Phytochemistry, 1971, Vol. 10. pp. 2975 to 2978. Pergamon Press. Printed in England.

SHORT COMMUNICATION

EFFECT OF RUST INFECTION ON MARQUIS WHEAT GRAIN PROTEINS*

W. BUSHUK and C. W. WRIGLEY

Department of Plant Science, The University of Manitoba, Winnipeg 19, Canada and C.S.I.R.O. Wheat Research Unit, North Ryde, N.S.W. 2113, Australia

(*Received* 6 *January* 1971, *in revised form* 6 *April* 1971)

Abstract—Rust infected common (bread) wheat (cv. Marquis) lacked one of the low molecular weight glutenin components that was present in the healthy sample of the same variety. This could explain the decrease in gluten content and sedimentation value that resulted from the rust infection. Amino acid analyses showed that the flour protein from the rusted sample contained more of the basic amino acids and less glutamic acid and proline. Rust infection did not affect the polyacrylamide gel electrophoretic patterns.

INTRODUCTION

SEVERE rust infection during grain development causes the grain produced to be pinched, shrivelled and virtually useless for milling and baking.[1] The effect of rusting on the grain proteins has not been investigated. This paper presents information on the effect of rust on one cultivar (Marquis).

RESULTS AND DISCUSSION

The effect of rust damage on milling quality is quite marked (Table 1). Flour yield for the rusted sample was extremely low, about 60% of that from non-rusted sample. In spite of the low yield, the flour still had a relatively high ash content. The breadmaking quality, as judged by the sedimentation value and wet gluten content, of the flour from the rusted

TABLE 1. ANALYTICAL DATA ON RUSTED AND HEALTHY MARQUIS WHEAT

Wheat	Rusted	Healthy
Weight per hectoliter, kg	50·5	84·7
1000 kernel weight, g	8·9	33·2
Protein, % (13·5% moisture)	13·9	14·0
Ash, % (13·5% moisture)	2·80	1·70
Fibre, % (as is basis)	20·9	12·7
Flour		
Yield,* %	45·0	72·0
Protein, % (14% moisture)	12·9	12·8
Ash, % (14% moisture)	1·42	0·40
Sedimentation value, ml	44	60
Starch damage†	14·1	26·6
Wet gluten, % (14% moisture)	36·8	39·9
Fibre, % (as is basis)	0·85	0·98

* Milled on an Allis Chalmers Experimental mill.
† Farrand units, *Cereal Chem.* **41**, 98–111 (1964).

* Contribution No. 266 of the Department of Plant Science, University of Manitoba, Canada.

sample was much inferior to that of the normal flour. These effects of rusting are well known from previous studies,[1] and are recorded here for comparison with the results on the proteins presented below.

The electrophoretic patterns were qualitatively similar for proteins from the rusted and healthy grain. It should be noted that only the proteins with mol. wt. below 100,000 daltons enter the polyacrylamide gels used in the present study. Glutenin proteins are excluded from the gel. The most notable difference between the electrophoretic patterns for the two samples was the slightly stronger intensity of the bands with R_f values of 0·17 and 0·25 (gliadins) for the rusted sample. These results underline previous conclusions[2] that the composition of wheat proteins is determined by genetic constitution and is unaffected by growth environment.

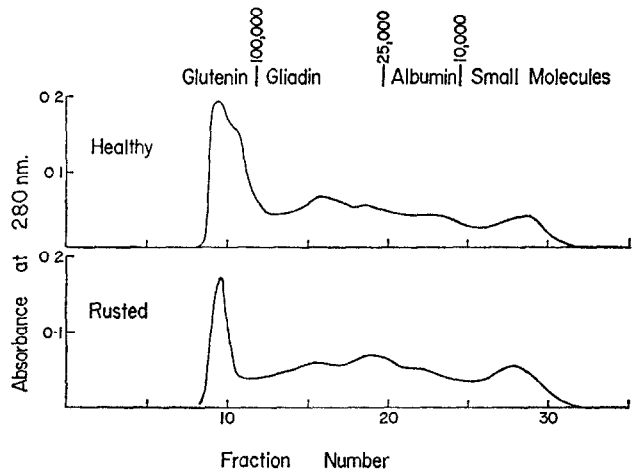

FIG. 1. GEL FILTRATION ON SEPHADEX G-150 OF AUC EXTRACTS OF GROUND GRAIN.

Gel filtration elution profiles (Fig. 1) are similar for the two samples except that the healthy wheat contains a low mol. wt. glutenin (*ca.* 300,000 daltons) that is absent in the rusted wheat. This glutenin component is synthesized in common (bread) wheats during the latter stages of maturation and is absent in durum wheats.[3] It appears that this component contributes to the superior breadmaking quality of bread wheats. Its presence increases substantially the proportion of glutenin in the endosperm proteins (Table 2), and presumably also the wet gluten content (Table 1). It is not known if the difference in the glutenins observed here could result from differences in growing conditions of the two locations where the wheat samples were grown. In normally developed grain, the effect of environment on breadmaking quality manifests through its effect on protein content and not because of any qualitative effect on the endosperm protein components.

