NOTE

Minerals and Protein Contents in Hard Red Winter Wheat Flours[1]

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ABSTRACT

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Twenty composite, experimentally milled, hard red winter wheat flours were analyzed for protein, ash, P, K, Mg, Ca, Zn, Fe, Mn, and Cu. Ten flours were location composites; each composite represented equal quantities of flour from 25 wheat cultivars/selections at a location. The other 10 flours were cultivar/selection composites; each composite represented equal quantities of flour from a wheat cultivar/selection grown at 23 locations in the Great Plains. Average flour milling extractions were 73.5% for the location composites and 72.9% for the cultivar/selection composites. Composition ranges and coefficients of variation of the location composites generally were larger than composition ranges and coefficients of variation of the cultivar/selection composites. Flour protein was over 90% of the wheat protein; total ash and individual flour minerals generally were less than one third of the wheat minerals. The average content of individual flour minerals, as percentage of the wheat minerals, was 66% for Ca; 20–30% for P, K, Mg, Zn, Fe, and Cu; and about 13% for Mn, both in the location and in the cultivar/selection composites. The most consistent correlations among wheat and flour components were between protein and Zn, and between Zn and Fe for the cultivar/selection composites and between protein and Ca for the location composites.

Milling wheat into flour reduces the levels of many nutrients from their original levels in the wheat (Kulp et al 1980). Most available information is on commercial wheats and flours in which the identity of the wheat and of the flour milled from it may be difficult to ascertain (Czerniejewski et al 1964, Farrell et al 1967, Lorenz et al 1977, Waggle et al 1967, Zook et al 1970). In practically none of the investigations, including those that studied the influence of wheat class (one variety from each of three classes), soil, and fertilizer treatment (El-Gindy et al 1957), has it been possible to determine effects of variety and location on mineral contents of wheats and flours in which the identity has been preserved. According to Erdman and Moul (1982), differences in mineral composition of wheat cultivars grown in a uniform test plot were small.

We reported recently on the ash, protein, and mineral contents of the 1973 hard red winter wheats composited by variety and location (Dikeman et al 1982). This study concerns the mineral and protein contents of flours milled on an experimental scale from those wheats.

MATERIALS AND METHODS

Wheat flour composites were prepared from the 1973 hard red winter Southern regional performance nursery samples. The wheats were milled on an Allis-Chalmers mill as described by Finney et al (1981).

Each cultivar composite represented equal quantities of flour from a wheat cultivar or selection from each of 23 locations; each location composite represented equal quantities of flour from each of 25 cultivars/selections at a location. The locations and the cultivars were selected to represent a wide range of growth conditions and compositions. They were described previously (Dikeman et al 1982). A total of 10 location composites and 10 cultivar composites were analyzed.

Analytical procedures were described previously (Dikeman et al 1982).

RESULTS AND DISCUSSION

Flour extraction rates of the location composites ranged from 70.0 to 75.3% and averaged 73.5%; extraction rates of the

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TABLE I
Protein, Ash, and Elemental Content (dry matter basis) of the Cultivar/Selection Composites from 23 Locations

	Wheat[a]			Flour			Flour as Percent of Wheat
Component	Range	Average	CV	Range	Average	CV	Average
Protein (%)	15.0–17.0	15.8	4.0	13.8–16.0	14.7	4.4	93
Ash (%)	1.82–2.01	1.91	3.1	0.45–0.50	0.48	4.2	25
P (%)	0.415–0.470	0.443	4.1	0.101–0.127	0.118	7.9	27
K (%)	0.420–0.518	0.465	6.3	0.096–0.124	0.109	9.9	23
Mg (%)	0.140–0.151	0.146	2.5	0.0265–0.0330	0.030	6.4	21
Ca (ppm)	409–538	487	7.1	286–353	319	8.2	66
Zn (ppm)	26.1–31.8	27.9	7.5	5.33–8.19	6.53	15.2	23
Fe (ppm)	44.1–53.9	49.9	6.2	11.3–19.3	13.7	19.2	28
Mn (ppm)	50.0–63.2	56.0	7.1	6.03–7.74	6.93	9.0	12
Cu (ppm)	4.25–5.84	5.14	8.1	1.15–1.72	1.49	15.0	29

[a]Dikeman et al 1982 (1973 samples).

