canton, produced malts having the highest alpha-amylase activities. The malts of wheats produced at Garden City and Thayer were significantly lower in alpha-amylase than those from other stations.

The protease activities of all Pawnee and Ponca malt samples were essentially equal for most of the stations. Triumph ranked third in protease activity, being higher than RedChief in all cases, except for the Garden City-grown samples. The samples from Belleville, Hutchinson, and Canton gave malts with the highest protease activity, while those from Garden City, Thayer, Columbus, and Mound Valley were least active.

TABLE III

EFFECT OF ENVIRONMENT AND VARIETY ON THE PROTEASE ACTIVITY
OF MALTED HARD RED WINTER WHEATS OF THE 1956 CROP

(Wheat steeped to 42% moisture content and germinated at 62°F. for 6 days)

STATION	VARIETY				Average
	Ponca	Pawnee	Triumph	RedChief	
	<i>HU/g</i>	<i>HU/g</i>	<i>HU/g</i>	<i>HU/g</i>	<i>HU/g</i>
Belleville	86.1	86.5	78.8	69.9	80.3
Canton	84.1	84.8	81.5	74.1	81.1
Columbus	77.1	76.0	72.3	70.5	73.7
Garden City	78.4	79.7	68.0	71.0	74.3
Hutchinson	86.7	86.7	78.7	70.0	80.5
Manhattan	82.8	78.5	75.6	70.2	76.8
Mankato	78.6	81.8	75.8	75.4	77.7
Mound Valley	75.0	75.5	71.9	67.3	72.4
Thayer	79.7	79.4	70.5	65.5	73.8
Mean	80.9	81.0	74.8	70.3	
Least significant difference = 1.9					

ANALYSIS OF VARIANCE

Source of Variation	D.F.	Mean Square
Variety	3	809
Station	8	148
Variety × station	24	22 ***
Replications, same station	9	24 ***
Replications × variety, same stations	27	1.7 ns
Remainder	72	0.36

TABLE IV

EFFECT OF ENVIRONMENT ON ENZYME ACTIVITIES OF DURUM WHEAT MALTS
(VARIETY LANGDON)

(Wheat steeped to 42% moisture and germinated at 68°F. for 12 days)

STATION	PROTEIN	ALPHA-AMYLASE	PROTEASE
	%	<i>SKB units/g</i>	<i>HU/g</i>
Edgeley	12.5	414	112.3
Williston	12.2	395	110.2
Minot	12.9	379	108.9

The effect of environment on alpha-amylase and protease activities of durum wheats (variety Langdon) is shown in Table IV. The malts produced from the wheats grown at Edgeley were higher in enzyme activities than those from wheats grown at Williston and Minot. The activities of the Williston sample were slightly higher than those of the Minot-grown wheat. Banasik and Harris (3) reported that malts from barley grown at Edgeley had higher alpha-amylase activities than those produced from barleys grown at Williston or Minot.

The effect of environment on alpha-amylase and protease activities of malted soft winter wheats is given in Table V. All samples grown at Wooster produced malts with slightly higher enzyme activities than those from Columbus.

TABLE V
EFFECT OF ENVIRONMENT AND VARIETY ON THE
ALPHA-AMYLASE AND PROTEASE ACTIVITIES OF SOFT RED WINTER WHEAT
(Wheats steeped to 42% moisture and germinated at 68°F. for 12 days)

VARIETY	STATION	PROTEIN	ALPHA-AMYLASE	PROTEASE
		%	SKB units/g	HU/g
Seneca	Columbus	9.9	356	106.5
	Wooster	10.4	366	112.6
Genesee	Columbus	9.2	417	109.6
	Wooster	10.4	430	112.4
Vigo	Columbus	9.0	403	105.3
	Wooster	10.9	420	110.5

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