Amino acid composition data (Table 3) showed differences that are consistent with the wet gluten content and gel filtration results. The rusted sample had higher contents of the

[1] W. Q. LOEGERING, C. O. JOHNSTON and J. W HENDRIX, in *Wheat and Wheat Improvement* (edited by K. S. QUISENBERRY and L. P. REITZ), American Society of Agronomy, Inc, Madison, Wisc. (1967).
[2] G. J. DOEKES, *J. Sci. Food Agric.* **19,** 169 (1968).
[3] W. BUSHUK and C. W. WRIGLEY, *Cereal Chem.* **48,** 448 (1971).

TABLE 2. COMPOSITION OF AUC EXTRACTABLE PROTEIN DETERMINED BY GEL FILTRATION ON SEPHADEX G-150

Protein	Rusted (%)	Healthy (%)
Glutenin	27	32
Gliadin	35	37
Albumin	18	17
Small molecules	20	14

basic amino acids (lysine, histidine and arginine) and lower amounts of glutamic acid and proline indicating that its endosperm contained more water-soluble and less gluten proteins.

The results presented here indicate that rust infection interferes with the normal development of glutenin that is required for breadmaking quality, in addition to the overall inhibition of the synthesis and deposition of starch and protein in the endosperm which, on maturation, results in kernel shrivelling.

TABLE 3. AMINO ACID COMPOSITION OF FLOUR FROM RUSTED AND HEALTHY MARQUIS (g AMINO ACID NITROGEN per 100 SAMPLE NITROGEN)

	Rusted	Healthy
Lysine	*2·60**	*2·32*
Histidine	*3·43*	*3·28*
Ammonia	20·20	19·70
Arginine	*7·68*	*6·92*
Aspartic acid	2·73	2·72
Threonine	2·06	1·99
Serine	3·94	4·02
Glutamic acid	*20·36*	*21·40*
Proline	*9·08*	*9·44*
Glycine	4·30	4·20
Alanine	2·97	2·82
Valine	2·98	2·96
Methionine	1·00	0·90
Isoleucine	2·26	2·26
Leucine	4·72	4·65
Tyrosine	1·44	1·46
Phenylalanine	2·60	2·62
N recovery %	93·8	94·2

* Values that differ by more than the experimental error are *in italic*.

EXPERIMENTAL

Two samples of hard red spring wheat (cv. Marquis) were used in the present study; one obtained from the Canada Department of Agriculture test plots at Glenlea, Manitoba, and the other from Lethbridge, Alberta. Plants from which the Manitoba sample was threshed were severely infected with stem rust (*P. graminis*) and leaf rust (*P. recondita*) while the Alberta sample was rust free (designated as healthy). The grain samples had similar protein content but differed greatly in kernel size (Table 1). Tests used for the characterization of the samples are those of the A.A.C.C.[4] except the fibre content which was determined by the method of Moss and Stenvert.[5]

[4] AMERICAN ASSOCIATION OF CEREAL CHEMISTS, *Cereal Laboratory Methods*, 7th Edn, St. Paul, Minnesota (1962).

[5] H. J. MOSS and N. STENVERT, *Austral. J. Agric. Res.* **22**, 547 (1971).

For disc electrophoresis, meal (1 g) milled from each sample was extracted with 2 M urea (6 ml) for 1 hr. The clarified (by centrifugation) extract was subjected to electrophoresis in a discontinuous buffer system of potassium-glycinium acetate (running pH 2·7 on a Buchler Instruments Polyanalyst Apparatus). Gels were stained with amido black.

For gel filtration chromatography, the extracts were made with AUC (aq. solution containing 0·1 M acetic acid, 3 M urea and 0·01 M cetyltrimethylammonium bromide) solvent. This solvent solubilizes almost all (98%) of the wheat protein. Chromatography procedure using Sephadex G-150 was that of Meredith and Wren[6] as modified by Bushuk and Wrigley.[3]

Amino acid composition of the flour was determined on the Beckman Model 121 amino acid analyser. The hydrolysate was prepared using 6 N HCl and a hydrolysis time of 24 hr under vacuum at 110°. Reported data are the average of two analyses. Replicate results differed by less than 3%. The half cystine content was too low to be determined accurately and therefore it was not included in the amino acid composition.

Acknowledgement—The wheat samples used in this study were provided by Dr. A. B. Campbell, C.D.A. Research Station, Winnipeg, Canada.

[6] O. B. MEREDITH and J. J. WREN, *Cereal Chem.* **43,** 169 (1966).