TABLE II
Protein, Ash, and Elemental Contents (dry matter basis) of Ten Location Composites for 25 Cultivars/Selections

Component	Wheat[a] Range	Wheat[a] Average	Wheat[a] CV	Flour Range	Flour Average	Flour CV	Flour as Percent of Wheat Average
Protein (%)	10.3–17.3	14.9	15.2	9.1–16.5	14.2	15.2	95
Ash (%)	1.68–2.14	1.89	8.1	0.44–0.53	0.48	6.5	25
P (%)	0.381–0.549	0.452	13.8	0.095–0.123	0.113	9.6	25
K (%)	0.439–0.642	0.496	11.9	0.101–0.128	0.117	7.6	24
Mg (%)	0.139–0.176	0.155	10.1	0.026–0.035	0.029	9.1	19
Ca (ppm)	350–607	468	17.2	263–367	310	11.0	66
Zn (ppm)	14.9–43.3	30.5	28.2	3.16–7.65	6.16	24.0	20
Fe (ppm)	27.6–62.6	43.8	24.4	9.83–15.8	12.7	12.5	29
Mn (ppm)	42.0–70.0	55.2	15.1	5.76–7.94	6.97	9.3	13
Cu (ppm)	3.51–6.28	4.98	15.6	0.92–1.73	1.26	28.5	25

[a]Dikeman et al 1982 (1973 samples).

TABLE III
Significant Correlation Coefficients for Wheat and Flours

Correlations	Dry Basis Wheat	Dry Basis Flour	Percent of Ash Wheat	Percent of Ash Flour
Cultivar/Selection Composites				
Ash to P	0.608*[a]	···	···	···
Ash to Zn	0.796**[b]	···	···	···
Ash to Mg	0.695*	···	···	···
Protein to P	0.773**	···	···	···
Protein to Mg	0.727*	···	···	···
Protein to Zn	0.759*	0.795**	0.760*	0.888**
P to Zn	0.849**	···	···	···
P to Cu	0.695*	···	0.672*	···
P to K	···	···	−0.752*	···
Mg to K	···	···	···	−0.665*
Mg to Mn	···	···	0.893**	···
K to Ca	···	0.701*	···	0.715*
Ca to Fe	0.646*	···	0.745*	···
Ca to Zn	···	···	0.809**	···
Zn to Fe	···	0.765**	0.659*	0.717*
Location Composites				
Ash to P	0.934**	···	0.681*	···
Ash to Mg	0.900**	···	···	···
Ash to K	···	0.891**	···	···
Protein to Ca	0.859**	0.733*	0.713*	0.792*
Protein to Fe	0.761**	···	0.895**	···
Protein to Mg	0.910**	···	···	···
P to Zn	···	0.915**	···	0.885**
Mg to Mn	···	−0.699*	···	···
Mg to Fe	0.801**	···	···	···
K to Ca	···	0.659*	···	0.740*
K to Fe	···	0.652*	···	···
Ca to Fe	0.717*	···	···	···
K to Zn	···	···	···	−0.717*

[a]$P = 0.05$
[b]$P = 0.01$

cultivar/selection composites ranged from 71.3 to 74.0% and averaged 72.9%.

Protein, ash, and mineral contents (ranges, averages, and coefficients of variation [CV]) are summarized in Table I for the cultivar composites and in Table II for the location composites. All results are expressed on a moisture-free basis. Ranges, averages, and CV in wheats are compared with ranges and averages in wheat flours. For the cultivar composites, CV for the flours was consistently larger than CV for the wheats; the opposite generally was true for the location composites. Coefficient of variation for the location composites was significantly larger than that for the cultivar composites. On the average, flour protein comprised 93 and 95%, ash 25 and 25%, P 27 and 25%, K 23 and 24%, Mg 21 and 19%, Ca 66 and 66%, Zn 23 and 20%, Fe 28 and 29%, Mn 12 and 13%, and Cu 29 and 25% of those components in whole wheat in cultivar and location composites, respectively. Thus, only small and nonsignificant differences were found in this respect between the cultivar and location composites, indicating that both groups were milled in a similar manner insofar as protein and mineral contents are concerned.

Correlation coeffients were calculated for the cultivar and location composites between ash, protein, P, K, Mg, Ca, Zn, Fe, Mn, and Cu, with the individual minerals expressed either as percentage of sample or as percentage of ash. In the first case, the results reflect changes in individual mineral components as they relate to total ash and/or total protein. In the second, the results reflect changes in the composition of ash, irrespective of total ash content. Significant correlations are indicated in Table III. The most consistent correlations for the cultivar composites were between protein and Zn, and between Zn and Fe and for the location composites between protein and Ca.

Results of this study point to certain associations among mineral components, and between Zn and protein in wheat cultivars. Confirmation of those associations for wheats from other classes might provide the basis for evaluation of their significance in plant physiological processes.

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